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RESEARCH PAPER

Effect of salinity stress on morphological, phenological and yield parameters in chickpea

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Abstract: A study was undertaken to know the effects of salinity levels (0, 3 dS/m and 6 dS/m) on the morphological, phenological and yield traits of 10 selected chickpea cultivars. Genotypes varied significantly in the manifestation of their morphological and phenological traits to salinity. Significant reduction in plant height and number branches was observed under salinity, salinity delayed the flower initiation, pod initiation and physiological maturity. It was observed that the genotypes JG 11, BGD 103, MNK 1 and ICC 1431 were less influenced by salinity stress on morpho-phenological and productivity traits when compared to other genotypes whereas, ICCV96029 and NBeG47 were severely influenced by salinity stress.

Key words: Chickpea, Salinity, Sodium chloride, Stress

Introduction

Chickpea (*Cicer arietinum* L.) is a legume crop and belongs to the family Fabaceae. It is self-pollinated, diploid (2n=2x=16) with a genome size of 740 Mbp. It is an annual crop that can complete its life cycle in 90 to 180 days depending on the prevailing meteorological conditions. It is the second most important legume crop after dry beans (Varshney *et al*., 2012). The species is grouped into *desi* and *kabuli* type: *desi* generally have small, darker coloured seeds, where as *Kabuli* is usually producing large, cream-coloured ones.

Salinity stress is the most deleterious abiotic stress that affects the growth and productivity of plants. Salinity imposes negative effect on the growth of plant by decreasing water potential of leaf, inducing morphological and phenological changes, increased osmotic stress, production of reactive oxygen species (ROS), ion toxicity and alters the biochemical processes (Khan *et al*., 2014). Factors responsible for salinity are climate, human activities, composition of salt and topography of lands. One of the most common sources of salinity is NaCl (Li *et al*., 2006). Salinity increases the concentration of Cl^- and Na^+ ions and decreases the concentration of PO_4^{-3}, N^+, Mg^{+2} , Ca^{+2} , and K^+ ions in leaves (Khalid and Cai , 2011). The growth of plants is affected by lack of nutrients, reduction in the uptake of water and accumulation of toxic sodium and chloride ions (Gehan, 2015). Chloride is utilized by plants as a micronutrient and as mineral nutrient by many halophytes, but over accumulation of these salts result in low biodiversity and reduced growth and reproduction of salt sensitive plants (Parida and Das, 2005). The presence of sodium and chloride ions at higher concentrations within the plant cell impairs the function of enzymes present in the cytosol. The study was conducted with ten chickpea genotypes subjecting to three NaCl treatments to understand the effect of salinity on morpho-phenological traits and and yield.

Material and methods

The pot experiment was conducted under rain out shelter, College of Agriculture, Vijayapur using 10 genotypes *viz.,* Annigeri 1, BGD103, GBM2, JAKI9218, JG11, MNK1, NBeG47,ICCV96029, ICC1431 and ICC5003 during 2019 following Completely Randomized Design (CRD) with three replications. There were three treatments including control and two salinity levels (3 and 6 dSm^{-1}) developed by using NaCl solution.

Plastic pots of 30 cm diameter and 30 cm in height (30 x 30 cm) were filled with 10 kg of air-dried soil and FYM in 6:1 ratio. Recommended Package of Practice (25:50:0 kg/ha) was followed for NPK application. Before sowing, pots were irrigated with 2.5 litres of water (control, C1) or salt solutions of different concentrations (C1 and C2). Salt solutions were prepared by using NaCl salt: 5 and 10 gram of NaCl salt dissolved in 1 litre of water for preparing 3 EC (C2) and 6 EC (C3) solutions respectively. Later, optimum moisture in the pots was maintained through normal watering uniformly across all the pots.

Morphological, phenological, yield and yield attributing traits were recorded from three randomly selected plants and data was subjected to statistical analysis.

Results and discussion

Effect of salt stress on morphological parameters

Salinity affected plant development including germination, vegetative growth and reproductive development. Plant height differed significantly at 30, 60 and 90 days after sowing with respect to salinity levels and chickpea genotypes (Table 1). At 30 days after sowing, among the salinity levels, significantly higher plant height was recorded in control (26.83 cm) followed by 3 dSm^{-1} and 6 dSm^{-1} (19.21 cm and 14.46 cm, respectively) and similar trend was noticed at 60 and 90 days after sowing. The decrease in overall plant growth can be attributed to alteration in the metabolic reactions and physiological process. Reduction of stem length and plant height was due to increased salinity levels with negative effect on rate of photosynthesis, decrease in the level of carbohydrates and growth hormones and the changes in the activity of enzymes was reported by Himaya and Prapagar (2019).

Among *desi* genotypes BGD103 recorded maximum plant height (38.64 cm) followed by JG11, which were found on par with each other and the genotype ICCV96029 (32.17 cm) was recorded significantly lower plant height at 90 days after sowing. The interaction between genotypes and salinity levels had significant difference for plant height. At 90 days after sowing, the plant height of MNK1, a *Kabuli* type, was 50.30 cm and was the tallest genotype, while BGD 103 and ICCV96029 (*desi* types) were found to be tallest among other *desi* genotypes under control. Further, the genotype ICCV96029 (19.03 cm) recorded lowest plant height under 6 dSm^{-1}. Rahman *et al.,* 2008, also observed the effect of salinity on plant height and reported that seedling height and growth of chickpea get reduced due to slow down or very less mobilization of reserve food material, suspending the cell enlargement, cell division and injuring during salinity. Shamsi *et al.* (2010) observed significant reduction in seedling shoot height of chickpea cultivars under different salinity levels.

The effect of salinity stress on number of branches was highly significant (Table 3). As the concentration of NaCl increased, the number of branches at all the level of salinity drastically decreased. Among the salt concentrations, significantly higher number of secondary branches were recorded under control (14.33) followed by 3 dSm^{-1} (11.60). Least number of secondary branches was recorded under 6 dSm^{-1} (5.73). Among the genotypes, JG11 recorded significantly higher number of secondary branches at harvest (12.00) followed by MNK1 (11.78) and BGD103 (11.56). However the genotypes ICC5003, GBM2, ICC1431 and JAKI9218 were found on par with each other. The least number of secondary branches were recorded in the genotype NBeG47 (9.22). The increased salt concentration resulted in reduction of plant height, number of flowers, number of branches and both fresh and dry weights (Alam *et al.,* 2016). The increased salinity levels, decreased plant height, branch number and leaf number per plant due to inhibitory behavior on cell expansion and cell division was observed in tomato (Parvin *et al*., 2015).

Effect of salt stress on phenological parameters

In chickpea, the flowering stage is considered as one of the most critical stages and has been noticed that time of flowering and physiological maturity are modulated strongly by genotype and various salinity levels. The data (Table 2 and Table 3) indicates the significant variation in phenological parameters as influenced by various salt concentrations.

The data showed that the days to first flowering varied significantly with respect to genotypes, salinity levels and their interactions. Among the genotypes significantly higher number of days to first flowering was recorded in JAKI9218 (46.67 days) followed by GBM 2 (46 days) and JG11 (45.89 days). The results on flowering were in agreement with opinion of Achard *et al*., (2007) that salt stress delays flowering process dependent on DELLA proteins acting as negative regulators of GA signaling and the plant hormone ethylene. The high salinity levels resulted into reduction in growth and flower initiation may be due to decrease in the production of photo assimilates, delaying cell elongation and production of plant growth regulators, further, high salinity prevent uptake of water and nutrients and caused ion toxicity (Na^+ and Cl^-) which reduce shoot and root growth compared to control in chickpea genotypes (Ebbisa and Getachew, 2015).

The phenological data (Table 2) showed that among the salinity levels, more number of days to 50 per cent flowering was recorded under 6 dSm^{-1} (62.67 days). However, least days to 50 per cent flowering was recorded in control (42.27 days). The interaction effect between genotypes and salinity levels differed significantly for days to 50 per cent flowering. Genotype, ICCV96029 recorded significantly more number of days to 50 per cent flowering (62.67 days) under 6 dSm^{-1}, followed by genotype NBeG47 (59.67 days) under same salinity level. In general there was delay in attaining 50 per cent flowering with increased salinity levels. However, the genotype BGD 103 and JG 11 showed least change in days to 50 per cent flowering with increased salinity levels. Krishnamurthy *et al*. (2011) noticed the significant effect of salinity stress on days to 50 per cent flowering, days to pod initiation, days to physiological maturity, seed yield, seed number and 100 seed weight in chickpea.

The number of days to pod initiation days to physiological maturity (Table 3) was high in JAKI9218 and ICC5003 (50.22 days) followed by JG11 (50.11 days) which was found on par with GBM2 (50.00 days). Significantly, least number of days to pod initiation was recorded in genotypes ICCV96029 (45.78 days) and MNK1 (46.78 days). Likewise, among the interaction effect, ICCV96029 recorded significantly more number of days to pod initiation (61days) under 6 dSm^{-1} followed by genotype NBeG47 (59.33 days) under same salinity level. Least number of days to pod initiation was recorded in genotype ICCV96029 (32.00 days) under the control followed by genotype Annigeri 1 under same salinity level (38.67 days). Na^+ and Cl^- ion accumulation and number of days required for pod initiation significantly increased and the number of pods per plant and pollen viability were significantly decreased during salinity (Turner *et al*., 2013). Kotula *et al*. (2015) also observed significant increase in days to first flowering and pod initiation at 50 mM NaCl concentration while decreased number of pods per plant.

Salinity stress delayed physiological maturity. The 6 dSm^{-1} recorded significantly more number days to physiological maturity (86.37 days) and the least days to physiological maturity was observed under control (77.73 days). Among the genotypes significantly higher number of days to physiological maturity was recorded in genotype ICC1431 (85 days) followed by genotype JAKI9218 (84.78 days) and BGD103 (84.11 days). Among the interactions, genotype ICC1431 recorded significantly higher number of days to physiological maturity (89.33 days) under 6 dSm^{-1} followed by genotype JAKI9218 (88.00 days) under same salinity level. Least number of days to physiological maturity was recorded in genotype ICCV96029 (70.67 days) under control. The salt sensitive chickpea genotypes were died at 60 to 70 days after sowing with few

Table 1. Effect of salinity stress on plant height (cm) at 30, 60 and 90 days after sowing in chickpea

Genotypes	Plant height at 30 days after sowing				Plant height at 60 days after sowing				Plant height at 90 days after sowing			
	0 dSm^{-1} (Control)	3 dSm^{-1}	6 dSm^{-1}	Mean	0 dSm^{-1} (Control)	3 dSm^{-1}	6 dSm^{-1}	Mean	0 dSm^{-1} (Control)	3 dSm^{-1}	6 dSm^{-1}	Mean
Annigeri 1	20.93	19.43	15.43	18.60	45.47	37.60	24.37	35.81	46.03	38.10	24.53	36.22
JAKI 9218	22.85	18.43	13.77	18.35	41.57	34.23	24.90	33.57	42.77	35.10	24.83	34.23
BGD 103	27.28	21.10	16.17	21.52	48.43	39.30	26.53	38.09	48.73	40.10	27.10	38.64
MNK 1	34.53	26.87	15.27	25.56	50.06	40.57	27.17	39.26	50.30	41.07	27.50	39.62
JG11	29.83	21.23	16.67	22.58	47.20	38.47	27.33	37.67	47.23	39.83	27.70	38.26
GBM 2	28.40	18.00	13.87	20.09	40.80	32.00	23.23	32.01	43.80	33.20	23.33	33.44
NBeG 47	25.30	16.90	12.20	18.13	43.60	31.23	21.70	32.18	44.13	32.80	22.23	33.06
ICC 1431	27.33	17.43	16.37	20.38	46.07	34.33	23.37	34.59	46.70	35.50	24.03	35.41
ICC 5003	25.90	18.10	14.53	19.51	42.13	33.83	25.37	33.78	43.17	35.00	25.83	34.67
ICCV 96029	25.93	14.57	10.37	16.96	48.10	28.43	18.30	31.61	48.20	29.27	19.03	32.17
Mean	26.83	19.21	14.46		45.34	35.00	24.23		46.11	36.00	24.61	
	S.Em.±		LSD @5%		S.Em.±		LSD @5%		S.Em.±		LSD @5%	
EC	0.08		0.21		0.08		0.22		0.07		0.19	
Genotypes	0.26		0.68		0.28		0.74		0.24		0.65	
Interaction (E*G)	0.77		2.05		0.83		2.21		0.73		1.94	

Table 2. Effect of salinity on days to first flowering and days to 50 per cent flowering in chickpea

Genotypes	Days to first flowering				Days to 50 per cent flowering			
	0 dSm^{-1} (Control)	3 dSm^{-1}	6 dSm^{-1}	Mean	0 dSm^{-1} (Control)	3 dSm^{-1}	6 dSm^{-1}	Mean
Annigeri 1	35.00	45.33	53.67	44.67	40.00	49.67	57.67	49.11
JAKI 9218	40.00	45.67	54.33	46.67	46.67	50.00	58.33	51.67
BGD 103	39.00	42.00	49.00	43.33	46.00	47.00	53.67	48.89
MNK 1	34.00	42.33	53.33	43.22	40.67	48.00	56.00	48.22
JG11	39.67	45.00	53.00	45.89	45.67	51.67	56.67	51.33
GBM 2	37.33	45.67	55.00	46.00	43.67	51.00	58.67	51.11
NBeG 47	35.33	46.00	54.67	45.33	41.33	51.33	59.67	50.78
ICC 1431	35.67	44.33	52.67	44.22	41.67	52.33	57.00	50.33
ICC 5003	38.00	45.00	52.33	45.11	43.33	52.00	57.33	50.89
ICCV 96029	27.33	40.67	56.67	41.56	33.67	46.33	62.67	47.56
Mean	36.13	44.20	53.47		42.27	49.93	57.77	
	S.Em.±		LSD @5%		S.Em.±		LSD @5%	
EC	0.09		0.24		0.10		0.25	
Genotypes	0.30		0.79		0.32		0.85	
Interaction (E*G)	0.89		2.38		0.95		2.54	

Table 3. Effect of salinity stress on days to pod initiation, days to physiological maturity and secondary branches in chickpea

Genotypes	Days to Pod initiation				Days to Physiological maturity			
	0 dSm^{-1} (Control)	3 dSm^{-1}	6 dSm^{-1}	Mean	0 dSm^{-1} (Control)	3 dSm^{-1}	6 dSm^{-1}	Mean
Annigeri 1	38.67	49.33	58.00	48.67	75.33	78.33	83.33	79.00
JAKI 9218	44.67	47.67	58.33	50.22	81.67	84.67	88.00	84.78
BGD 103	43.33	46.33	53.00	47.56	80.33	84.33	87.67	84.11
MNK 1	39.00	46.33	55.00	46.78	78.67	83.00	85.33	82.33
JG11	44.00	50.00	56.33	50.11	77.00	82.67	87.00	82.22
GBM 2	41.33	49.67	59.00	50.00	75.67	82.00	84.33	80.67
NBeG 47	40.00	50.33	59.33	49.89	78.00	83.33	86.67	82.67
ICC 1431	40.33	51.33	56.67	49.44	81.00	84.67	89.33	85.00
ICC 5003	42.33	50.67	57.67	50.22	79.00	82.67	87.00	82.89
ICCV 96029	32.00	44.33	61.00	45.78	70.67	77.67	85.00	77.78
Mean	40.57	48.60	57.43		77.73	82.33	86.37	
	S.Em.±		LSD @5%		S.Em.±		LSD @5%	
EC	0.11		0.29		0.14		0.37	
Genotypes	0.36		0.95		0.46		1.22	
Interaction (E*G)	1.07		2.86		1.37		3.65	

Table 4. Effect of salinity stress on secondary branches, pod number and pod weight per plant at harvest in chickpea

Genotypes	Secondary branches				Pod number per plant				Pod weight per plant (g plant^{-1})			
	0 dSm^{-1} (Control)	3 dSm^{-1}	6 dSm^{-1}	Mean	0 dSm^{-1} (Control)	3 dSm^{-1}	6 dSm^{-1}	Mean	0 dSm^{-1} (Control)	3 dSm^{-1}	6 dSm^{-1}	Mean
Annigeri 1	14.67	11.33	3.33	9.78	18.33	9.00	4.00	10.44	9.70	4.68	3.05	5.81
JAKI 9218	13.67	11.00	5.67	10.11	16.00	8.67	3.33	9.33	6.66	4.35	2.79	4.60
BGD 103	16.33	13.00	5.33	11.56	17.33	10.67	5.67	11.22	6.42	5.82	4.48	5.57
MNK 1	16.00	12.33	7.00	11.78	17.00	10.33	5.00	10.78	7.49	5.54	4.05	5.69
JG11	15.67	13.67	6.67	12.00	19.67	11.00	6.33	12.33	7.17	6.20	4.94	6.10
GBM 2	13.33	10.67	7.33	10.44	15.67	8.00	2.67	8.78	7.99	3.97	2.52	4.83
NBeG 47	12.33	10.33	5.00	9.22	14.67	7.67	2.33	8.22	5.68	3.69	2.10	3.82
ICC 1431(c)	14.00	12.00	4.67	10.22	16.33	10.00	4.67	10.33	8.62	5.33	3.60	5.85
ICC 5003(c)	14.33	11.67	6.00	10.67	17.67	9.67	4.33	10.56	9.06	5.00	3.40	5.82
ICCV96029(c)	13.00	10.00	6.33	9.78	18.00	6.33	1.33	8.56	5.93	3.13	1.05	3.37
Mean	14.33	11.60	5.73		17.07	9.13	3.97		7.47	4.77	3.20	
	S.Em.±		LSD @5%		S.Em.±		LSD @5%		S.Em.±		LSD @5%	
EC (E)	0.04		0.11		0.05		0.14		0.01		0.04	
Genotypes(G)	0.14		0.38		0.18		0.48		0.05		0.13	
Interaction (E*G)	0.43		1.14		0.54		1.43		0.14		0.39	

Table 5. Effect of salinity stress on test weight, seed yield per plant and harvest index in chickpea

Genotypes	Test weight (g)				Seed yield (g plant^{-1})				Harvest index (%)			
	0 dSm^{-1} (Control)	3 dSm^{-1}	6 dSm^{-1}	Mean	0 dSm^{-1} (Control)	3 dSm^{-1}	6 dSm^{-1}	Mean	0 dSm^{-1} (Control)	3 dSm^{-1}	6 dSm^{-1}	Mean
Annigeri 1	21.99	19.00	16.91	19.30	7.83	4.19	2.92	4.98	52.91	39.21	28.42	40.18
JAKI 9218	24.59	18.61	16.08	19.76	6.66	3.98	2.61	4.42	50.65	38.22	25.88	38.25
BGD 103	29.45	24.65	18.67	24.26	8.06	5.49	3.88	5.81	59.10	48.35	34.90	47.45
MNK 1	32.87	25.83	18.28	25.66	8.33	5.10	3.67	5.70	59.02	45.71	33.84	46.19
JG11	25.18	22.18	19.17	22.18	9.00	5.93	4.33	6.42	59.15	50.91	38.29	49.45
GBM 2	21.83	18.25	15.57	18.55	6.36	3.65	2.41	4.14	48.73	36.47	24.22	36.47
NBeG 47	20.73	17.92	14.70	17.78	7.50	3.18	2.07	4.25	58.43	32.29	20.82	37.18
ICC 1431(c)	22.95	21.66	17.84	20.82	5.10	4.81	3.43	4.45	38.14	43.88	31.87	37.96
ICC 5003(c)	22.07	19.81	17.51	19.79	6.98	4.47	3.15	4.86	48.96	40.95	30.08	39.99
ICCV96029(c)	22.64	16.78	13.85	17.76	5.99	2.84	1.00	3.28	45.15	29.41	11.56	28.71
Mean	24.43	20.47	16.86		7.18	4.37	2.95		52.02	40.54	27.99	
	S.Em.±		LSD @5%		S.Em.±		LSD @5%		S.Em.±	LSD @5%		
EC (E)	0.03		0.08		0.01		0.02		0.09	0.24		
Genotypes (G)	0.10		0.25		0.03		0.08		0.30	0.81		
Interaction (E*G)	0.29		0.76		0.09		0.24		0.91	2.42		

pods or no pods under 60 mM NaCl level and compared to control, in salinity, flower number was decreased up to 40 per cent at 40 mM NaCl (Samineni *et al.*, 2011).

Effect of salt stress on yield parameters

Yield and yield components are complex characters which involve the interaction of several external and intrinsic factors. Environmental factors influence uptake of water, nutrient and mobilization of photosynthates towards sink and affect the yield. Salt stress, typically impact the various physiological processes (low water uptake, decreased respiration, and photosynthesis) and ultimately yield of the crop (Hussain *et al.*, 2018).

In the present study, yield and yield components were influenced in most of the genotypes under saline condition. The differences in seed yield among chickpea genotypes at different salinity levels was due to variation in chlorophyll content, relative water content and dry matter accumulation. Under control (0 dSm^{-1}) significantly higher seed yield of 7.18 g plant^{-1} was recorded followed by 4.37g plant^{-1} (3 dSm^{-1}) and the least seed yield of 2.95 g plant^{-1} was recorded under 6 dSm^{-1}. Among the genotypes, JG11 recorded significantly higher mean seed yield (6.42 g plant^{-1}) followed by BGD103, MNK1, Annigeri1 and ICC5003. Significantly lowest seed yield per plant was observed in ICCV96029 (3.28 g plant^{-1}). Disruption in transport of carbohydrates to grain may be the important reason for the grain yield reduction under stress conditions and the environmental stresses have a tendency to shorten the grain filling period there by grain yield significantly reduced. Other yield parameters like number pods per plant also got affected by salinity stress was observed by Parande *et al.* (2012).

There was significant variation (Table 4) for number of pods per plant, an important yield attributing trait, was observed across different salinity levels. The genotype JG11 recorded significantly higher mean number of pods (12.33) followed by

BGD-103 (11.22) and MNK1 (10.78) whereas significantly least number of pods per plant was recorded in the ICCV96029 (8.56). The excess salt within the root zone of plant has a deleterious effect on growth of plant which manifests as nearly equivalent reductions in the growth rates, transpiration and yield (Rhoades *et al*., 1992). The results on pod weight per plant revealed the significant variation across genotypes, salinity levels and interactions. Annigeri 1 exhibited maximum pod weight per plant (9.70 g) under 0 dSm^{-1} followed by ICC 5003 (9.06 g), whereas, 1.05 g per plant of pod weight was recorded in ICCV 96029 under 6 dSm^{-1}. Like other yield attributing traits 100 seed weight was also severely affected by salinity stress. The lowest mean 100 seed weight of 16.86 g was recorded under 6 dSm^{-1}, whereas, 24.43 g under control and 20.47 g at 3 dSm^{-1}. Reduction in yield and yield related traits under elevated salt concentration may be the result of various factors acting simultaneously like the reduction in the photosynthesis and the subsequent decline in leaf area and stomatal conductance, which would result in the reduction of accumulated biomass (Rasool *et al*., 2012; Samineni *et al*., 2011; Grewal, 2010).

Harvest index (HI) reflects the capacity of crop genotypes to mobilize the assimilates to part of plants having economic value. It is interesting to note that *desi* type of chickpea have recorded a higher harvest index under abiotic stress than *kabuli* chickpea (Krishnamurthy *et al.*, 2007). JG 11 was found to be superior for mean HI (49.45 %) when compared to other genotypes, whereas ICCV 96029 recorded lowest mean HI of 27.99 per cent. Negative effects of salinity on the crop productivity and harvest index seemed to be correlated directly with reduced water uptake, plant biomass production and grain yield and the possible explanation for this yield reduction could be attributed to chloride ion (Cl^-) toxicity (Sheldon *et al*., 2004).

Conclusion

Salinity has the most deleterious effect on the growth and productivity of plants. The current study indicates that plant height was significantly decreased in salinity than control in all the genotypes; however the reduction level was differed among genotypes. The genotypes JG 11, BGD 103, MNK 1 and ICC 1431 showed lesser impact of salinity stress on morpho-phenological and productivity traits as compared other genotypes while ICCV96029 and NBeG47 were severely influenced by salinity stress. These less sensitive genotypes are to be further evaluated and utilized in breeding programme.

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