

COMPARATIVE QUANTIFICATION OF MINERAL HOMEOSTASIS IN SALINITY-STRESSED COWPEA (*VIGNA UNGUICULATA* (L.) WALP.) CV. KONKAN SAFED INDUCED BY SODIUM SALTS

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Abstract

Mineral homeostasis is essential for normal growth, enzyme activity and stress tolerance in crop plants. The present study evaluated changes in iron (Fe), phosphorus (P) and chloride (Cl) content in cowpea (*Vigna unguiculata* (L.) Walp.) Cultivated variety Konkan Safed exposed to neutral sodium chloride (NaCl; 10mM, 20mM and 40 mM), alkaline sodium bicarbonate (NaHCO_3 ; 6mM, 9mM and 13 mM) and sodium sulphate (Na_2SO_4 ; 10mM, 20mM and 30 mM) at 21 days after sowing. Iron increased in roots under all salt treatments, with the highest value recorded under 9 mM NaHCO_3 . Phosphorus increased in shoots under NaHCO_3 and Na_2SO_4 but declined in roots at higher salt levels. Chloride accumulation was most pronounced under NaCl, particularly in roots and leaves. The results suggest that cowpea regulates mineral distribution in an organ-specific manner, with roots acting as a major site of iron accumulation and chloride retention under salinity stress.

Keywords: Cowpea, mineral homeostasis, iron, phosphorus, chloride, salinity, NaCl, NaHCO_3 , Na_2SO_4

Introduction

Cowpea is an important pulse crop valued for its protein-rich seeds and ability to improve soil fertility through nitrogen fixation. However, its growth and yield are often restricted by soil salinity, especially

in coastal and irrigated areas where sodium salts accumulate.

Excess salts disturb the uptake and distribution of essential mineral nutrients. Sodium competes with potassium and other cations, while chloride accumulation can interfere with normal cellular metabolism. Salt stress may also alter the availability and transport of micronutrients such as iron and macronutrients such as phosphorus.

Iron is required for chlorophyll formation, electron transport and enzyme function. Phosphorus is essential for energy transfer, nucleic acid synthesis and membrane structure. Chloride, though required in small amounts, becomes toxic when it accumulates excessively in plant tissues. Therefore, changes in Fe, P and Cl levels can provide useful information about mineral balance under salt stress.

The present investigation was carried out to compare the effects of neutral NaCl and Na_2SO_4 with alkaline NaHCO_3 on iron, phosphorus and chloride accumulation in shoot, root and leaves of cowpea cv. Konkan Safed.

Materials and Methods

Seeds of cowpea cv. Konkan Safed were grown under controlled conditions. The plants were subjected to different sodium salt treatments: NaCl at 10, 20 and 40 mM; NaHCO₃ at 6, 9 and 13 mM; and Na₂SO₄ at 10, 20 and 30 mM. Untreated plants served as the control. Samples of shoot, root and leaves were collected at 21 days after sowing.

Iron, phosphorus and chloride were estimated from oven-dried plant samples and expressed as g/100 g dry weight. Iron (Elvehjem (1930) and phosphorus (Fiske and Subbarow (1925) were determined using standard spectrophotometric methods, while chloride (Volhard (1956) was estimated by titrimetric analysis. The values obtained for each treatment were compared with the control to assess mineral homeostasis under salinity stress.

Observations

Iron content

The control plants recorded iron content of 0.286, 0.797 and 0.171 g/100 g dry weight in shoot, root and leaves, respectively. Roots contained the highest iron level among the three organs.

Under NaCl treatment, iron increased in shoot and root up to 20 and 40 mM, respectively. Shoot iron rose from 0.467 to 0.689 g/100 g dry weight at 20 mM but declined to 0.220 g/100 g dry weight at 40 mM. Root iron increased progressively from 1.581 to 1.813 g/100 g dry weight. Leaf iron showed only a slight increase.

NaHCO₃ caused a strong increase in root iron, reaching 2.155 g/100 g dry weight at 9 mM. Shoot iron also increased up to 9 mM but declined at 13 mM. Leaf iron

increased gradually with increasing NaHCO₃ concentration.

Na₂SO₄ increased root iron at 10 and 20 mM, followed by a decline at 30 mM. Leaf iron increased continuously from 0.239 to 0.289 g/100 g dry weight, whereas shoot iron decreased with increasing Na₂SO₄ concentration.

Iron(g/100g dry weight) (21 DAS)										
	C o n t r o l	NaCl			NaHCO3			Na2SO4		
		1 0 m M	2 0 m M	4 0 m M	6 m M	9 m M	1 3 m M	1 0 m M	2 0 m M	3 0 m M
S h o o t	0. 2 8 6	0. 4 6 7	0. 6 8 9	0. 2 0	0 . 2 8 9	0 . 3 2 7	0. 2 8	0. 2 8 1	0. 2 5 8	0. 1 8 7
R o o t	0. 7 9 7	1. 5 8 1	1. 7 5 3	1. 8 1 3	2 . 0 0 3	2 . 1 5 5	2. 0 7	1. 3 8 8	1. 8 0 6	1. 5 4 7
L e a v e s	0. 1 7 1	0. 1 8 2	0. 1 8 9	0. 1 9	0 . 2 0 3	0 . 2 0 9	0. 2 1 1	0. 2 3 9	0. 2 7 3	0. 2 8 9

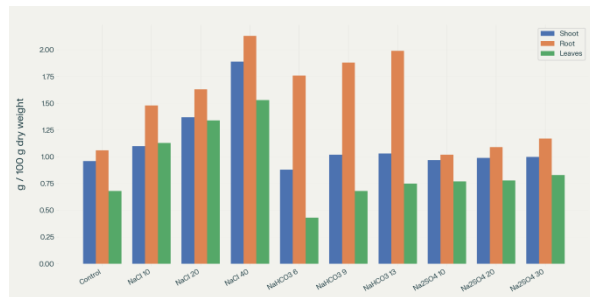


Figure 1. Effect of NaCl, NaHCO₃ and Na₂SO₄ on iron content in shoot, root and leaves of cowpea cv. Konkan Safed at 21 DAS.

Phosphorus content

In control plants, phosphorus content was 0.457, 0.348 and 0.154 g/100 g dry weight in shoot, root and leaves, respectively. NaCl slightly increased shoot phosphorus at 10 and 20 mM, but reduced it at 40 mM. Root phosphorus declined progressively with increasing NaCl concentration, while leaf phosphorus increased.

NaHCO₃ produced a marked increase in shoot phosphorus at 6 mM, where the value reached 0.984 g/100 g dry weight. However, shoot phosphorus declined sharply at 9 and 13 mM. Root phosphorus decreased under all NaHCO₃ treatments, while leaf phosphorus increased gradually.

Na₂SO₄ increased shoot phosphorus at all concentrations, with the highest value of 0.599 g/100 g dry weight at 10 mM. Root phosphorus declined at 10 mM but recovered partially at 20 and 30 mM. Leaf phosphorus increased with increasing Na₂SO₄ concentration.

Phosphorus (g/100g dry weight) (21 DAS)				
	C	NaCl	NaHCO ₃	Na ₂ SO ₄
o				
n				
t				
r				

	1								
		1	2	4	6	9	1	1	2
		0	0	0	m	m	3	0	0
		m	m	m	M	M	m	m	m
		M	M	M			M	M	M
S	0.	0.	0.	0.	0	0	0.	0.	0.
h	4	5	5	4	.	.	4	5	5
o	5	1	0	1	9	4	1	9	6
ot	7	3	6	7	8	2	2	9	8
					4	2			
R	0.	0.	0.	0.	0	0	0.	0.	0.
o	3	3	3	2	.	.	2	2	3
ot	4	1	1	6	2	2	5	7	0
	8	7	3	2	4	7	3	4	9
					2	5			
L	0.	0.	0.	0.	0	0	0.	0.	0.
e	1	1	1	2	.	.	2	1	1
a	5	6	8	2	1	2	3	7	8
v	4	7	3	3	9	0	8	6	9
e					8	9			
s									

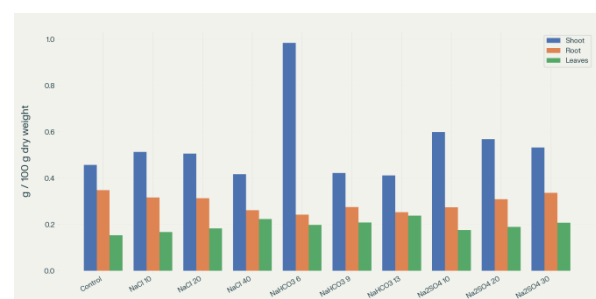


Figure 2. Effect of NaCl, NaHCO₃ and Na₂SO₄ on phosphorus content in shoot, root and leaves of cowpea cv. Konkan Safed at 21 DAS.

Chloride content

Control plants showed chloride content of 0.96, 1.06 and 0.68 g/100 g dry weight in shoot, root and leaves, respectively. NaCl caused a strong and concentration-dependent increase in chloride in all plant parts. At 40 mM NaCl, chloride reached

1.89, 2.13 and 1.53 g/100 g dry weight in shoot, root and leaves, respectively.

NaHCO₃ also increased chloride content, especially in roots. Root chloride increased from 1.76 to 1.99 g/100 g dry weight as NaHCO₃ concentration rose from 6 to 13 mM. However, leaf chloride remained lower than the control at 6 mM and increased only slightly at higher levels.

Na₂SO₄ caused only a minor increase in chloride content. Shoot chloride remained close to the control value, while root and leaf chloride increased slightly with increasing Na₂SO₄ concentration.

Chloride(g/100g dry weight) (21 DAS)										
	C o n t r o l	NaCl			NaHCO ₃			Na ₂ SO ₄		
		1 0 m M	2 0 m M	4 0 m M	6 m M	9 m M	1 3 m M	1 0 m M	2 0 m M	3 0 m M
S h o o t	0.96	1.10	1.137	1.189	0.88	1.102	1.103	0.97	0.99	1.00
R o o t	1.06	1.148	1.163	2.133	1.176	1.188	1.199	1.102	1.109	1.117
L e a v e s	0.68	1.13	1.134	1.153	0.443	0.668	0.75	0.77	0.78	0.83

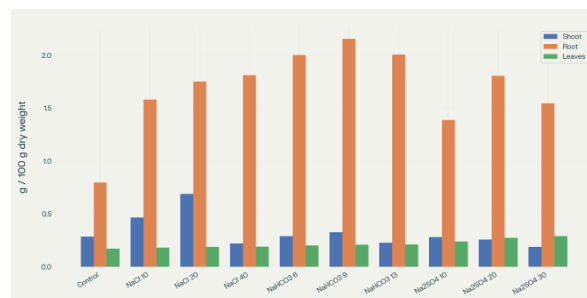


Figure 3. Effect of NaCl, NaHCO₃ and Na₂SO₄ on chloride content in shoot, root and leaves of cowpea cv. Konkan Safed at 21 DAS.

Discussion

The increase in root iron under NaCl, NaHCO₃ and Na₂SO₄ treatments suggests that roots act as a major accumulation site for iron during salt stress. This may represent a protective response, where excess iron is retained in roots to prevent its toxic accumulation in leaves. The higher root iron under NaHCO₃ may also be related to changes in soil pH and iron availability under alkaline conditions.

The decline in shoot iron at higher NaCl and Na₂SO₄ concentrations indicates that excessive salt may restrict iron transport from root to shoot. This can affect chlorophyll synthesis and photosynthetic activity, as iron is essential for chlorophyll formation and electron transport.

Phosphorus showed an organ-specific response. Its increase in shoots under NaHCO₃ and Na₂SO₄ may reflect a stress-induced adjustment in phosphorus metabolism (Zhu, J. K. (2001). However, the reduction in root phosphorus under NaCl and NaHCO₃ suggests that salt stress interferes with phosphorus uptake or retention in root tissues.

Chloride accumulation was highest under NaCl because chloride is supplied directly by this salt. The greater increase in root and leaf chloride indicates that NaCl stress may lead to chloride translocation from roots to aerial parts (Grattan, S. R., & Grieve, C. M. (1999)). Excess chloride can disturb enzyme activity, photosynthesis and ion balance. In contrast, Na₂SO₄ caused only a small rise in chloride, confirming that chloride accumulation is mainly associated with chloride-containing salts.

Overall, the findings indicate that mineral homeostasis in cowpea is affected differently by neutral and alkaline sodium salts. Roots appear to play an important role in regulating iron and chloride distribution, while phosphorus shows a more variable response depending on the salt type and plant organ.

Conclusion

Salinity stress altered iron, phosphorus and chloride homeostasis in cowpea cv. Konkan Safed. Iron mainly accumulated in roots under all salt treatments, with the highest increase observed under NaHCO₃. Phosphorus increased in shoots under NaHCO₃ and Na₂SO₄ but declined in roots under NaCl and alkaline stress. Chloride accumulation was strongest under NaCl, especially in roots and leaves.

The study suggests that cowpea attempts to maintain mineral balance by retaining iron in roots and adjusting phosphorus distribution among organs. However, excessive chloride accumulation under NaCl stress may disturb normal metabolism. Management of chloride-rich saline soils and maintenance of adequate

phosphorus and iron nutrition may help improve cowpea growth under salinity stress.

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