Annals of Arid Zone 25(1) : 69-72, 1986

INFLUENCE OF SODIUM BICARBONATE ON GROWTH, NUTRIENT UPTAKE AND METABOLISM OF PEA

B.K. GARG[1] AND O.P. GARG

Department of Botany, Haryana Agricultural University, Hissar - 125 004

High amounts of bicarbonate and carbonate ions in irrigation waters are reported to be harmful to soil properties and crop growth (Allison, 1965, Bernstein, 1975). Bicarbonate precipitates calcium in the soil solution and thus increases the exchangeable sodium percentage which in turn deteriorates soil structure. The excessive bicarbonate ion concentration also adversely affects protein synthesis and respiration, reduces absorption of nutrients and increases chlorosis in many plants (Steward and Preston, 1941: Miller and Thorne, 1956; Brown, 1960).

To study the effects of bicarbonate on plant growth and metabolism, an experiment was carried out with pea (*Pisum sativum* L. cv Multifreezer) under sand culture conditions in the net house using polythene lined earthen pots filled with acid washed river sand. The treatments consisted of 20, 40 and 60 me l^{-1} of $NaHCO_3$ solutions supplied to the pots (slightly in excess of the saturation capacity of the sand) one day before sowing of the seeds. Tap water served as the control. Two plants of comparable growth were maintained in each pot. The plants were supplied once every week with equal amounts of complete Hoagland nutrient solution.

Observations on plant height, dry weight of shoot, root and pods were based on randomly arranged 10 pots (replicates) under each treatment. The chemical analysis of shoot and root at maturity was carried out separately for N,P, Na, K, Ca and Mg according to the standard analytical procedures. Biochemical estimations were carried out in leaves at 30, 60 and 90 days after sowing. All the leaves on a plant were detached, weighed and cut into small pieces. Representative samples of 200 mg (3 replicates in each treatment) were then taken for the estimation of chlorophyll, RNA, protein, free proline and free amino acids as described by Garg and Garg (1982).

$NaHCO_3$ had a suppressive effect on shoot and root growth as well as on pod yield (Table 1). At 60 me l^{-1} concentration the reduction in pod yield was as much as 85 per cent while the shoot and root weights were also reduced by 70 and 76 per cent, respectively.

Increasing the $NaHCO_3$ concentrations progressively decreased the concentration of potassium, magnesium and calcium in both shoot and root (Table 2). However,

1 Scientist S-2 (Plant Physiology) C.A.Z.R.I., Jodhpur 342 003.

sodium concentration increased markedly under the influence of increasing leaves of $NaHCO_3$. The increase was of the order of 3 to 6 times in shoot and 5 to 10 times in root over control. There was a marginal increase in the contents of nitrogen and phosphorus which was found to be significant only at 60 me l^{-1} concentration. Thus, deficiency of Ca, Mg and K and accumulation of Na to toxic levels under the effect of increasing $NaHCO_3$ was one of main causes of reduced growth and pod yield of pea.

Dry matter of leaves declined with increasing salt concentration (Table 3). The deleterious effect of salt increased with the growth of the plants and at 90 days after sowing the reduction was 67% at 60 me l^{-1} $NaHCO_3$ when compared with control. A

Table 1. Influence of $NaHCO_3$ on final plant height and dry weights of shoot, root and pods at maturity

$NaHCO_3$ (me l^{-1})	Plant height (cm)	Dry weight shoot (g $plant^{-1}$)	Dry weight root (g $plant^{-1}$)	Dry weight pods (g $plant^{-1}$)
0	30.6	2.32	2.45	1.56
20	26.2	1.49	1.22	1.15
40	21.3	0.80	0.69	0.53
60	19.9	0.68	0.59	0.22
CD 5%	5.0	0.47	0.19	0.25

Table 2. Influence of $NaHCO_3$ on concentration (per cent) of different macro-nutrients and sodium in shoot and root of *Pisum sativum*

Nutrient (per cent)	$NaHCO_3$ (m le^{-1}) 0	20	40	60	CD 5%
		SHOOT			
Nitrogen	3.44	3.36	3.72	3.86	0.32
Phosphorus	0.12	0.14	0.17	0.19	0.04
Potassium	2.75	2.45	2.31	2.20	0.42
Sodium	0.12	0.37	0.51	0.73	0.12
Calcium	3.00	3.00	3.00	2.20	0.42
Magnesium	1.80	1.68	1.20	1.08	0.18
		ROOT			
Nitrogen	2.72	2.76	2.76	3.04	0.21
Phosphorus	0.10	0.08	0.11	0.12	*NS
Potassium	2.70	2.50	2.43	2.25	0.36
Sodium	0.16	0.80	1.17	1.90	0.14
Calcium	3.20	3.00	2.18	1.80	0.30
Magnesium	1.68	1.80	I.22	1.02	0.14

*NS—Not significant

significant reduction in the chlorophyll content was obtained under the influence of $NaHCO_3$ at or above 40 me l^{-1}, at all the growth stages (Table 3). The decrease in chlorophyll content under salinity may be due to the loosening of bond between chlorophyll and chloroplast proteins (Strogonov and Ivanitskaya, 1954) leading to higher chlorophyll destruction. The magnitude of reduction in RNA content also increased with a rise in salt concentration and time. The reduction in RNA content under salt stress may be due to the increased activity of cytoplasmic RNase as reported by several investigators (Rauser and Hanson 1966; Sheoran and Garg, 1978).

Similarly protein and free amino acids of leaves decreased markedly with increasing salt concentration and significant decline commenced at 40 me l^{-1}. At 60 and 90 days after sowing the decrease in protein content was about 60 per cent under $NaHCO_3$ at 60 me l^{-1}. (Table 3). However, the reduction in free amino acids was much more pronounced under salt stress. For instance even at 30 days after sowing the decrease was 50 per cent at the highest concentration employed. The magnitude of reduction increased with time and at 90 days of growth more tkan 70 per cent decrease was observed. A decrease in protein content under salt stress has been altributed to decre-

Table 3. Influence of $NaHCO_3$ on dry matter of leaves and contents of chlorophyll, RNA, Protein, free amino acids and free proline (mg per plant) in leaves of *Pisum sativum* at various growth stages

Observation	Days from sowing	$NaHCO_3$ (mel^{-1}) 0	20	40	60	CD 5%
Dry matter	30	133	126	91	80	14
	60	238	228	175	137	18
	90	820	696	520	272	52
Chlorophyll	30	2.19	2.09	1.34	1.08	0.34
	60	3.18	3.02	2.02	1.13	0.42
	90	9.66	7.87	5.35	3.00	0.85
RNA	30	2.06	1.90	1.45	1.30	0.31
	60	4.03	4.08	2.60	1.94	0.40
	90	9.38	10.00	6.80	3.82	0.71
Protein	30	31.7	28.2	19.2	17.5	3.4
	60	57.1	51.2	39.2	22.5	4.8
	90	126.8	122.7	75.4	47.8	13.3
Free amino acids	30	17.5	15.7	13.7	8.2	4.0
	60	32.8	18.2	16.0	12.8	5.5
	90	55.9	39.6	25.0	14.6	11.3
Free proline	30	0.16	0.20	0.13	0.15	*NS
	60	0.23	0.36	0.30	0.24	NS
	90	0.69	0.91	0.72	0.71	0.20

*NS—Not significant

ased synthesis and increased proteolysis. However, in present study decreased synthesis appeared to be the main cause as the contents of free amino acids also decreased with increasing concentration of $NaHCO_3$. Free proline was, however, not affected significantly during 30 and 60 days growth but an increase was found to occur at 90 days sampling. The non accumulation of free proline suggests that specific ions effects are probably more important than pure osmotic effects under alkali conditions.

In nature sodic irrigation waters are composed both of carbonate and bicarbonate ions, and their specific effect on the crop growth may not be visible directly in the soil due to their preciptiation as the carbonates of calcium and magnesium. However, it is evident indirectly in the form of sodium-hazard, but in this study the specific effect of $NaHCO_3$ sand culture, was quite evident by the reduced plant growth due to imbalance in the uptake of nutrients and impaired metabolism.

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