RESULT AND DISCUSSION

1. Growth

Many investigators have reported about growth retardation due to salinity. The effect of 0.05M, 0.1M, 0.15M and 0.2M NaCl on growth and development of 2 hybrid varieties of chillies PC1 x DB and LxDB has been studied. The results are compared with control plants. The effect of NaCl on growth and development in terms of plant height, root length, fresh weight, dry weight, leaf area and number of leaves per plant of PC1xDB and LxDB is shown in Fig. 4,5,6 Table 1 .

From the present investigation it is clear that PC1xDB showed a decrease in plant height as the salinity level increases. At all salinity levels there is a decrease in the plant height over control. Where as in LxDB hybrid variety enhancement of plant height is observed upto 0.1 M salinity level, further this level however there is a constant decrease.

The root length of both the hybrid varieties showed a decrease at higher levels of salinity, except in PC1xDB where it increased upto 0.1M salinity level. However roots of PC1xDB seemed to be more resistant to salinity.

Both the hybrid varieties show similar results to NaCl salinity with respect to dry weight production. It is seen that dry weight of PC1xDB and LxDB plants is decreased at all the levels of salinity.

In present investigation the effect of NaCl on the leaf area of both the plants show different results. In PC1xDB hybrid variety there is a decrease in leaf area at all the levels of salinity whereas in LxDB hybrid variety there is a increase in leaf area upto 0.1M NaCl salinity level, however there was a decrease at higher levels of salinity.

Similar results were observed about increase in plant height at lower levels of salinity and decrease at higher levels by Bhandari (1988) in Capsicum annuum cultivars Pant C1 and NP 46A. Strogonov (1984) stated that plant height is a good indicator of growth and development. Lipman (1938) recorded that chloride ions at low concentrations can stimulate growth of Buckwheat. Morachan and Shante (1974) have studied the comparitive tolerance of minor millets to saline irrigation.

There are different responses of plants towards different salinity (Strogonov 1964). A growth stimulation by salts have been observed in case of halophytes by Strogonov (1964) Clarke and Hannon (1970) and Kleinkopf *et al.*, (1975). Neiman studied the salt tolerance of 12 crops and found a stimulation of growth in garden beet and spinach, Farias and flores *et al.*, (1989) have reported about stimulation of growth at higher levels of salinity in Blutaparon portalacoides (st.H.I) Mears (Amaranthaceae)

There are negative results about the plant growth in NaCl salinity. There are reports about stunted plant growth due to salinity (Hayward 1955, Bernstein and Hayward 1958, Riley, 1968

Strogonov (1964) reported a 50% inhibition of growth in tomatoes growth in soils containing 0.1% NaCl. Heikal (1976) found that NaCl salinity in the culture solution induces a decrease in fresh weight and dry weight of leaves, root and leaf area and volume per plant in kidney bean Increase in salinity level decreases the leaf area Kale (1962); and St Omer.

A decrease in plant growth due to salinity is also reported by Hoffman *et al.*, (1980) in Capsicum annuum, Chavan (1980) in Ragi, Garg and Garg (1980) in Pisum sativum. Patil and Patil (1983) in *syzygium cumini*.

Decrease in fresh weight and dry weight with increasing salinity level is observed by Seemann and Chritchley (1985) in *Phaseolus vulgaris* Setia and Narang (1985) in Pisum sativum, Murumkar (1986) in *Cicer arientum* and Shennon *et al*., (1987) in *Aster tripolium*. Mirza and Khalid (1986) in *Phaseolus aureus* cv. 6601. There were results about decrease in Plant height by Sadale (1989) in *Crotolaria juncea* plants as the salinity level in growth medium increases. Giridhar (1989) have reported about the response of sunflower to saline water irrigation and changing zone salinity and observed plant height, number of leaves, leaf are decreased at higher levels of salinity. Charizoulakis (1992) studied the effect of NaCl salinity on germination, growth and yield of green house cucumber. The effect was studied on cucumber hybrid Pepinex and observed reduction in plant growth due to salinity.

From the present investigation it is clear that the plant height of PC1xDB hybrid variety decreases at all the salinity level whereas there is increase of plant height in LxDB hybric variety at low concentration of NaCl salinity.

The leaf area of both the varieties decreases at all the levels in PCxDB hybrid variety where as in LxDB variety there is increase in leaf area at low salinity level.

There is increase in root length in PC1xDB at low NaCl levels whereas in LxDB variety the root length decreases as the NaCl level increases. The number of leaves were less than control plants as compared to the plants which were grown in NaCl concentrations. In PC1xDB variety the leaf number decreased at all the levels of salinity whereas in LxDB variety the number of

Table no 1.

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl ON <u>*Capsicum annuum*</u> HYBRID VARIETIES PC1 x DB AND L x DB ON PLANT HEIGHT, LEAF AREA, NUMBER OF LEAVES AND ROOT LENGTH.

Hybrid	Concentration of NaCl (M)	Plant height (cm)	leaf area (sqcm)	Number of leaves	Root length (cm)
PC1 x DB	Control	35	11.0	190	8
	0.05M	34	10.5	150 "	10
	0.1 M	30	7.9	130 "	13
	0.15M	27	8.1	100 "	9
	0.2 M	24	7.4	75 "	6
L x DB	Control	55 cm	13.3	220	7.6
	0.05M	57 "	14.0	200 "	7
	0.1 M	59 "	13.5	180 "	5
	0.15M	40 "	12.1	140 "	4
	0.2 M	39 "	11.7	120 "	3.5

Values of plant height, number of leaves and root length are pxpressed in cms and leaf area is expressed in sq.cms.

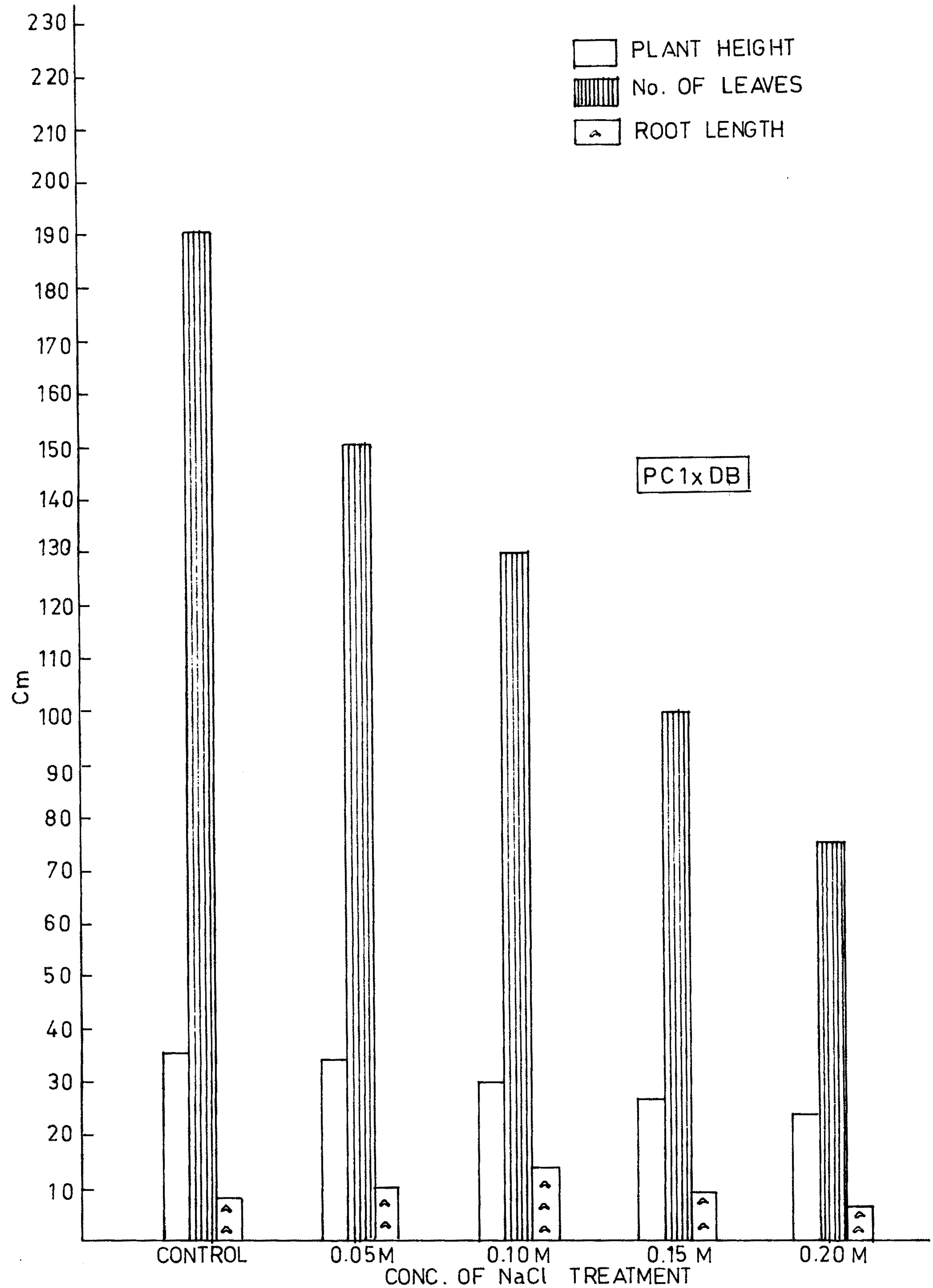

Fig No 4 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON PLANT HEIGHT, No. OF LEAVES, ROOT LENGTH OF Capsicum annuum HYBRID VARIETY.

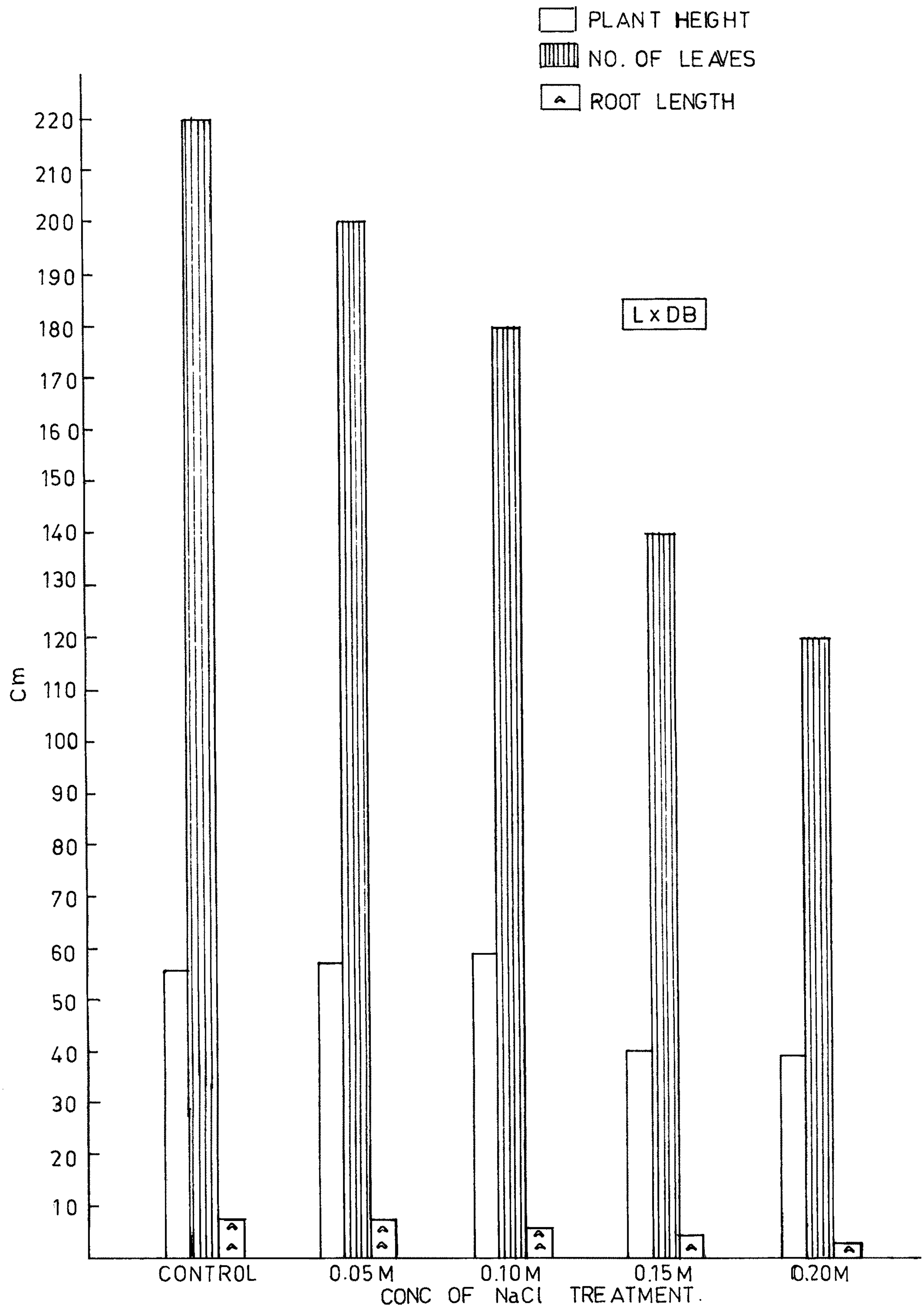

Fig No 5. EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON PLANT HEIGHT, No OF LEAVES, ROOT LENGTH OF <u>Capsicum annuum</u> HYBRID VARIETY

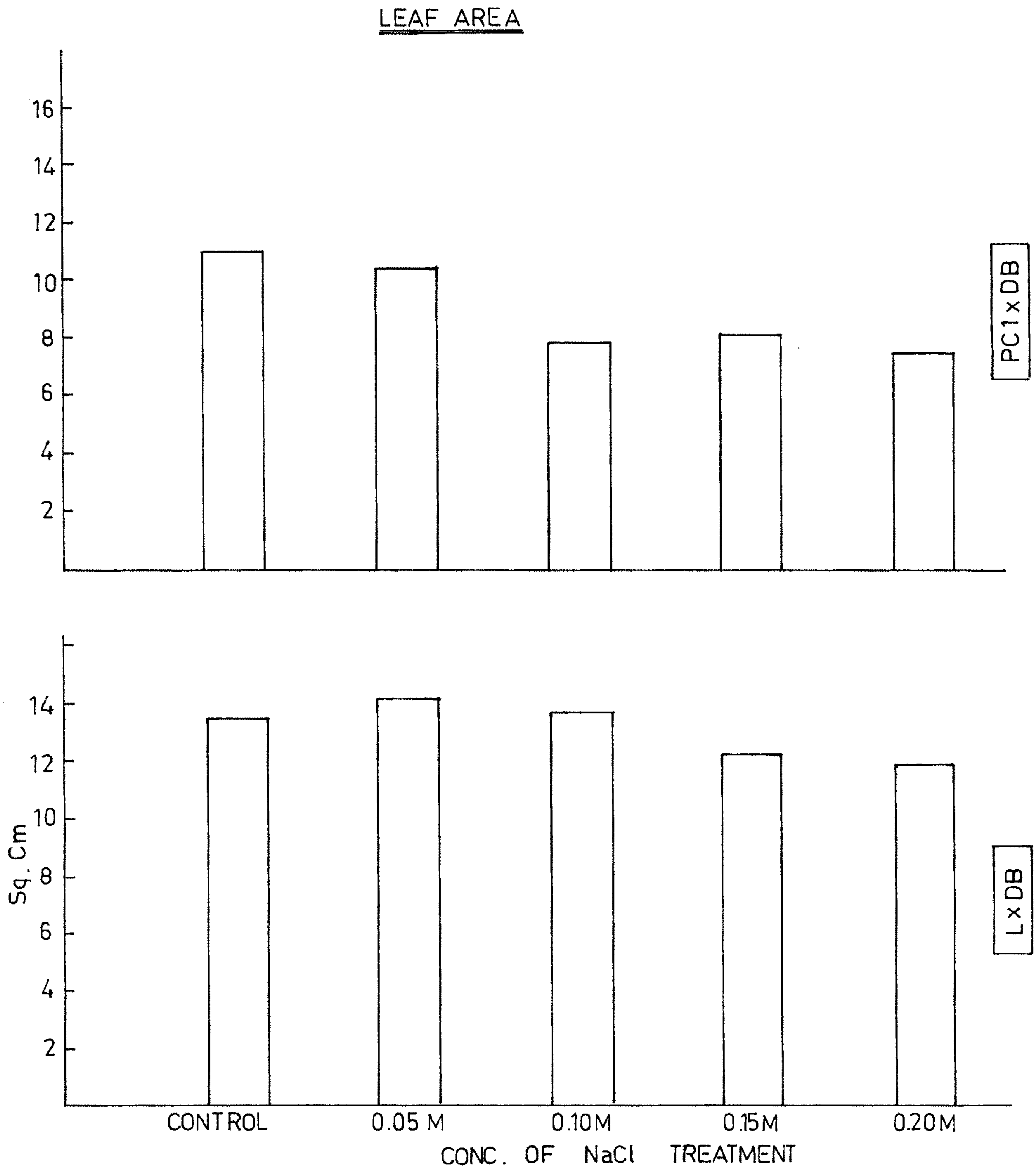

Fig No 6. EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON LEAF AREA OF *Capsicum annuum* HYBRID VARIETIES

Table no. 2.

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl ON MOISTURE PERCENTAGE OF 2 *Capsicum annuum* HYBRID VARIETIES PC1xDB AND LxDB.

Hybrid varieties	Conc. of NaCl	Leaves	Stem	Root
PC1xDB	Control	77.5	77.5	71
	0.05M	79.5	80	75
	0.1 M	84.2	82.5	77.5
	0.15M	84.1	84	80
	0.2 M	82.5	85.5	81
LxDB	Control	77.5	66.5	72.5
	0.05M	76	75	70
	0.1 M	83.5	78.5	75
	0.15M	84.5	84	81
	0.2 M	85	89	81.5

Values are expressed in percentage.

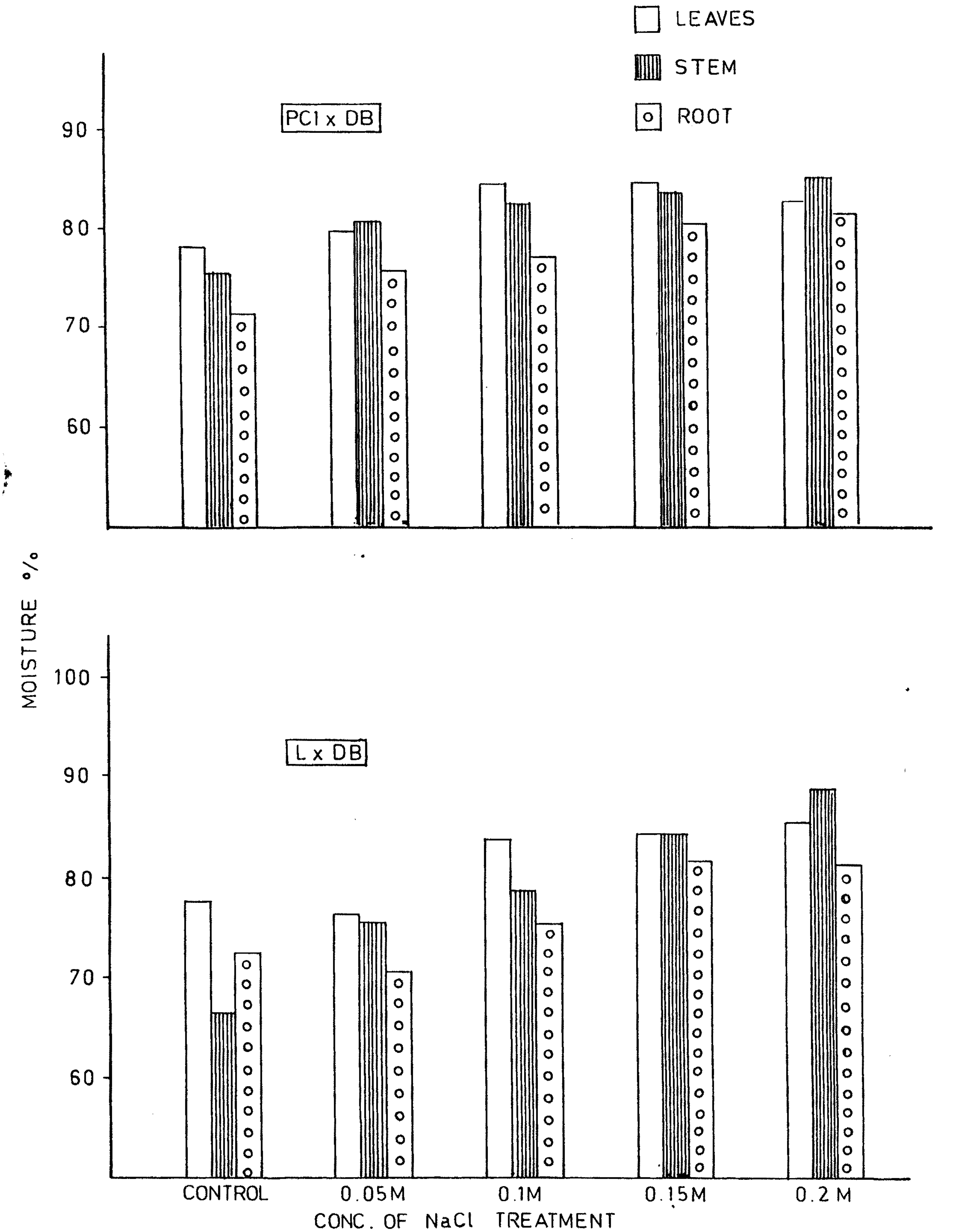

Fig. No. 7. EFFECT OF VARIOUS CONCENTRATIONS OF NaCl ON MOISTURE PERCENTAGE OF 2 *Capsicum annuum* HYBRID VARIETIES PC1xDB & LxDB leaves increased at lower levels of salinity.

From these observations, it is clear that PC1xDB shows a salt sensitive nature whereas LxDB variety shows a salt tolerant nature at lower levels of salinity.

2. Chlorophyll

Chlorophyll content is one of the important physiological parameter because it determines the rate of photosynthesis. chlorophyll content is influenced by the surroundings in which the plant grows. Salinity is one of such factor which affects the chlorophyll content in plants.

Effect of NaCl salinity on chlorophyll content of leaves of two hybrid varieties of Capsicum annuum viz. PC1xDB and LxDB is shown in table 3 and Figure 8,9.

It is evident from table and figure that there is increase in total chlorophyll content in both hybrid var. at 0.05M salinity level, while at higher salinity levels (0.1M, 0.15M and 0.2M), total chlorophyll content decreases over control plants with one exception in LxDB at 0.2M. Further, it is clear that effect of different levels of salinity on chlorophyll 'a' and chlorophyll 'b' content in PC1xDB and LxDB shows the same pattern of effect of NaCl salinity on total chlorophyll content.

There is increase in chlorophyll a:b ratio in leaves of PC1xDB while it decreased in L x DB hydrid which suggests that chlorophyll b is more suceptible to NaCl Salinity in PC1xDB, where as L x DB hybrid variety indicated that chlorophyll b is more syntesised than chlorophyll a.

There are many Reports about enhancement of chlorophylls at low levels of salinity. Workers like Ahmed etal (1980) in Leguminous plants, Helal and Mengel (1981) in young broad beans, Chavan (1980) in Elevsine Coracana, Karadge (1981) in succulents, Despande (1981) in Cajanus Cajan and Kawathe (1985) in Carthamus tinctorius observed that low concentration of NaCl and Na_2SO_4 showed stimulatory effects , while higher levels of both the salts proved to be inhibitory.

Nieman (1962) has studied the effects of NaCl salinity on chlorophyll synthesis in various crops and reported that salt stunted leaves of bean, raddish and turnip externally attained high chlorophyll content, while beet and other became chlorotic due to salt stress, so he suggested that individual species differ in their response to salt strees.

There are also early reports about increase in chlorophyll by many authors.

Increased chlorophyll content in saline habitats has been established for tomatoes by Koval's kaya (1945) and various. Glycophytes by Pokrovs Kaya (1958) Stronger (1973) pointed out that generally chlorophyll content increases in salt resistant plants while decreases in the salt sensitive one's due to salt stress. Varshney and Baijal (1977) observed that in the leaf tissues of 4 grasses (Panicum antidotale, Setaria Sphacelate, Chloris gayana and Penniseturn pedicellatum), the valvues of chlorophyll a, b and total chlorophylls were higher with gradual increase in salinity range. Passera and Albuzio (1979) in wheat spp Ahmed et al.,(1979) in castor bean, flax and sunflower also observed an increase in chlorophyll due to salinity .

Decrease in chlorophyll content under saline conditions has been observed by Malakondaiah and Rajeshwara Rao (1980) in groundnut, Guru Raja Rao and Rajeshwara Rao (1981) in Arachis hypogea, Hegde and Patil (1982) in Parthenium hysterophorus, Murumkar and chavan

Table no 3

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl ON CHLOROPHYLL CONTENT OF *Capsicum annuum* HYBRID VARIETIES PC1xDB AND L x DB

Hybrid Varieties		Chlorophyll 'a'	Chlorophyll 'b'	Total Chlorophyll
PC1xDB	Control	101.388	66.84	169.14
	0.05M	119.556	77.512	198.132
	0.1 M	65.59	40.956	107.116
	0.15M	99.386	63.236	163.496
	0.2 M	101.926	62.3	165.1
L x DB	Control	110.472	72.176	183.636
	0.05M	174.986	122.212	298.832
	0.1 M	71.596	51.768	120.84
	0.15M	100.85	71.38	173.18
	0.20M	112.474	75.78	189.28

Values are expressed as mg 100^{-} g fresh leaf material.

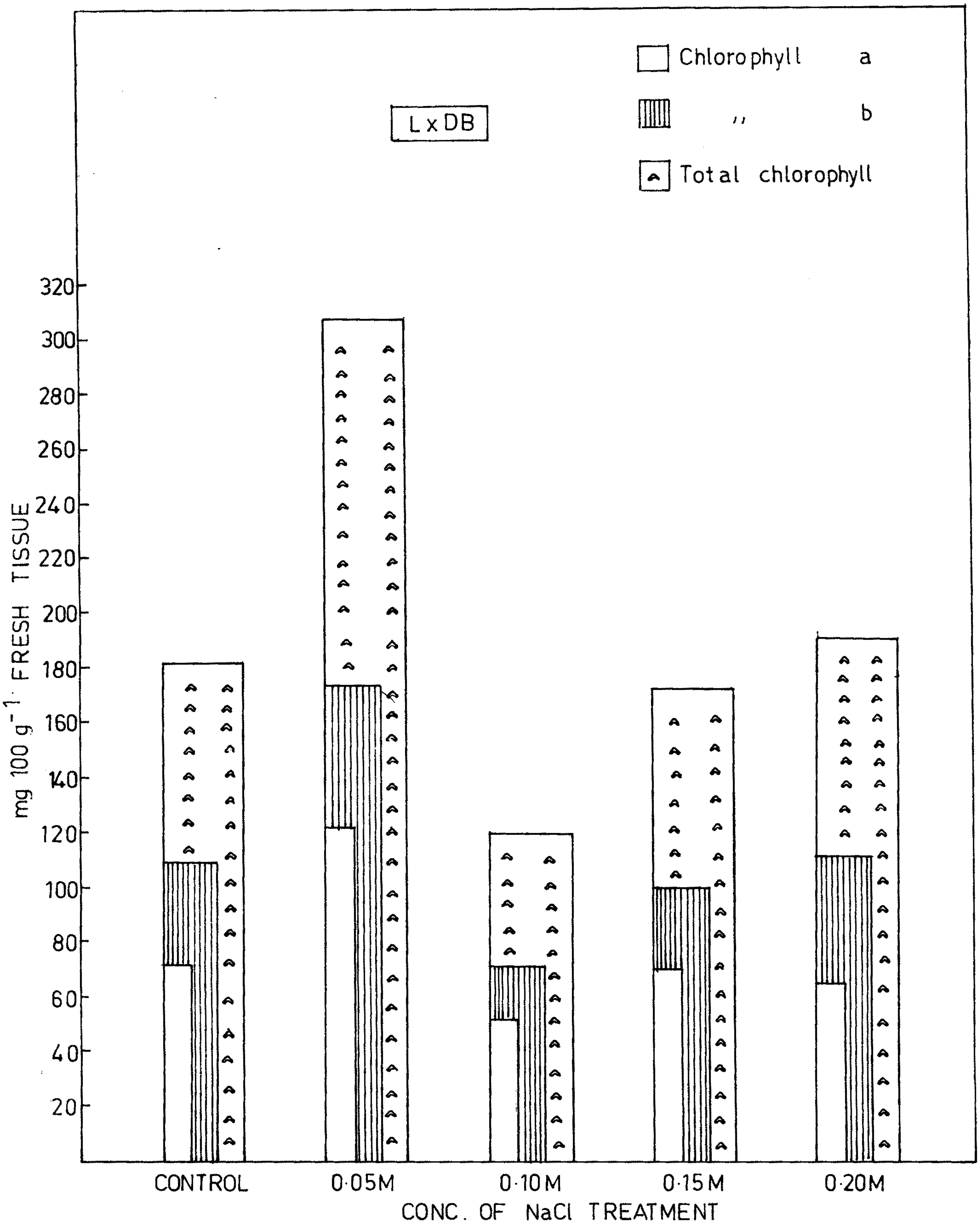

Fig.No. 8. EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON CHLOROPHYLL CONTENT OF *Capsicum annuum* HYBRID VARIETIES PC1xDB AND LxDB

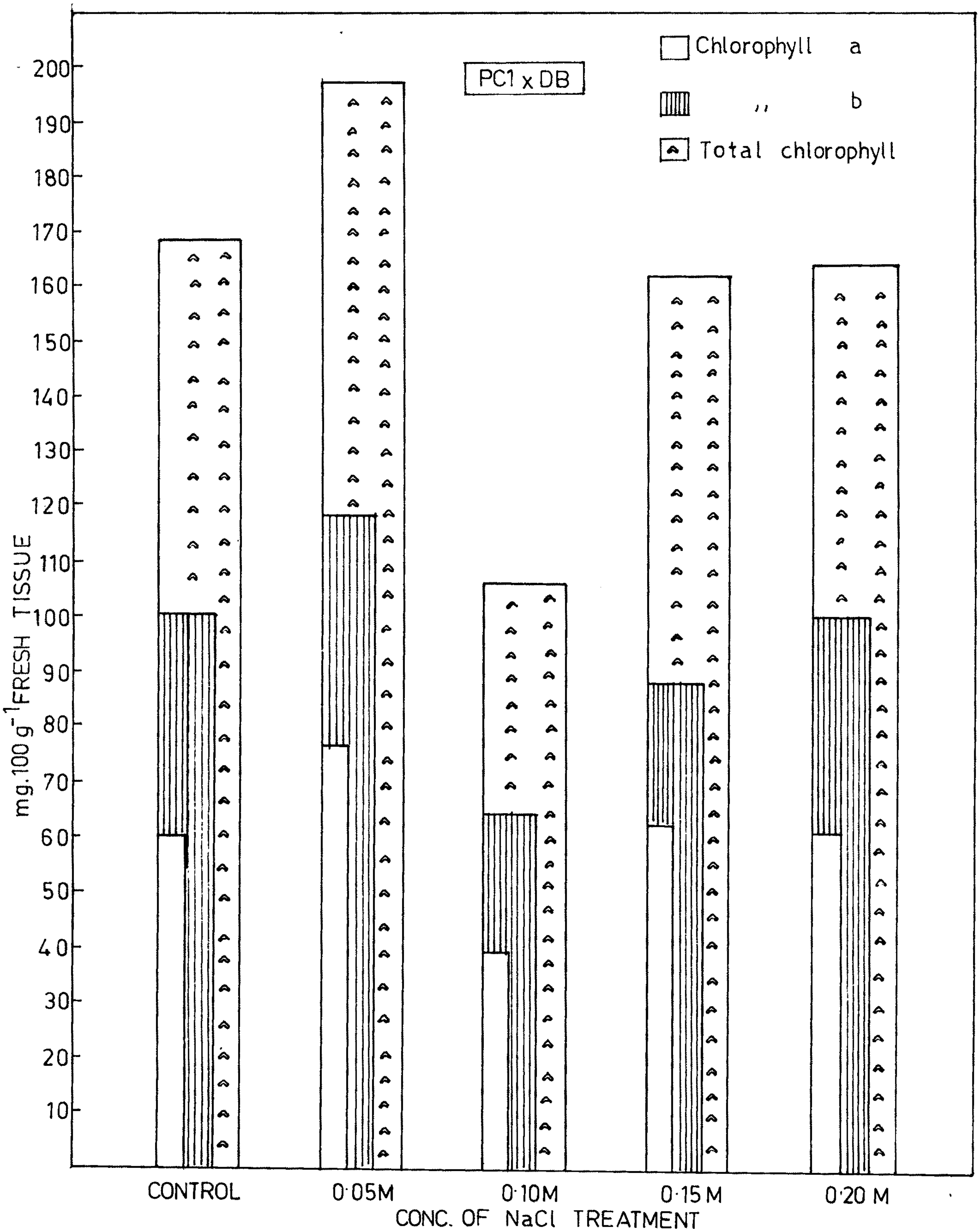

Fig. No. 9. EFFECT OF VARIOUS CONC. OF NaCl ON CHLOROPHYLL CONTENT OF Capsicum annuum HYBRID VARIETIES PC1 x DB AND L x DB

(1986) in Cicer arientum Ball and Anderson (1986) in Aviceria and Pisum Sativum.

In halophytes also effects of NaCl on chlorophyll content differs. As NaCl treatment increased, chlorophyll content increased in Salicornia robra, where as it decreased in Distichillis stricta (Tiku, 1976)

Results of present investigation show that there is enhancement of chlorophyll content at low levels of salinity while higher levels of salts resulted to be inhibitory in crosses PC1 x DB and L x DB (with one exception). Inhibition of chlorophyll content at higher levels of salinity suggests that both the hybrid varieties are sensitive to NaCl salinity.

3. Titratable acid number (TAN)

TAN represents the ml of decinormal NaOH required to neutralize the acids contents in 100 g . fresh material. The effect of Salinity on TAN in hybrids of Capsicum annuum i.e. PC1xDB and L x DB has been presented in table ..4..... fig ..10 ..

In the present study it is seen that there is decrease in TAN at all levels of salinity in hybrid PCL x DB where as in L x DB hybrid variety there is a slight increase in TAN at 0.05 M salinity level but further there is decrease in TAN at higher levels of salinity.

Similar results are observed about the decrease in TAN by Bhandari (1988) in Capsicum annuum cultivars ____ Pant C1 and NP 46A, at all levels of salinity. Chavan (1980) observed an initial increase of TAN at lower conc. 0.05m of salinity and an inhibition at higher conc. of salinity in ragi. There are also results about decrease in TAN by Azizbekova and Rasulova (1972)

Table no. 4.

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl ON TAN of leaves OF <u>Capsicum</u> <u>annuum</u> HYRBID VARIETIES PC1xDB AND L x DB.

Hybrid varieties	Concentration of NaCl salinity	Titratable acid number (TAN)
PC1xDB	Control	78.409
	0.05M	61.363
	0.1 M	68.818
	0.15M	63.636
	0.2 M	38.636
L x DB	Control	51.136
	0.05M	56.818
	0.1 M	36.36
	0.15M	34.909
	0.2 M	45.45

Values are expressed in ml of decinormal alkali required to neutralize 100^{-1} gm fresh material

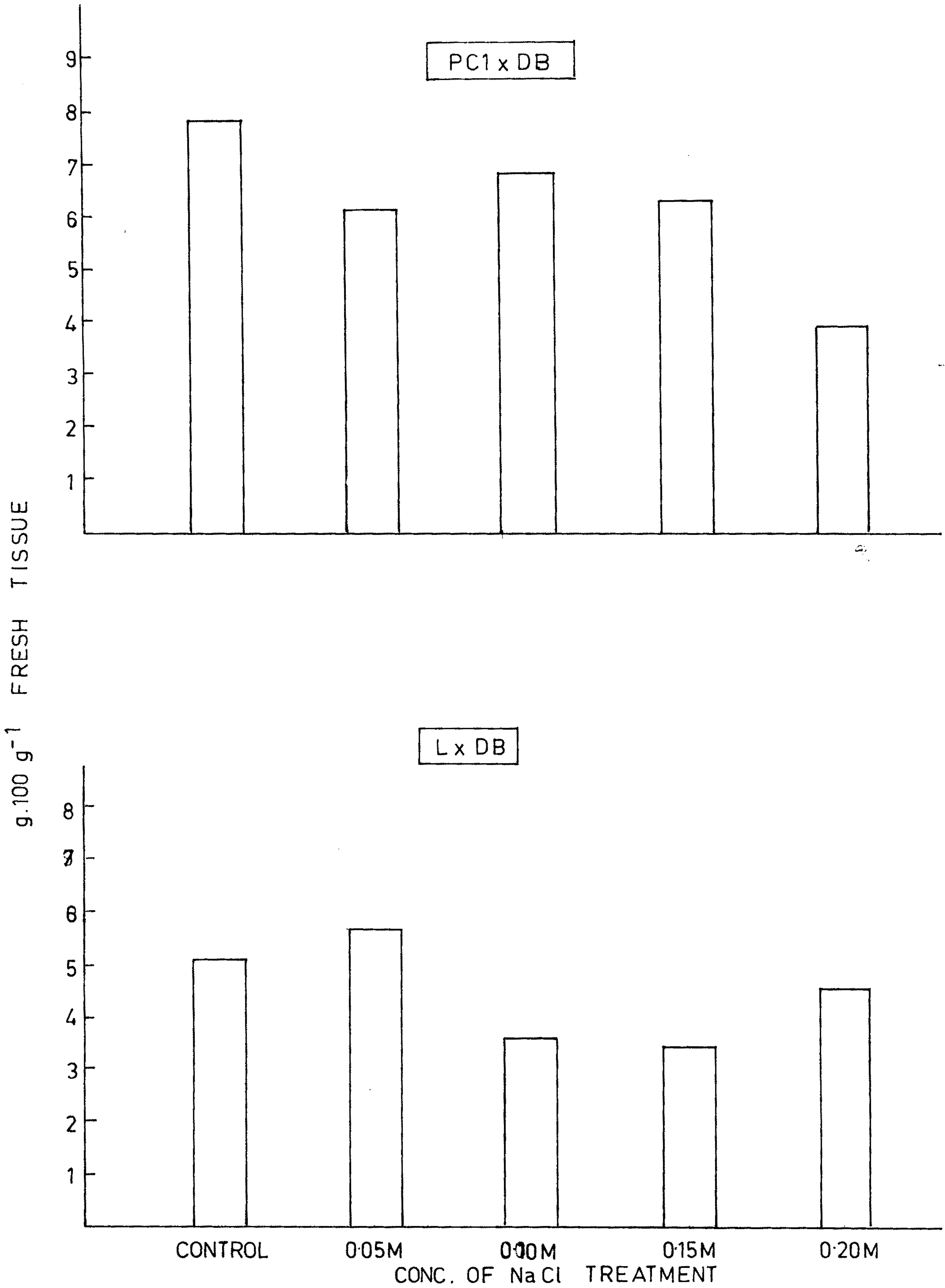

Fig No 10 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON TAN OF *Capsicum annuum* HYBRID VARIETIES PC1xDB AND LxDB in cotton. Flowers and Hall (1980) *Insuada maritima* and Abdel Rasoul *et al.*,(1980) in *Portulaca oleraceae* Zea mays

There are many reports about increase in TAN due to NaCl salinity. Strogonov (1964, 1974) observed increased in Organic acid content due to NaCl salinity. Shetty (1971) has recorded increase in TAN of leaves of Acrosticum at 20mm NaCl treatment. Nimbalkar (1973) has also reported a considerable increase in TAN value in sugar cane leaves treated with 150 NaCl (1976) have also reported that the salinity caused increase in free acidity in tomato leaves. Wallace (1982) in *Atriplex polycarpa* found higher conc. of Organic acids in the leaves treated with NaCl

Strogonov *et al.*,(1970) postulated that organic acids play a protective role in plants under saline conditions. Ackerson and youngner (1975) have suggested that salinity tolerance of bermuda grass might be by redistribution or increased conc. of Organic acid in cell sap.

The present investigation reveal that there is decrease in TAN at higher levels of salinity our investigation does not make it clear about the significance of TAN in NaCl salinity.

4. CARBOHYDRATES

Effect of salinity on carbohydrate content (reducing sugars, Total sugars, Starch and Total Carbohydrates of different parts of Capsicum annuum hybrid varities PC1xDB and LxDB has been shown in Table 5a,b Fig 11 to 16

In our present investigation it is evident that reducing sugars in the leaves of PC1xDB and LxDB increased at lower concentrations but at higher concentration it was less. It means that as the level of salinity increases the reducing sugar content decreases.

The total sugar content in leaves of PC1xDB and LxDB, decreases at all levels of salinity. This decrease in total sugar content is generally proportionally to the salinity level i.e. as the level of salinity is high the total sugar content in leaves of PC1xDB and LxDB is low. There is uniform decrease in starch content at all levels of salinity in PC1xDB and LxDB.

In stem of PC1xDB and LxDB there is increase in reducing sugars at low levels of salinity whereas higher levels show inhibition. The total sugars in stem decreased at all the levels of salinity in PC1xDB whereas in LxDB it slightly increased at lower levels and decreased at higher levels. The starch content decreases as the level of salinity increases in both the varieties. In roots in both the varieties reducing sugars were less than control at all levels of salinity. The total sugars are less than control in PC1xDB at all levels, whereas in LxDB hybrid variety there is increase in total sugars at higher levels and decrease at lower levels of salinity. The starch content increased over control at all the levels of salinity in PC1xDB whereas there is decrease in starch content in roots of LxDB as the level of salinity increases.

In both the hybrid varieties PC1xDB and LxDB Total carbohydrates decreases as the level of salinity increases over control.

Similar results were observed by Bhandari (1988) in two _Capsicum annuum_ cultivars Pant C1 and NP46A. She observed that reducing sugars, total sugars, starch differently affected in different peaks of cultivars.

There are many other reports about the increase in carbohydrate metabolism due to salinity which is stated by Hayward and Long (1941), Gauch and Eaton (1942) Maas (1945).

Strogonov (1964) has also observed an increase in glucose and fructose in maize sap due to salinity. Meiri et al., (1971) have reported an increase in sugar % in bean plants under chloride and sulphate salinities.

It was evident in the work of Genkel and Benkanova (1974) that low doses of NaCl favoured sugar content in tomato.

It was noted by stark et al., (1975) that carbohydrates may accumulate in the bean leaves if their translocation is inhibited by saltstress. Wignarajah et al.,(1975) observed higher conc. of sucrose in bean leaves due to NaCl salinity and increase in glucose content in earlier stages of plant growth was followed by decline during later stages of growth.

Petolino and Leone (1980) recorded an increase in the content of soluble sugars without any significant change in starch content of salinised bean plants. Ahmid and Abdullah (1982) reported an increase in reducing sugars in Potato due to salinity.

Rathert and Doering (1983) observed that salinity caused an increase in total carbohydrates in leaf and root more in Jackson variety of Soybean (salt sensitive) than in Lee (salt tolerant). It is suggested by them that ion independent pathways of carbohydrates metabolism may contribute to Physiological salt tolerance mechanism in soyabean cultivars.

There are many results about inhibition of carbohydrates due to salinity. El-Saidi and Hawash (1971) reported a decline in carbohydrates content in leaves and stem of Hibiscus sps due to saline water. Matar et al, recorded a considerable decrease in glucose, fructose and suckrose content in leaves and roots of salt sensitive plant (lettuce) while salt tolerant plant (spinach) followed similar pattern except greater accumulation of

Table no. 5a

Effect of NaCl salinity on carbohydrate fractions of leaves, stem and roots of PC1xDB.

Hybrid	Conc.ns of NaCl	Reducing Sugars	Total Sugars	Starch	Total Carbohydrate
PC1xDB Leaves	Control	0.78	1.48	4.15	5.63
	0.05M	1.056	1.1	4.32	5.42
	0.1 M	0.704	0.93	4.04	4.97
	0.15M	0.748	1.008	4	5.008
	0.2 M	1.20	1.118	4.13	5.248
PC1xDB	NaCl conc.ⁿ				
Stem	Control	0.050	0.07	1.68	1.75
	0.05M	0.070	0.12	1.24	1.36
	0.1 M	0.068	0.096	1.48	1.57
	0.15M	0.030	0.16	1.6	1.76
	0.2 M	0.020	0.13	1.2	2.40
PC1xDB	NaCl conc.ⁿ				
Root	Control	0.4400	0.600	2.128	2.728
	0.05M	0.0384	0.064	2.408	2.47
	0.1 M	0.089	0.128	2.85	2.97
	0.15M	0.0174	0.0174	2.58	2.66
	0.2 M	0.01	0.03	2.49	2.52

Values are expressed in g. 100 g^{-1} dry tissue.

Table no 5b

Effect of NaCl salinity on carbohydrate fractions of leaves, stem and roots of L x DB.

Hybrids	Conc.ns of NaCl	Reducing Sugars	Total Sugars	Starch	Total Carbohydrate
L x DB Leaves	Control	0.27	0.36	3.68	3.98
	0.05M	0.15	0.21	3.06	3.27
	0.1 M	0.10	0.40	2.85	3.24
	0.15M	1.28	1.3	1.61	2.91
	0.2 M	0.81	1.06	2.3	3.36
L x DB	NaCl conc.^{n}				
Stem	Control	0.062	0.104	3.84	3.944
	0.05M	0.092	0.13	2.72	2.85
	0.1 M	0.18	0.11	2.36	2.47
	0.15M	0.075	0.12	2.06	2.18
	0.2 M	0.05	0.055	2.49	2.545
L x DB	NaCl conc.^{n}				
Root	Control	0.1188	0.7884	3.26	4.048
	0.05M	0.3536	0.408	1.1	1.508
	0.1 M	0.48	0.432	1.15	1.582
	0.15M	0.096	0.9	1.14	2.04
	0.2 M	0.0752	1.184	1.13	2.314

Values are expressed in g. 100 g^{-1} dry tissue.

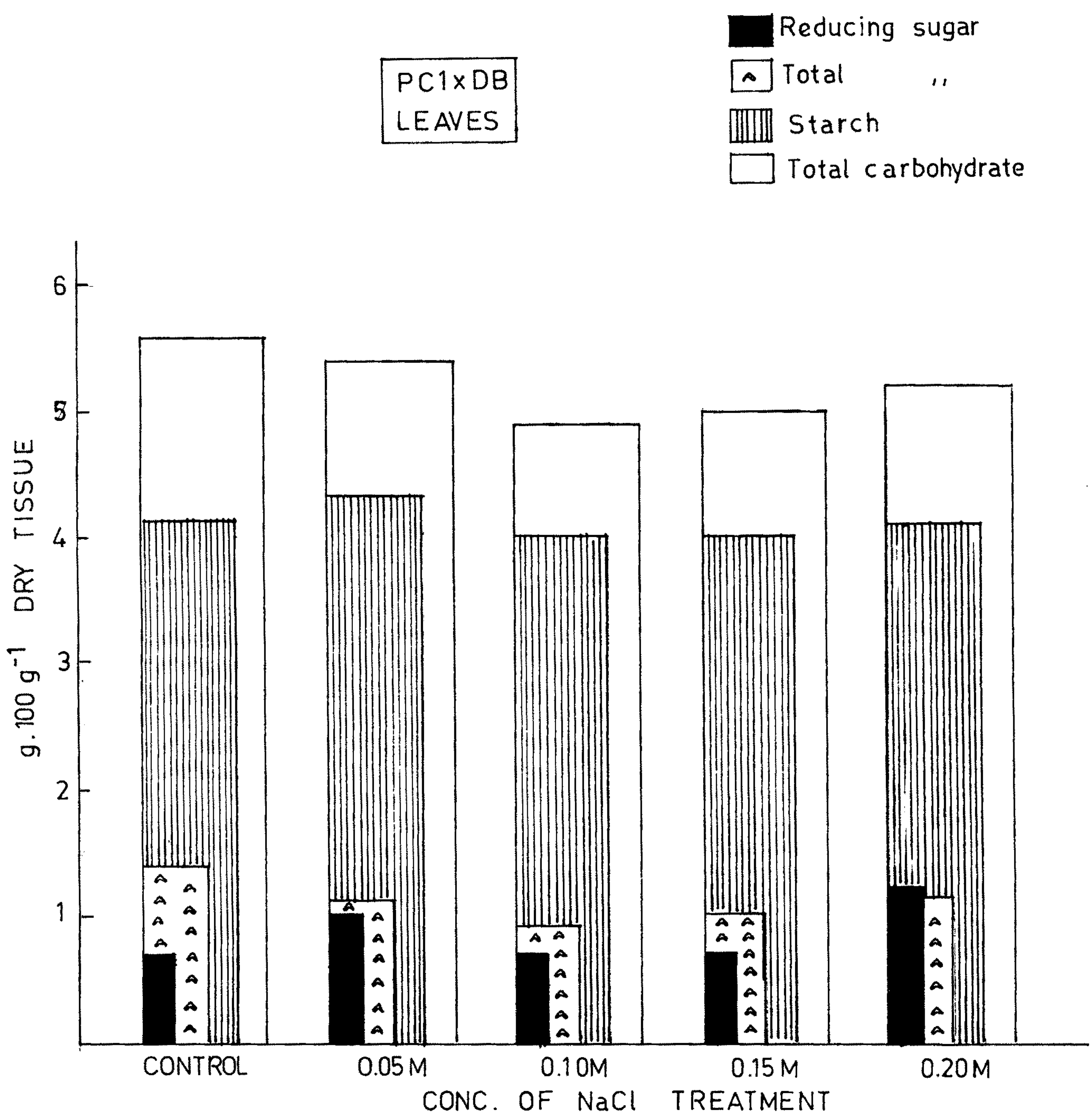

Fig.No. **11** EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON CARBOHYDRATE CONTENT OF <u>Capsicum annuum</u> HYBRID VARIETY

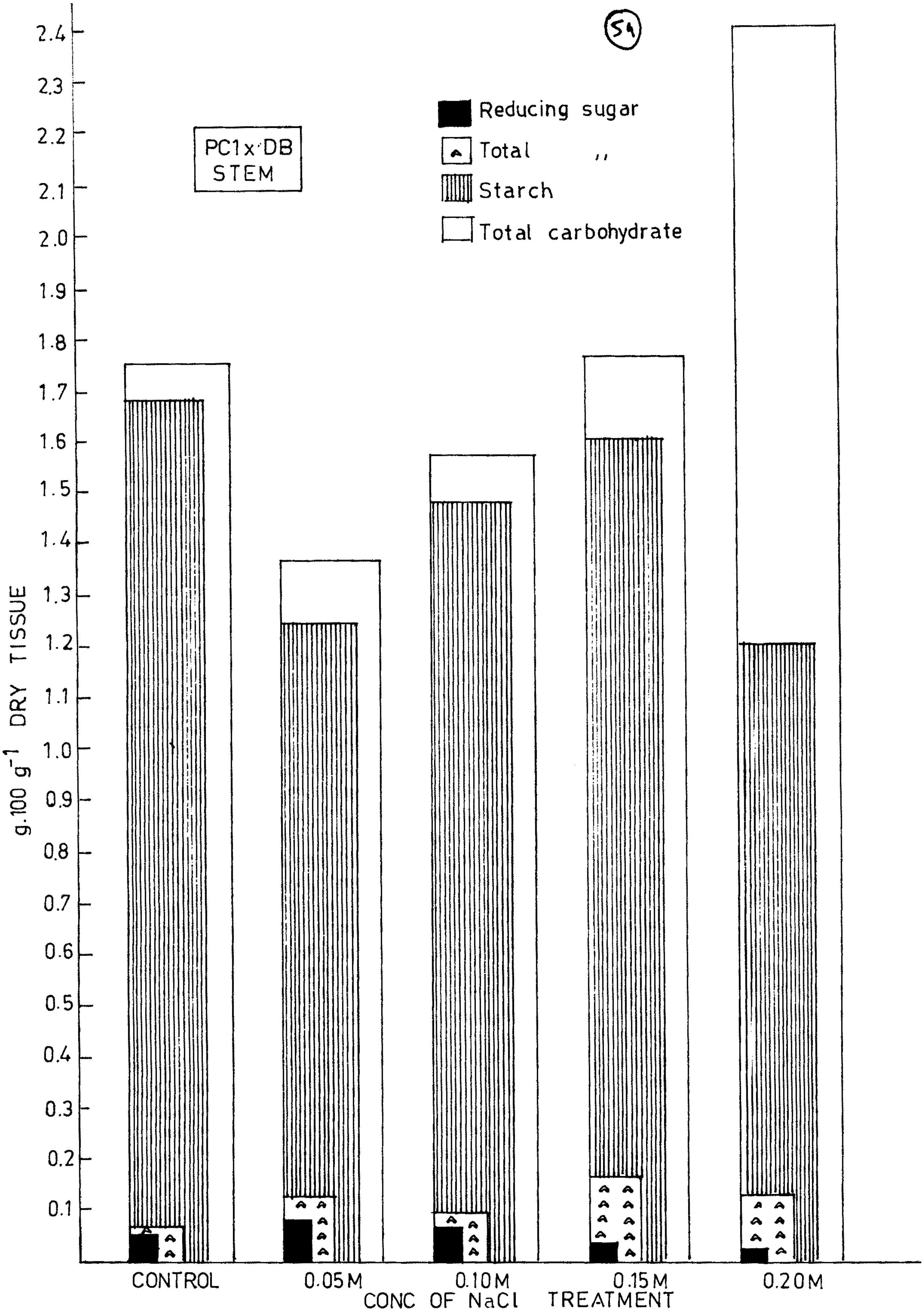

Fig.No. 12 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON CARBOHYDRATE CONTENT OF Capsicum annuum HYBRID VARIETY

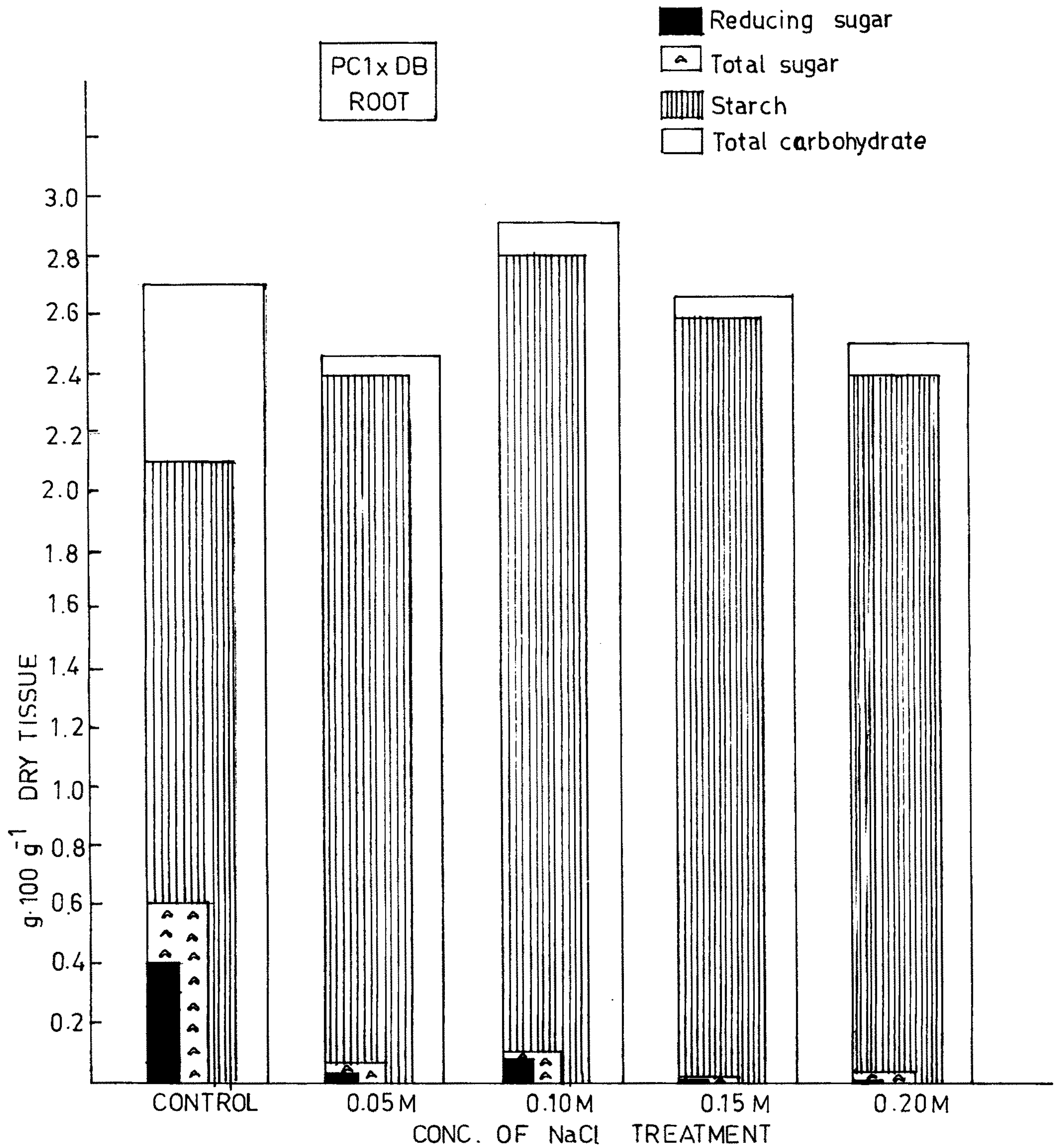

Fig. No. 13 EFFECT OF VARIOS CONC. OF NaCl SALINITY ON CARBOHYDRATE CONTENT OF *Capsicum annuum* HYBRID VARIETY

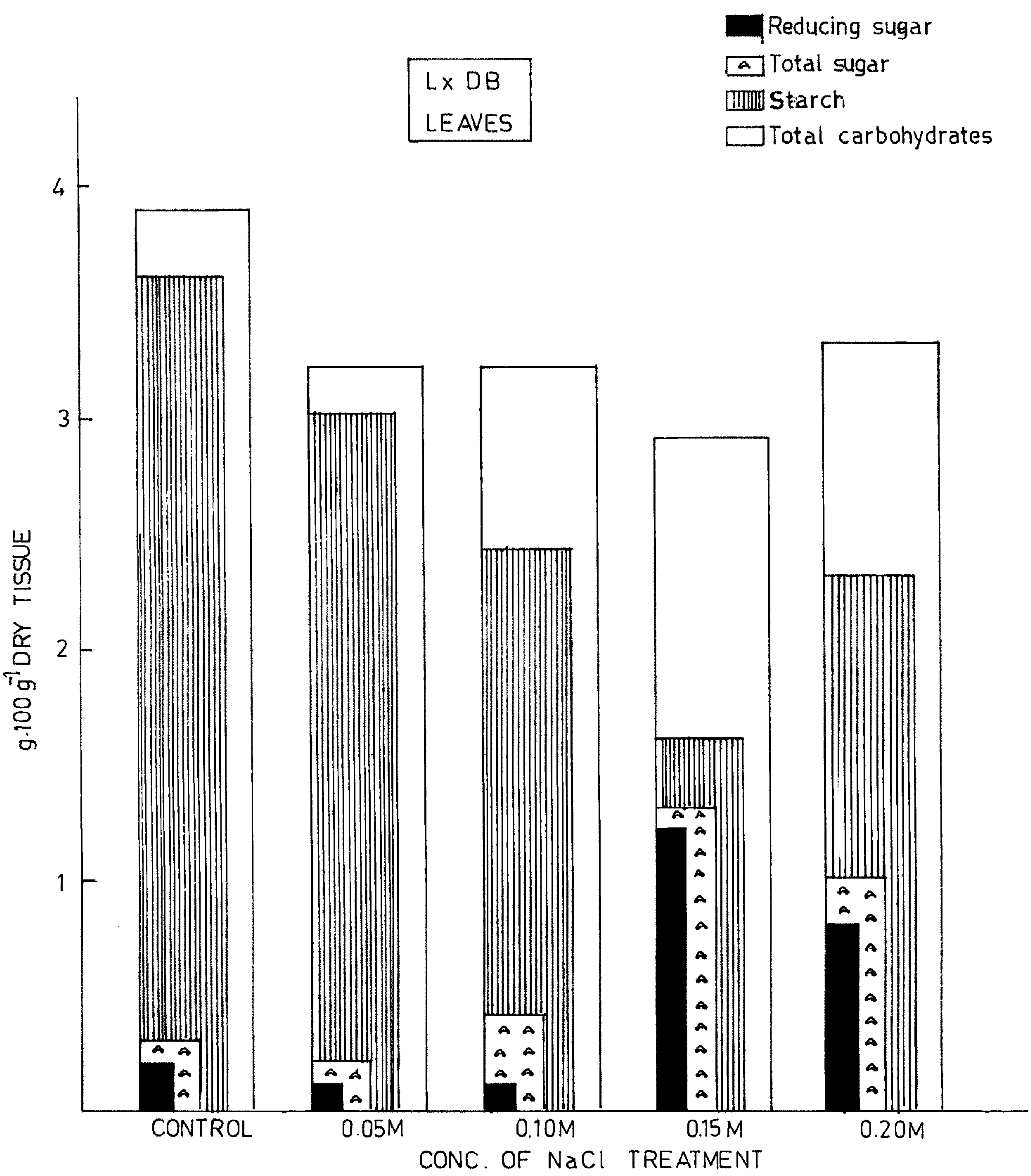

Fig No **14** EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON CARBOHYDRATE CONTENT OF Capsicum annuum HYBRID VARIETY

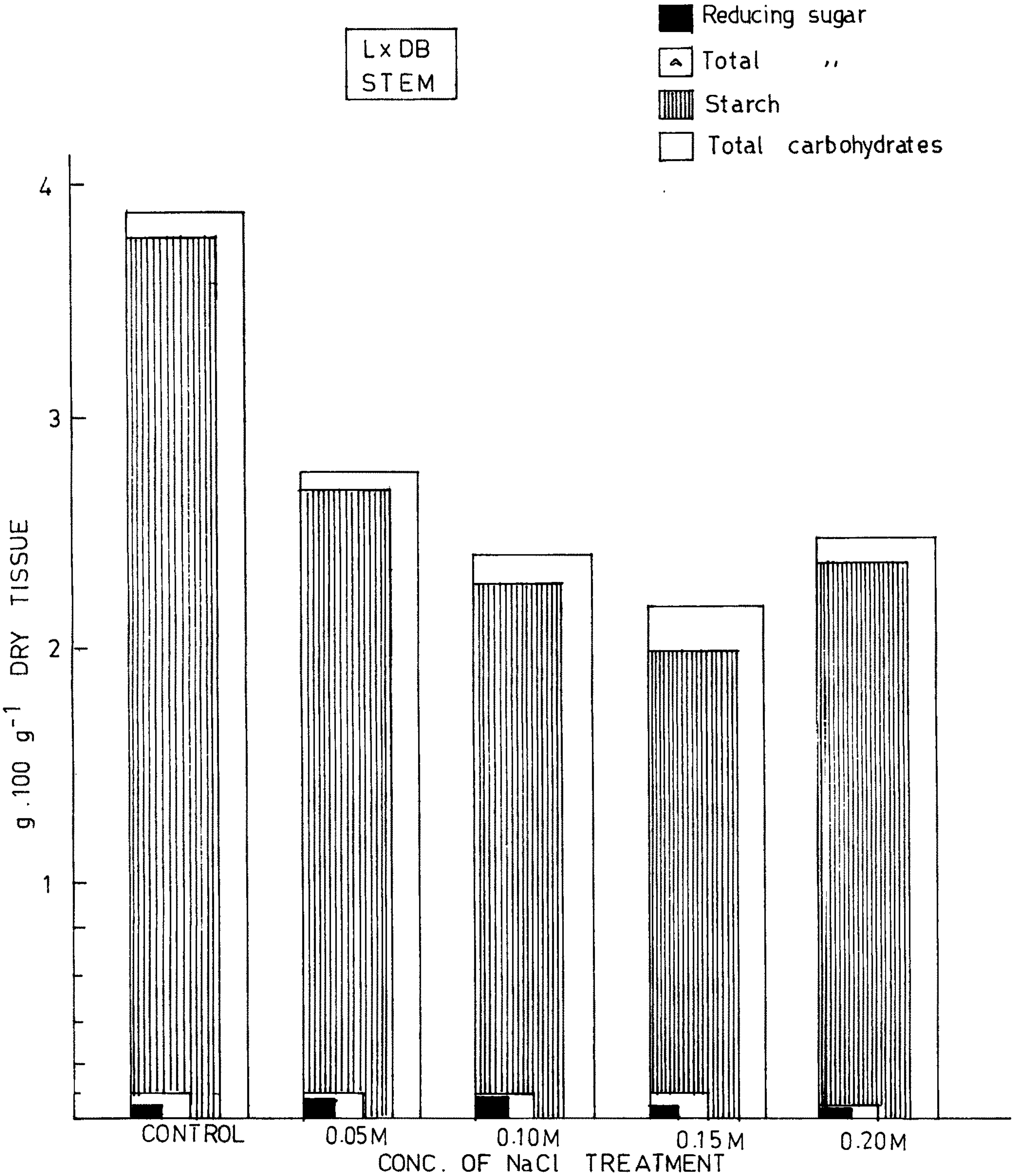

Fig.No. **15**. EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON CARBOHYDRATE CONTENT OF *Capsicum annuum* HYBRID VARIETY

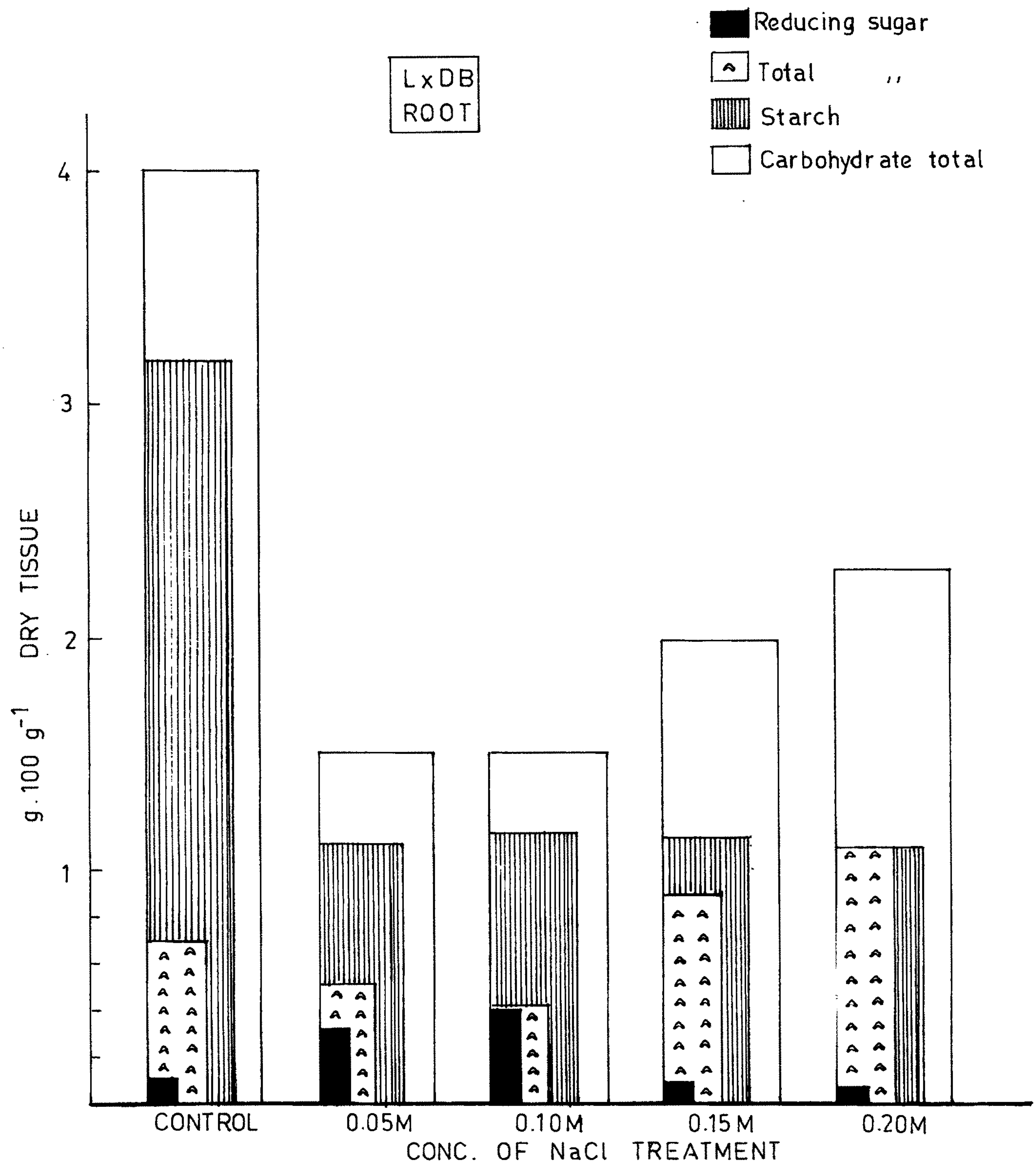

Fig. No. **16** EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON CARBOHYDRATE CONTENT OF Capsicm annuum HYBRID VARIETY sucrose under NaCl and Na_2SO_4 treatments. Despande (1981) reported decrease in total sugar and starch except reducing sugars in Pigeonpea under saline condns. Malik et al (1983) reported that the content of total and reducing sugars was increased in raddish and turnip and decreased in carrot due to salinity Jeschke (1986) and Aslam et al (1986) reported that soluble sugars and starch content were not affected with increase in conc. of NaCl in Atriplex amnicola.

It seems from the observations that different salinity levels and different varities show different effect on the carbohydrate metabolism.

From our present investigation it is clear that the effect of salinity on the Carbohydrate metabolism of 2 varieties of Capsicum annuum is different in leaves stem and roots. Mostly there is a linear increase and decrease or there is a increase in low conc.n and decrease in higher conc.n of NaCl.

5. Proline

Proline plays a important role in resistance to drought and salinity (Singh et al., 1973). Proline is generally compatible with enzyme and Organelle function. Schobert and Tschescbe (1978) reported that Proline increased the solubility of proteins.

The exact role of Proline in the mechanism of salt tolerance is not clear. Under salt stress Proline accumulates in plants (Strogonov, 1964), Palfi and Junasz (1970) also observed rise in level of Proline due to salinity.

It was suggested that Proline accumulation in response to salinity could be due to a disturbance in tissue water deficits. (Chu et al., 1976) Proline is a cyclic amino acid belonging to glutamic acid family. A correlation between proline content and salt tolerance of plants has been proposed by Goas (1968) while Stewart and Lee (1974) have made similar observations in _Ameria martima_. Trieichel (1975) suggested that greater proline content in halophytes was a water stress effect than a salt stress effect.

Effect of NaCl salinity on proline content on _Capsicum annuum_ hybrids is shown in Fig 17,18 Table 6

In our present investigation in the 2 _Capsicum annuum_ hybrid varieties PC1xDB and LxDB there is increase in the proline content at all the levels of salinity in leaves stem and roots. Similar observations were observed by Bhandari (1988) in 2 cultivars of _Capsicum annuum_ L. Pant C1 and NP46A under saline conditions.

The accumulation of proline under saline conditions is observed in many glycophytes (Bala, 1978, Dowton and Loveys 1981; Dix and Pearce, 1981; Larher, 1982; Roeb _et al_, 1982; Murry and Ayres, 1986). Accumulation of proline in potato plants under saline stress suggests the basis of Osmoregulation for building up salt tolerance (Abdullah _et al_. 1981). Salt stress dramatically increased protein synthesis from glutamate in exised barley leaves was suggested by Buhl and Stewart (1983). Recently Pandey, and Srivastava (1990) have observed the proline accumulation in twelve paddy genotypes tested at 15 Ece level of salinity. Kalaratta, Damodar and RPA-5929 were rated as salt tolerant and others moderately tolerant and showed significant positive association with salinity as well as proline accumulation. Evidently, proline accumulation may serve as one of the promising indices for breeding salt tolerant glycophytes in rice.

Palovskava, Khramov (1990) observed the effect of salts on the growth of Sorghum seedlings and proline accumulation. A co-relation was observed between growth delay and proline accumulation. A conclusion was made about the possibility of using proline content as a test in breeding sorghum cultivars resistant to drought and salinization.

There are many workers who have reported about the decrease in proline content due to salinity.

Shevyukova and Komizerko (1969) in callus of cabbage leaves, Totawat and Saxena (1971) in Phaseolus aureus, Stewart and Lee (1974) in plantago and Joshi and Naik (1980) in sugarcane. Tal and Andriana (1980) noticed an inhibition of cell of calli grown on external proline accumulation to the culture media in tomatoes under saline conditions. Despande (1981) also reported that failure of pigeon pea crop at high salinity was due to less proline accumulation. Murry and Ayres (1986) observed that salt tolerant nature of barley is due to its ability to accumulate proline under saline conditions.

Based on the work with crop species such as Triticum durum, T. aestivum, T. speltata, T. boeticum, Aegilops squarrosa, Hordeum vulgaris, Secale cereale, Avena sativa and Zea may's, Drier (1983a) recently tried to suggest a possible relationship between salt-tolerance and proline accumulation. According to him there is a certain conc. of NaCl above which proline content of plants strongly rises.

From the present investigation it can be seen that there is increase in proline content at all the levels of salinity in both the hybrid varieties of Capsicum annuum. PC1xDB and LxDB. It is

Table no. 6.

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl SALINITY ON PROLINE CONTENT OF *Capsicum annuum* HYBRID VARIETIES PC1xDB AND L x DB.

Hybrid varieties	Conc.^{n} of NaCl	Leaves	Stem	Root
PC1xDB	Control	0.09	0.010	0.010
	0.05M	0.12	0.014	0.010
	0.1 M	0.106	0.012	0.011
	0.15M	0.10	0.016	0.012
	0.2 M	0.11	0.018	0.018
L x DB	Control	0.11	0.004	0.024
	0.05M	0.13	0.008	0.025
	0.1 M	0.12	0.022	0.034
	0.15M	0.12	0.028	0.028
	0.20M	0.115	0.03	0.032

Values are expressed in g 100^{-1} g dry tissue.

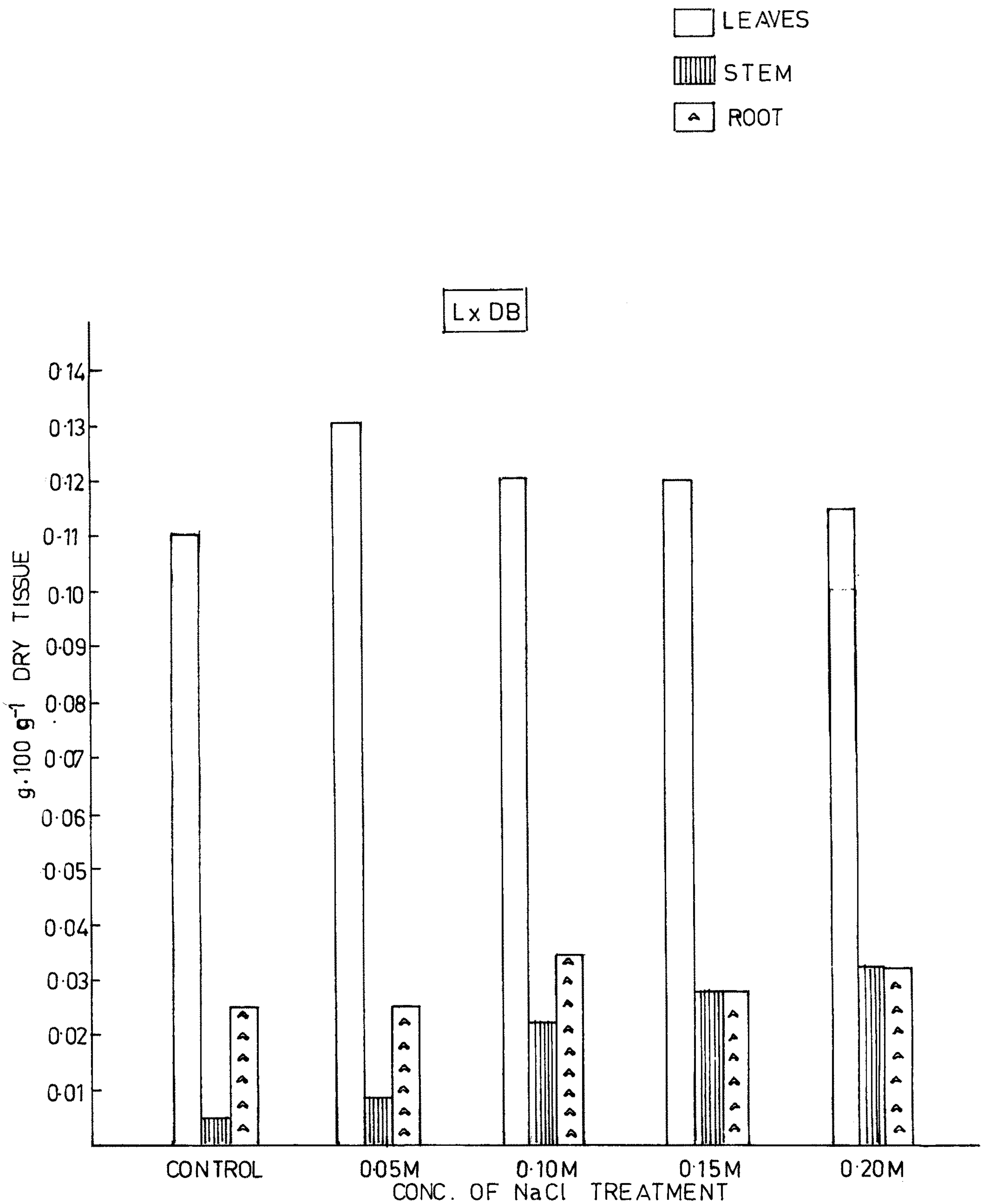

Fig No 17. EFFECT OF VARIOUS CONC. OF NaCl SALNNITY ON PROLINE CONTENT OF *Capsicum annuum* HYBRID VARIETY

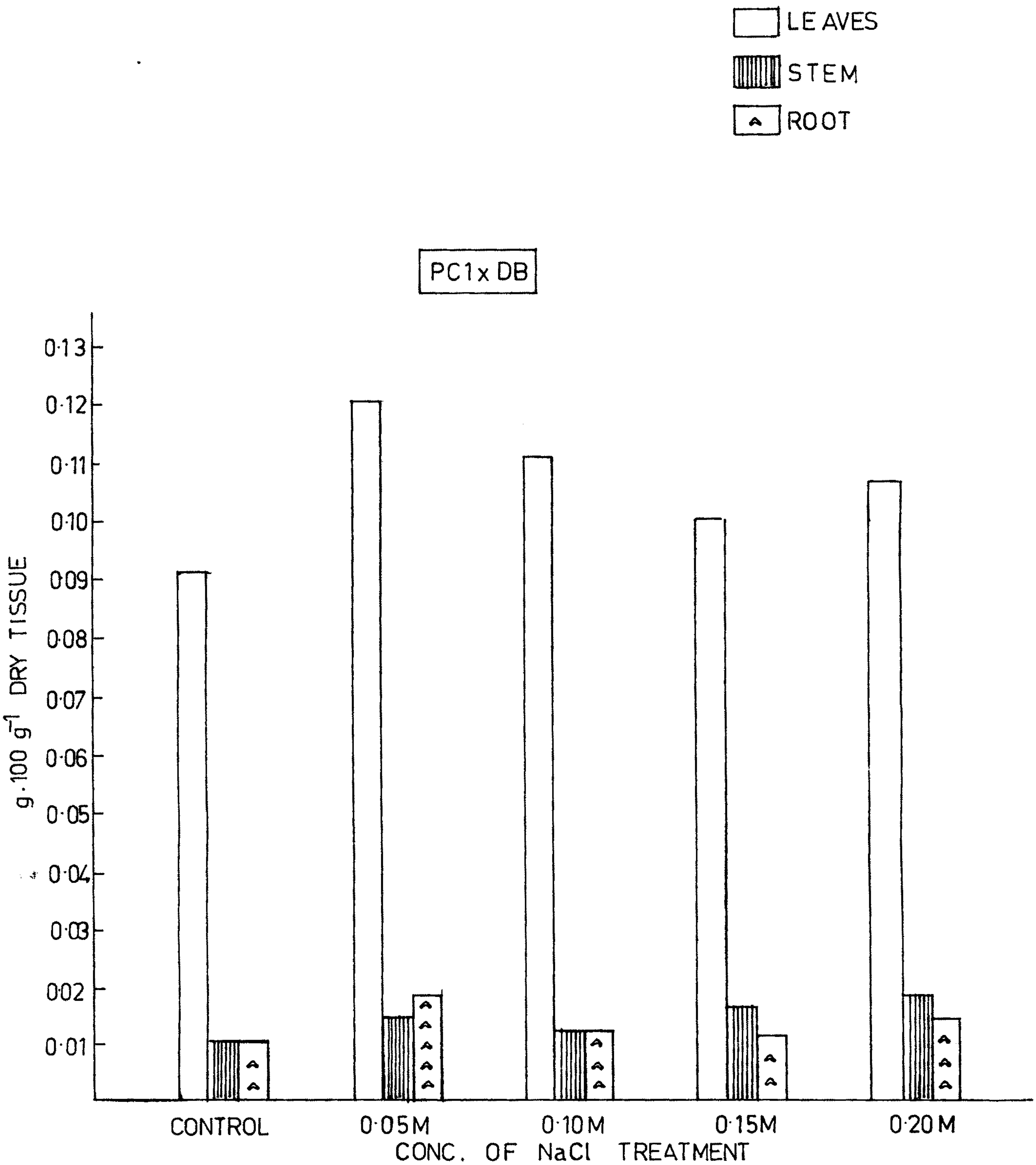

Fig No. 18 EFFECT OF VARIOUS CONC OF NaCl SALINITY ON PROLINE CONTENT OF Capsicum annuum HYBRID VARIETY observed that accumulation of proline under saline conditions is prominent in PC1xDB and LxDB. Higher proline content is observed in the leaves than in the roots and stem.

Thus our results indicate that proline may help the plant to withstand the salinity and survive.

6. **Polyphenols**

Polyphenols are widely distributed in plants. They are commonly known as tannins. Recently considerable importance has been attached to this group of chemical as some of the phenolic compounds act as phyto harmones.

According to Finkle (1967), the mode of action by which the Phenolic acids affect the growth of plants. According to Kokate and Patil (1975) recorded 1.2 and 2.5% Polyphenols from leaves of *Sorghum vulgare* from fields. Shetty (1971) reported that Polyphenol contents in saline form. *Archrosticum aureum*, range from 2.78 to 5.23 g per 100 g dry tissue.

The effect of NaCl on 2 *Capsicum annuum* hybrid varieties is shown in Table 7 Fig 19, 20

In present investigation, it is observed that there is increase in polyphenols as the level of salinity increased in hybrid variety PC1xDB while in LxDB the polyphenols are decreased as the level of salinity increases.

In stem and roots the Polyphenols were in higher content at lower levels, whereas they decreased at higher levels of salinity in both the hybrid varieties.

From the present investigation it is observed that Polyphenols are accumulated maximum in PC1xDB as compared to LxDB hybrid varieties.

Not much work is done about the influence of salinity on Polyphenols. Lewis and Papavizas (1967), observed the effect of tannin on the spore germination and growth of fusarium solani and verticillium albo-atrum.

There are results about enhancement of Polyphenols at lower conc. of NaCl in Achrosticum aeurum, a brackish water fern has been reported by Shetty (1971). Jamale (1975) indicated that mangrooves are rich in Polyphenols. Increase in Polyphenol content due to salinity in groundnut cv. TMV-10 has been observed by Karadge and Chavan (1980). They have further suggested that synthesis and accumulation of Polyphenols in leaves indicates, probably, NaCl salinity induces the secondary metabolic changes which are apparently related to the salt tolerance capacity of the plants. Murumkar (1986) has also observed an increase in the level of Polyphenols with the increasing level of salinity in chickpea. Chavan (1980), observed considerable increase in Polyphenol content of Eleusine coracana leaves due to chloride and sulphate salinities.

There are results of decrease in Polyphenols due to salinity. Sadale (1989) have observed about decrease in Polyphenols in Crotolaria Juncea and Sesbania grandiflora under saline condns. Decrease in Polyphenols of leaves is recorded by Karadge (1981) in Portulaca oleraceae, Patil (1984) in groundnut and Krishnamoorthy and Siddique (1985) in Cowpea. Wadkar (1989) observed decrease in Polyphenols due to salt stress in Crotolaria Verrucosa and C. Juncea leaves.

From the present observations, it is clear that Polyphenols increases as the level of salinity increases, in PC1xDB hybrid variety. But in LxDB hybrid variety there is a decrease in

Table no. 7.

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl SALINITY ON POLYPHENOL CONTENT OF *Capsicum annuum* HYBRID VARIETIES PC1xDB AND L x DB.

Hybrid varieties	Conc.^{n} of NaCl	Leaves	Stem	Root
PC1xDB	Control	1.50	0.450	0.60
	0.05M	1.70	0.50	0.85
	0.1 M	1.80	0.30	0.55
	0.15M	1.60	0.40	0.45
	0.2 M	2.00	0.40	0.65
L x DB	Control	1.75	0.66	0.60
	0.05M	1.60	0.55	0.45
	0.1 M	1.40	0.45	0.50
	0.15M	1.50	0.50	0.40
	0.20M	1.55	0.35	0.55

Values are expressed as g 100^{-1} g dry tissue.

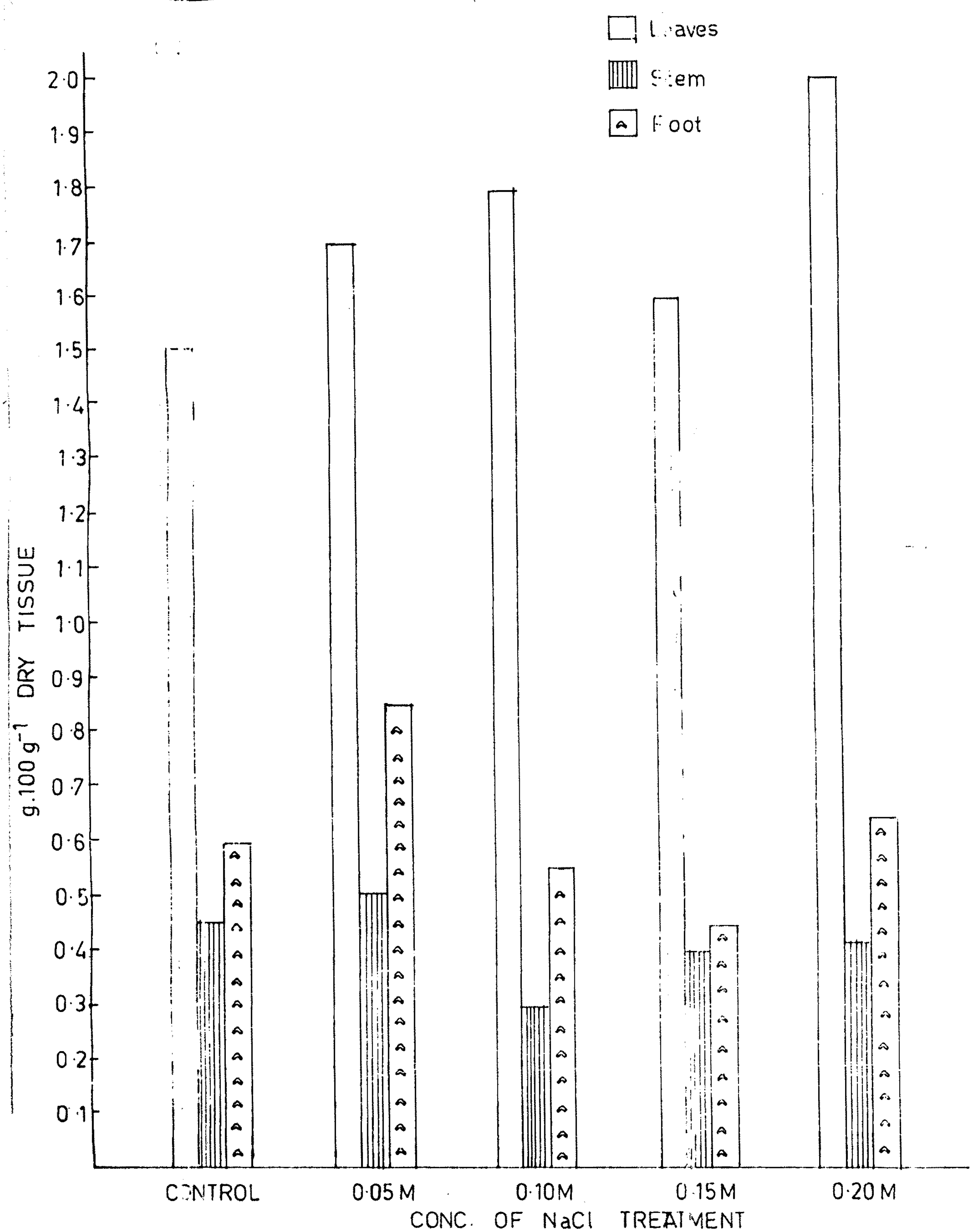

Fig No 19 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON POLYPHENOLS CONTENT OF Capsicum annuum HYBRID VARIETY PC1xDB

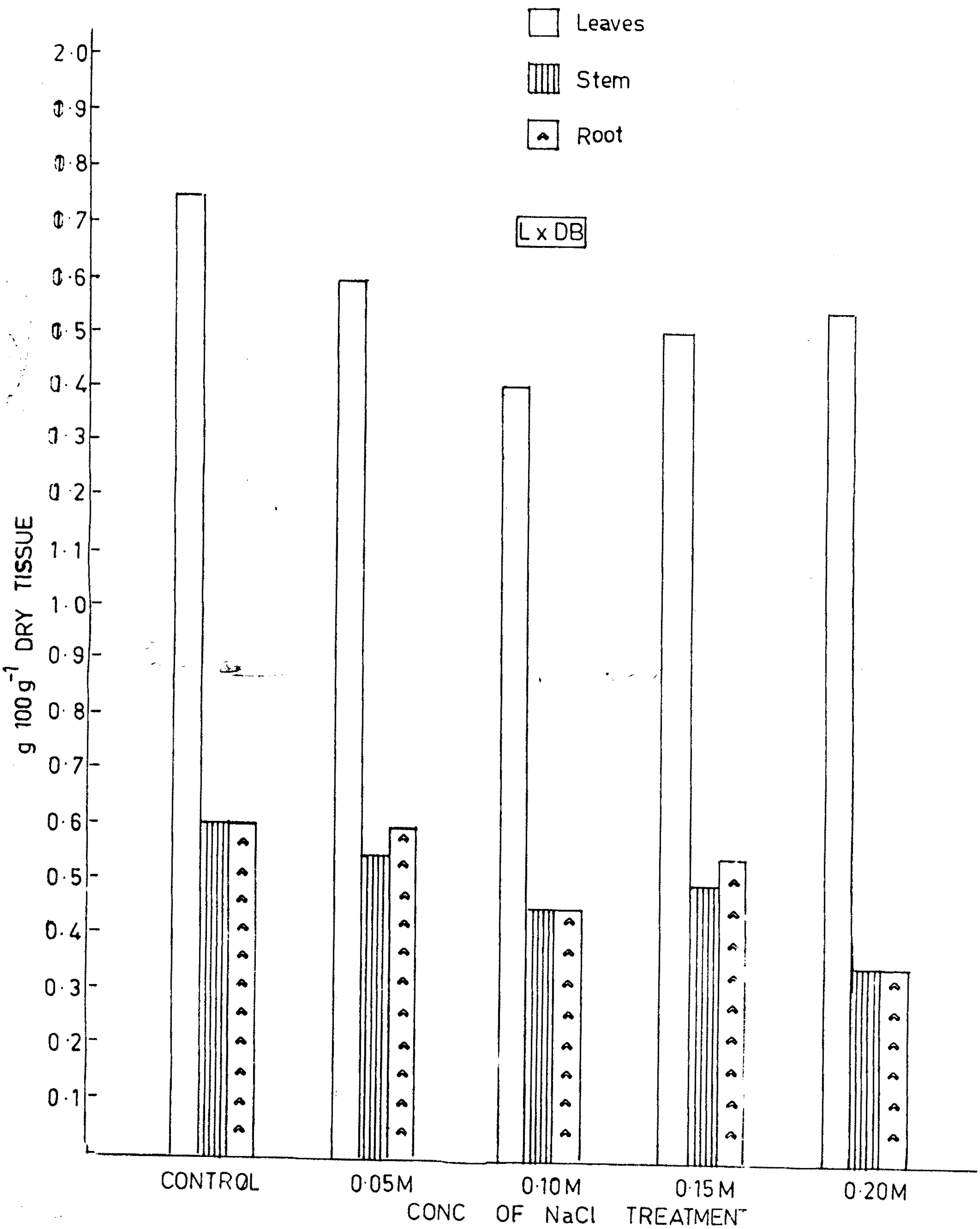

Fig No 20 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON POLYPHENOLS CONTENT OF *Capsicum annuum* HYBRID VARIETY

Polyphenols as the level of salinity increases. As compared to control the values of Polyphenols are less at all the levels of salinity in LxDB variety.

7. Nitrogen Metabolism

Nitrogen is an important constituent as many physiological reactions centre around protein molecules. Strogonov (1964) has pointed out that the nitrogen metabolism is the main source of salt injury in plants.

The effect of different concentrations of NaCl on nitrogen content of leaves, stem and roots of 2 hybrid varieties of *Capsicum annuum* PC1xDB and LxDB is shown in Table 8 Fig 21.

From the present investigations it is observed that in leaves of both the hybrid varieties there is increase in nitrogen content at all the levels of salinity except at 0.20 M where there is a slight decrease.

In the stem of both the varieties there was increase of nitrogen content at all the levels of salinity except in LxDB variety where it showed a slight decrease at 0.20 M salinity level. The roots showed increase in nitrogen content at all the levels of salinity except at 0.20 M salinity level where it decreased. There was increase in Proteins at all the levels of salinity except at 0.2M salinity level where it decreases in both the hybrid varieties.

There are many scientists who have observed a increase in the nitrogen content in plants growing under saline conditions. Miniberg and Le-Zu (1974) have observed that moderate salinity increases protein as well as non protein nitrogen and especially free amino acids in bean leaves. Increase in total nitrogen content due to salinity was observed by Chavan (1980) in stem and leaves of *Eleusine Coracana*. In experiments of Imamul Huq and Larher (1983 b,c) on bean and Cowpea plants, as much as 170% increase in total nitrogen over control in shoots and roots has

Table no. 8

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl SALINITY ON NITROGEN AND PROTEINS CONTENT OF *Capsicum annuum* HYBRID VARIETIES PC1xDB AND L x DB.

Hybrid varieties	Conc.^{n} of NaCl	Leaves		Stem		Root	
		Nitrogen	Proteins	Nitrogen	Proteins	Nitrogen	Proteins
PC1xDB	Control	5.25	32.8	0.85	5.3	1	6.25
	0.05M	6.75	42.1	1.3	8.1	1.25	7.81
	0.1 M	7	43.7	0.9	5.62	1.5	9.3
	0.15M	7.75	48.4	1	6.25	1.6	10
	0.2 M	5.25	32.8	1.25	7.81	1	6.25
L x DB	Control	4	25	1.8	11.2	1.8	11.2
	0.05M	4.5	28.1	1.05	6.56	1.25	7.81
	0.1 M	6	37.5	1.25	7.81	1.9	11.8
	0.15M	6.25	39.0	2	12.5	2	12.5
	0.20M	5.75	35.9	1.3	8.12	1.75	10.9

Values are expressed as g 100^{-1} g dry tissue.

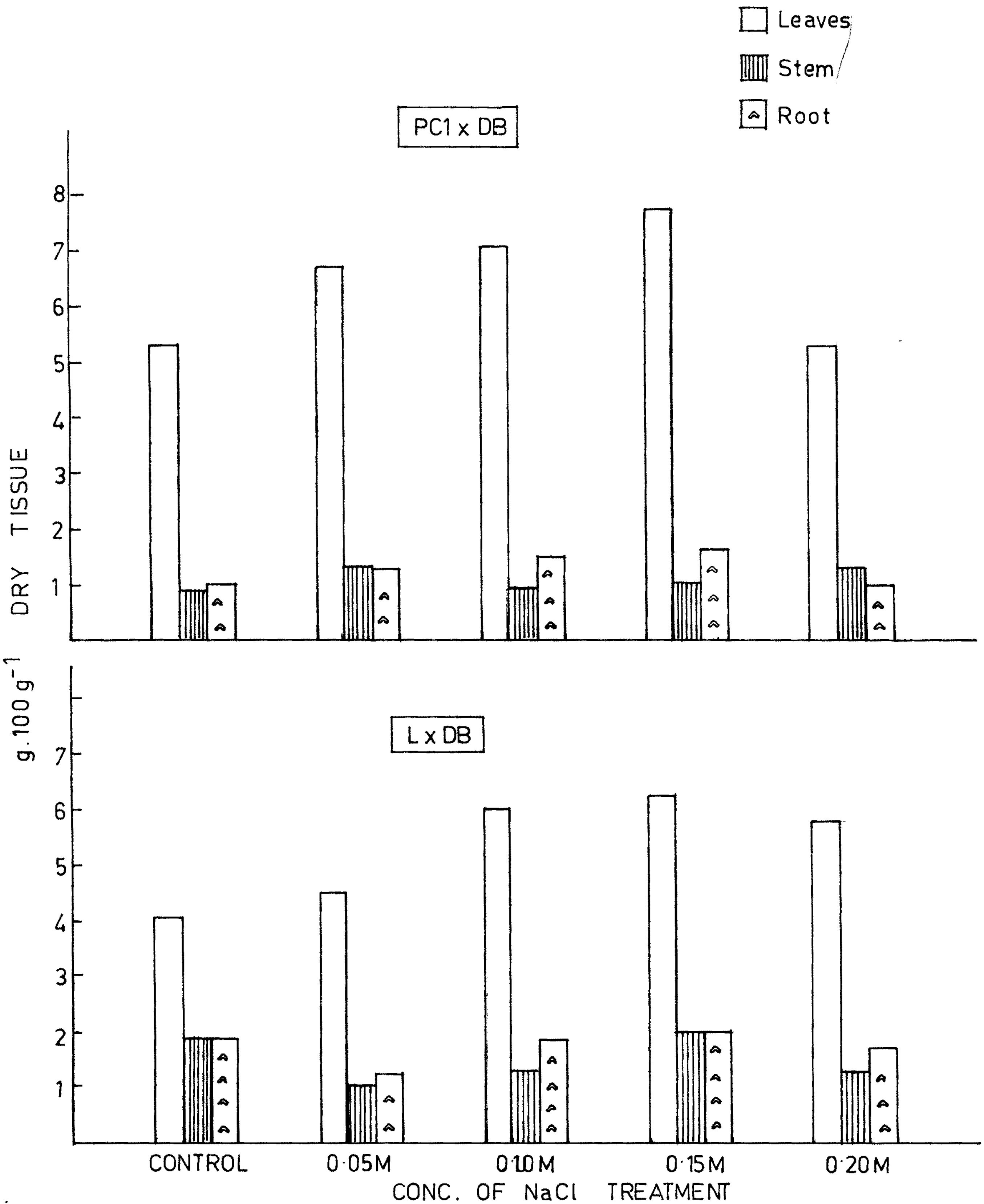

Fig No 21 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON NITROGEN CONTENT OF *Capsicum annuum* HYBRID VARIETIES been noted in salt stressed bean plants. Similar observations were also reported by Smith et al., (1980) in rye, grass and timothy. Rajmane (1984) in winged beans, Murumkar (1986) in chickpea and Chippa and Lal (1985) in wheat. Weil and Khall (1988) studied the salt tolerance of winged beans and soyabeans and observed that for the soyabean, the tissue nitrogen content was unchanged but for winged beans it was increased significantly with increasing salinity.

There are many reports about decline in nitrogen content. Bhandare (1988) observed a decrease in nitrogen content in Pant C1 and NP46A cultivers of Capsicum annuum. She observed that in both varieties nitrogen content was less than control at all the levels of salinity in leaves, stem and roots.

Lal and Bharadwaj (1984) observed a decrease in total nitrogen content in Pisum sativum var. arvensis due to the effect of salinity. Similarly a decrease in total nitrogen content is observed by Uprety and Sarin (1976) in Pisum sativum, Karadge (1981) in Portulaca oleraceae, Masshady et al.,(1982) in wheat and triticales, Patil and Patil (1983) in Syzygium. Sadale (1989) observed a decrease in nitrogen content in Sesbania grandiflora and Crotalaria juncea.

Our observations indicate that there is greater accumulation of total nitrogen by the 2 hybrid varieties of Capsicum annuum. The leaves accumulate more nitrogen than the stem and the roots. There was increase in Proteins at all the levels of salinity except at 0.20 salinity level where it decreases in both the hybrid varieties.

8. Nitrate reductase

Nitrate reductase was first detected by Evans and Nason (1953) in soyabean leaves. Nitrate reductase is the key enzyme of nitrogen metabolism. It is a source of inorganic nitrogen from the soil. Nitrate uptake by the roots of the plant must be reduced to ammonia prior to its availability in the overall nitrogen economy of the plant. This important process, called nitrate reduction consists basically 2 steps, the reduction of NO_3^- to NO_2^- and the further reduction of NO_2^- to NH_3^-. The two enzymes involved in the process are nitrate reductase and nitrite reductase (Hewitt 1975; and Beevers 1976).

Nitrate reductase is present in all parts of the plant e.g. cotyledons, roots, shoots leaves (Beevers and Hageman, 1969) Flower buds (Jones and Sheard 1972) and embryos (Rijven, 1958). There has been however much controversy with regard to the location of the enzyme within the cell. Losada et al., (1965); Coupe et al.,(1967) are of the opinion that the NR activity is associated with the chloroplast but the general view is that the enzyme is synthesized and localised in the cytoplasm (Ritenour et al., (1967) Schrader et al., (1968) Stewart (1968); Joy (1969); Dalling et al., (1972) a and b Venkatraman and Das (1982).

The results of nitrate and nitrite reductase activities in root, stem and leaves of *Capsicum annuum* hybrids PC1xDB and LxDB is shown in Table 9 Fig 22, 23

It is clear from the results that the leaves contain higher nitrate reductase activity as compared to stem and roots in both the *Capsicum annuum* hybrid varieties PC1xDB and LxDB.

Decrease in NR activity in roots, stem and leaves is observed in PC1xDB hybrid variety where the NR activity decreases as the level of NaCl salinity increases. While in LxDB hybrid variety there is higher NR activity at lower levels of salinity and decrease at higher levels of salinity in leaves stem and roots.

The effect of NaCl on Nitrite reductase is shown in Table 78 and Fig 78b.

On the other hand the NIR activity was less in PC1xDB hybrid variety than LxDB hybrid variety.

The nitrite reductase activity decreases as the level of NaCl salinity increases in PC1xDB variety in roots stem and leaves while there was stimulation of nitrite reductase activity at lower levels and inhibition at higher levels of NaCl salinity in LxDB hybrid variety in roots stem and leaves.

There are conflicting reports regarding effects of salt stress on this enzyme activity. Boucaud (1972) reported a stimulatory response of NaCl salinity on NR activity in Suaeda maritima var. Macrocarpa and Flexilis Austenfeld (1974) observed that at low and moderate NaCl salinity there was enhancement of NR activity in the leaves of Salicornia europea and Chenopodium alba while higher salinity inhibited it. By using different concentrations of glucose and comparing with salt, it was speculated that the effect of salt was not due to osmotic effect. Sankhla and Huber (1975) observed promotion of NR activity in Phancolus aconitifolius seedlings by NaCl. Smith et al., (1980) recorded an increase in the NR activity of rye grass and timothy due to NaCl salinity. They have correlated it to the increased uptake of nitrate rather than specific effect of the salt on the enzymes. Chavan (1980) observed stimulation of NR activity of rye grass and timothy due to NaCl salinity. They have correlated it to the increased uptake of nitrate rather than specific effect of the salt on the enzymes. Chavan (1980) observed stimulation of NR activity due to salinity in leaves of ragi and suggested that this increase probably enables the plant to cope with the changes in the nitrogen metabolism.

The stimulation of NR activity in sugarbeet by low salt concentrations is observed by Dias and Costa (1983), Krishnamoorthy and Siddique (1985) in Cowpea and Wadkar (1989) in *Crotolaria* spp.

There are also many reports about decrease in Nitrate reductase. Kleinkopf *et al.*,(1975) have reported that NaCl salinity causes to decrease the soluble protein and NO_3^- content and the loss of NR activity in *Atriplex confertifola* Billard and Boucoud (1982) observed a decrease in NR activity in a halophyte, *Suaeda macrocarpa* under saline conditions. Safaraliev *et al.*, (1984) recorded decreased NR activity in legumes under saline conditions. They suggested that the dissociation of FAD (in leaves) and Mo (in roots) from the apoprotein is mainly responsible for decreased NR activity. Aslam *et al.*, (1984) observed a severe inhibition of NR when salts were added *in vitro*, where as, in anaerobic *in vivo* conditions it was slightly affected. [Huber (1982) has tested the action of NaCl salt on NR activity and found inhibitory in *Lemna minor*. Gaikwad *et al.*,(1986) have reported that under saline conditions NR activity decreases in sensitive varieties and increases in tolerant ones, than control in millet species. In field pea, nitrate reductase activity was found to be suppressed due to soil salinization upto 8.0 $mscm^{-1}$ NaCl (Lal and Bharadwaj, 1987). Decrease in NR activity has also been observed by Rajmane (1984) in winged beans *Psophocarpus tetragonolobus* and Murumkar (1986) in chickpea, Bhandari (1988) observed a decrease in Nitrate reductase activity in two cultivars of *Capsicum annuum* Pant C1 and NP46A under saline condition.

Very few reports are available which describe the behaviour of NiR in plants under saline condition. A decrease in NiR activity in sugarbeet under saline conditions is observed by HeVer and Plant (1979), Rajmane ((1984) observed that activity of this enzyme is inhibited by salinity in a legume, Psophocarpus tetragonolobus. According to him, unavailability of sub-strate is a probable reason for this decline. Murumkar (1986) has also observed inhibition of NiR in chickpea due to salt stress. However, this reduction observed by him is not so conspicuous as that of NR in leaves of chickpea exposed to salt stress. Bottacin et al., however, has observed no effect of salinity on NiR in Panicum americanum genotype.

Increase in NiR activity in the leaves and roots of Setaria italica cv. SIC-1 with a decrease in nitrite content of the tissue is observed by Toro (1987). This increase in Nir is found to be well correlated with the increase in NR activity.

All the above results indicate that there is decrease in Nitrate reductase as well as nitrite reductase at higher levels of salinity. The PC1xDB hybrid variety show decreased Nitrate reductase activity as the concentrations of NaCl salinity increases whereas in LxDB variety there is slight stimulation of NR and NiR at lower levels of salinity and inhibition at higher levels of salinity . So it suggests that the LxDB hybrid variety shows a better Nitrate and Nitrite reductase activity while PC1xDB variety is affected more under saline conditions.

Salinity and Mineral Nutrition

Influence of salinity on mineral constituents in different parts of Capsicum annuum hybrid var. PC1xDB and LxDB is recorded in Tables 20 . It is evident that salinity exerts a remarkable influence on the uptake and distribution of mineral nutrients in

Table no. 9

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl ON NITRATE Reductase in root/stem leaves of *Capsicum annuum* HYBRID VARIETIES PC1xDB AND LxDB.

Hybrid varieties	Conc. of NaCl	Leaves	Stem	Root
PC1xDB	Control	0.2660	0.055	0.0184
	0.05M	0.205	0.052	0.0164
	0.1 M	0.200	0.04	0.0152
	0.15M	0.123	0.035	0.014
	0.2 M	0.100	0.03	0.012
LxDB	Control	0.30	0.063	0.07
	0.05M	0.300	0.053	0.068
	0.1 M	0.205	0.042	0.062
	0.15M	0.123	0.04	0.06
	0.2 M	0.100	0.035	0.05

Nitrate Reductase
Values are expressed as nm NO_2 liberated g^{-1} fresh tissue.

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl ON NITRITE Reductase in root, stem leaves of *Capsicum annuum* HYBRID VARIETIES PC1xDB AND LxDB.

Hybrid varieties	Conc. of NaCl	Leaves	Stem	Root
PC1xDB	Control	0.164	0.153	0.15
	0.05M	0.153	0.142	0.11
	0.1 M	0.150	0.140	0.12
	0.15M	0.142	0.132	0.10
	0.2 M	0.130	0.13	0.09
LxDB	Control	0.174	0.148	0.1
	0.05M	0.170	0.132	0.09
	0.1 M	0.169	0.135	0.07
	0.15M	0.165	0.138	0.06
	0.2 M	0.16	0.12	0.05

Values are expressed as nm NO_2 Used g^{-1} fresh tissue.
Nitrite Reductase.

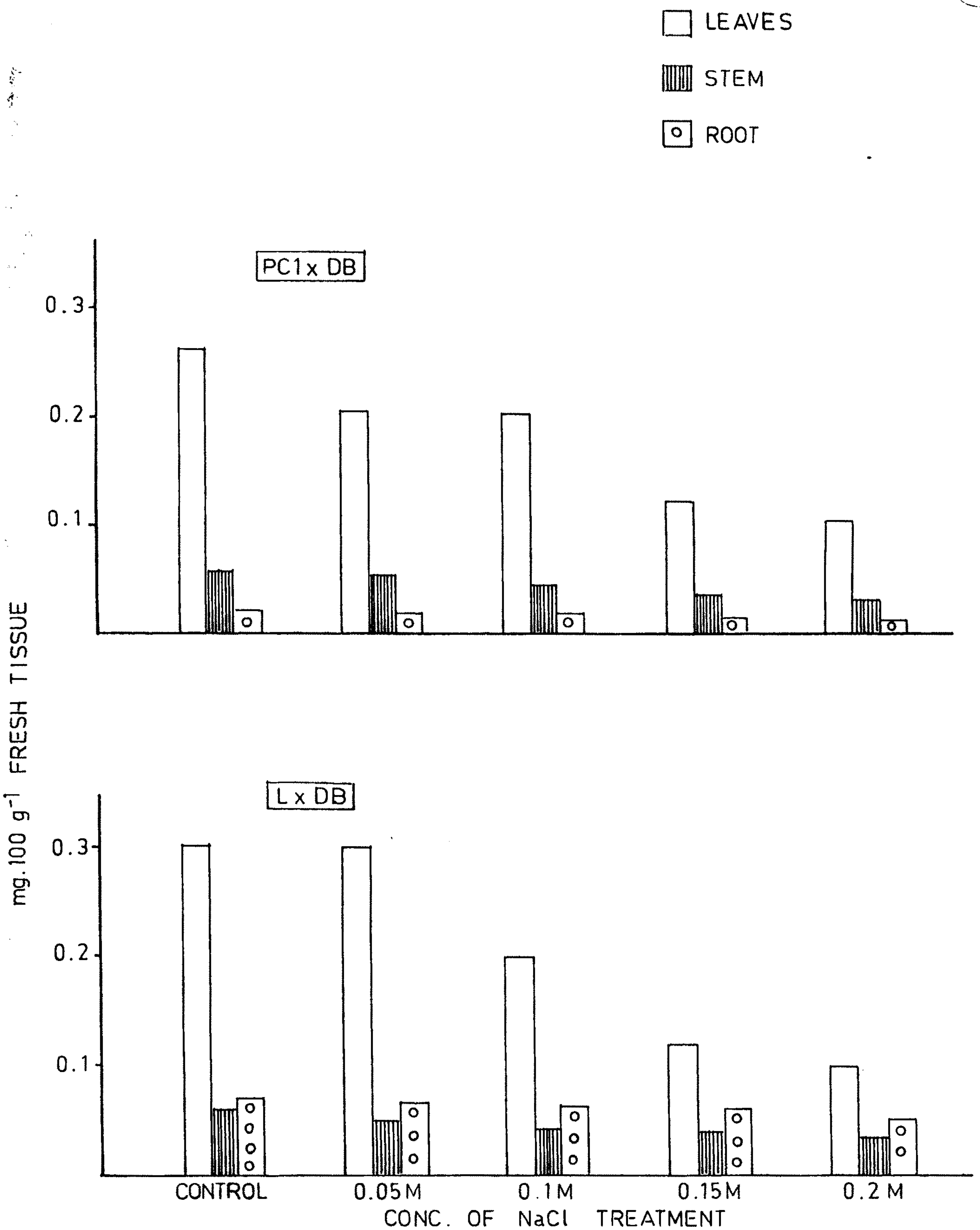

Fig.No. 22. EFFECT OF VARIOUS CONC. OF NaCl ON NIRATE Reductase OF 2 *Capsicum annuum* HYBRID VARIETIES PC1xDB & LxDB

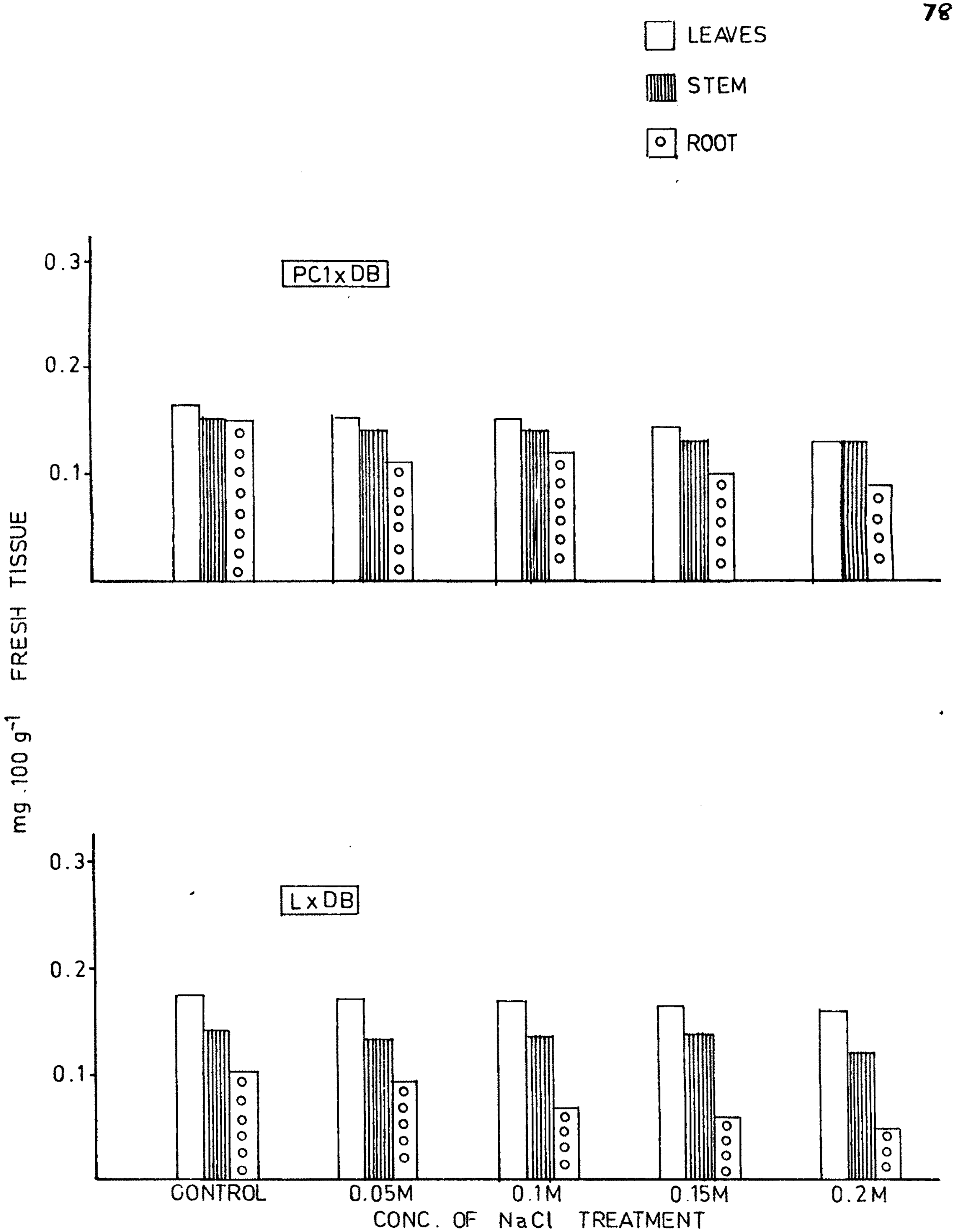

Fig. No. 23 EFFECT OF VARIOUS CONC. OF NaCl ON NITRITE Reductase OF 2 *Capsicum annuum* HYBRID VARIETIES PC1xDB & LxDB

Table no. 10

Table : 10 Effect of various concentrations of NaCl salinity on Mineral composition of <u>Capsicum annuum</u> hybrid variety - PC1xDB

Mineral Element	NaCl treatment (M)				
	Leaf				
	C	0.05M	0.1 M	0.15M	0.2 M
Na^+	0.06	0.056	0.068	0.128	0.1
Cl^-	5.57	5.25	4.82	6.22	7.1
K^+	1.6	3.6	4.4	3.0	1.2
Ca^{2+}	4.0	2.8	3.2	4.8	3.6
Mg^{2+}	1.21	1.82	1.9	0.48	0.73
P^{5+}	0.35	0.45	0.67	0.4	0.27
Fe^{3+}	0.08	0.12	0.1	0.06	0.04
Mn^{2+}	0.0066	0.0064	0.0056	0.0044	0.0028
Cu^{2+}	0.0124	0.0164	0.0138	0.0136	0.011
Zn^{2+}	0.0146	0.0164	0.0167	0.0134	0.0106

Values are expressed as g 100^{-1} g dry matter

Table : 10 Effect of various concentrations of NaCl salinity on Mineral composition of <u>Capsicum annuum</u> hybrid variety - PC1xDB

Mineral Element	NaCl treatment (M)				
	Stem				
	C	0.05M	0.1 M	0.15M	0.2 M
Na^+	0.05	0.118	0.076	0.12	0.06
Cl^-	1.28	1.6	1.82	2.03	
K^+	0.132	0.088	0.054	0.06	0.176
Ca^{2+}	2.8	2.6	2.48	2.4	2.4
Mg^{2+}	0.48	0.85	0.68	0.97	2.19
P^{5+}	0.15	0.125	0.10	0.05	0.25
Fe^{3+}	0.052	0.08	0.06	0.056	0.22
Mn^{2+}	0.002	0.004	0.0016	0.0014	0.0012
Cu^{2+}	0.0102	0.0104	0.021	0.0158	0.012
Zn^{2+}	0.0076	0.008	0.0126	0.0098	0.0082

Values are expressed as g 100^{-1} g dry matter

Table : 10 Effect of various concentrations of NaCl salinity on Mineral composition of *Capsicum annuum* hybrid variety - PC1xDB

Mineral Element	NaCl treatment (M)				
	Root				
	C	0.05M	0.1 M	0.15M	0.2 M
Na^{+}	0.06	0.082	0.086	0.096	0.112
Cl^{-}	1.0	1.1	1.6	1.9	2.0
K^{+}	0.176	0.174	0.12	0.064	0.076
Ca^{2+}	2.4	2.6	3.2	2.8	2
Mg^{2+}	2.19	1.58	2.92	0.73	2.92
P^{5+}	0.25	0.27	0.3	0.17	0.22
Fe^{3+}	0.22	0.16	0.12	0.14	0.26
Mn^{2+}	0.0086	0.0096	0.0076	0.006	0.0046
Cu^{2+}	0.016	0.0166	0.0172	0.0168	0.0118
Zn^{2+}	0.014	0.013	0.0116	0.011	0.009

Values are expressed as g 100^{-1} g dry matter

Table : 10 Effect of various concentrations of NaCl salinity on Mineral composition of <u>Capsicum annuum</u> hybrid variety - L x DB

Mineral Element	NaCl treatment (M)				
	Leaf				
	C	0.05M	0.1 M	0.15M	0.2 M
Na^{+}	0.048	0.046	0.064	0.082	0.118
Cl^{-}	5.36	5.89	6.97	6.75	7.29
K^{+}	3.6	3.4	2.2	3.8	4.0
Ca^{2+}	2.8	3.6	2.8	4.8	4.4
Mg^{2+}	1.94	0.97	3.41	1.70	2.19
P^{5+}	0.35	0.25	0.275	0.45	0.5
Fe^{3+}	0.12	0.1	0.06	0.088	0.08
Mn^{2+}	0.0054	0.0044	0.0054	0.0062	0.0084
Cu^{2+}	0.0134	0.0154	0.0148	0.0152	0.0162
Zn^{2+}	0.0136	0.0134	0.0024	0.0014	0.001

Values are expressed as g 100^{-1} g dry matter

Table : 10 Effect of various concentrations of NaCl salinity on Mineral composition of <u>Capsicum annuum</u> hybrid variety - L x DB

Mineral Element	NaCl treatment (M)				
	Stem				
	C	0.05M	0.1 M	0.15M	0.2 M
Na^{+}	0.038	0.048	0.092	0.066	0.114
Cl^{-}	0.858	1.5	1.71	1.82	1.93
K^{+}	0.116	0.112	0.126	0.106	0.088
Ca^{2+}	2.40	2.0	2.36	2.60	2.8
Mg^{2+}	1.46	2.19	0.51	0.12	2.68
P^{5+}	0.2	0.1	0.12	0.15	0.125
Fe^{3+}	0.08	0.064	0.04	0.08	0.076
Mn^{2+}	0.0014	0.0016	0.002	0.0022	0.0024
Cu^{2+}	0.017	0.0186	0.0164	0.0152	0.0118
Zn^{2+}	0.01	0.011	0.0106	0.0104	0.0088

Values are expressed as g 100^{-1} g dry matter

Table : 10 Effect of various concentrations of NaCl salinity on Mineral composition of Capsicum annuum hybrid variety - L x DB

Mineral Element	NaCl treatment (M)				
	Root				
	C	0.05M	0.1 M	0.15M	0.2 M
Na^{+}	0.012	0.090	0.086	0.114	0.134
Cl^{-}	0.9	1.0	1.2	1.4	1.8
K^{+}	0.178	0.132	0.14	0.16	0.13
Ca^{2+}	5.21	4.0	2.0	3.6	2.8
Mg^{2+}	0.73	1.46	1.94	1.21	3.41
P^{5+}	0.32	0.17	0.22	0.25	0.27
Fe^{3+}	0.2	0.26	0.12	0.14	0.16
Mn^{2+}	0.008	0.0116	0.0084	0.008	0.009
Cu^{2+}	0.0152	0.01	0.0128	0.014	0.013
Zn^{2+}	0.012	0.008	0.0108	0.0124	0.0128

Values are expressed as g 100^{-1} g dry matter

different parts(leaves, stem and root) of this plant.

1. Na^{+} (Sodium)

Na^{+} is present in large amounts on this earth. It is useful for the plants in very less quantities, but its abundance causes the inhibition of plant growth. Kratz and Mayers (1955) have shown that both Na^{+} and K^{+} are required for better growth in many members of cyanophyceae. The work of Joham (1955 and 1957) and Whittenberg and Joham (1964) showed tht sodium can partially substitute ca^{2+} in maintaining carbohydrate translocation (Greenway (1962) has found tht Hordeum vulgaris leaves attained high dry wt during NaCl treatment that after sodium chloride removal).

In our present investigation we have observed the following results as shown in the Table no 10 Fig no 24

It is clear in our present investigation that Na^{+} content in both the hybrid varieties of *Capsicum annuum*. L. PC1xDB and LxDB increases as the salinity level increases in leaves, stem and roots.

In leaves there is a increase in Na^{+} content at all the levels of salinity except at 0.05M salinity level where it slightly decreases in both the varieties PC1xDB and LxDB.

In the stem there is increase in Na^{+} content at all the levels of salinity.

The roots showed a increase in Na^{+} content at all the levels of salinity. As the salinity level increases the Na^{+} content also increases in both the varieties.

Increased accumulation of sodium has been reported by many workers (Ansari *et al*., 1978; Downton; 1978, Laszlo and Kuiper, 1979; Chavan and Karadge 1980)

With increasing chloride salinity, Na^{+} uptake as well as dry matter productivity increased in Lippia nudiflora (Karadge et al., 1983) These results indicate that with internal high Na^+, barley variety Vijay and Lippia nudiflora maintained their normal growth.

There are many reports about increase of Na^+ content under saline conditions (Strogonov (1972) in pea plants, Meiri et al.,(1971) in bean plants, Ayoub (1975) in Phaseolus bean, Akerson and Youngner (1975) in bean, Lessani and Marschner (1978) in various crops, D'Arrigo et al., (1983) in bean, West and Taylor; (1980) in Phaseolus vulgaris, Rathert et al.,(1983) in bush bean and sugarcane, Abdel Rahaman (1987) in cowpea. Bhandari (1988) also observed an increase in Na^+ contents in two Capsicum annuum cultivars. Pant C1 and NP46A.

According to Hasson - Porath et al., (1972) Sodium was restricted only to the roots and it was hardly transported to shoot in pea seedlings. Similar results have been observed by Marschner and Mix (1973) in beans. An increase in Na^+ content is also observed by Pakroo and Kashirad (1981) in sunflower from 0 to 1.5 ppm of NaCl. Yadav and Sharma (1980) observed an increased Na^+ content has decreased plant height, number of pods and seed yield per plant etc. in field experiment on gram. Kawasaki et al., (1983) investigated the plant growth under both NaCl and PEG induced stress condition. These workers observed that in all 3 crops studied viz. beans, maize and sorghum. Sodium accumulated to a greater extent in shoot region than in root region with increasing salinity stress. Aly et al., (1989) studied salt tolerance of Lycopersicon esculentum III and observed a increase in Na^+ content due to salinity. Roth, Hannelore (1989) studied the influence of sodium chloride or sodium sulphate on growth and

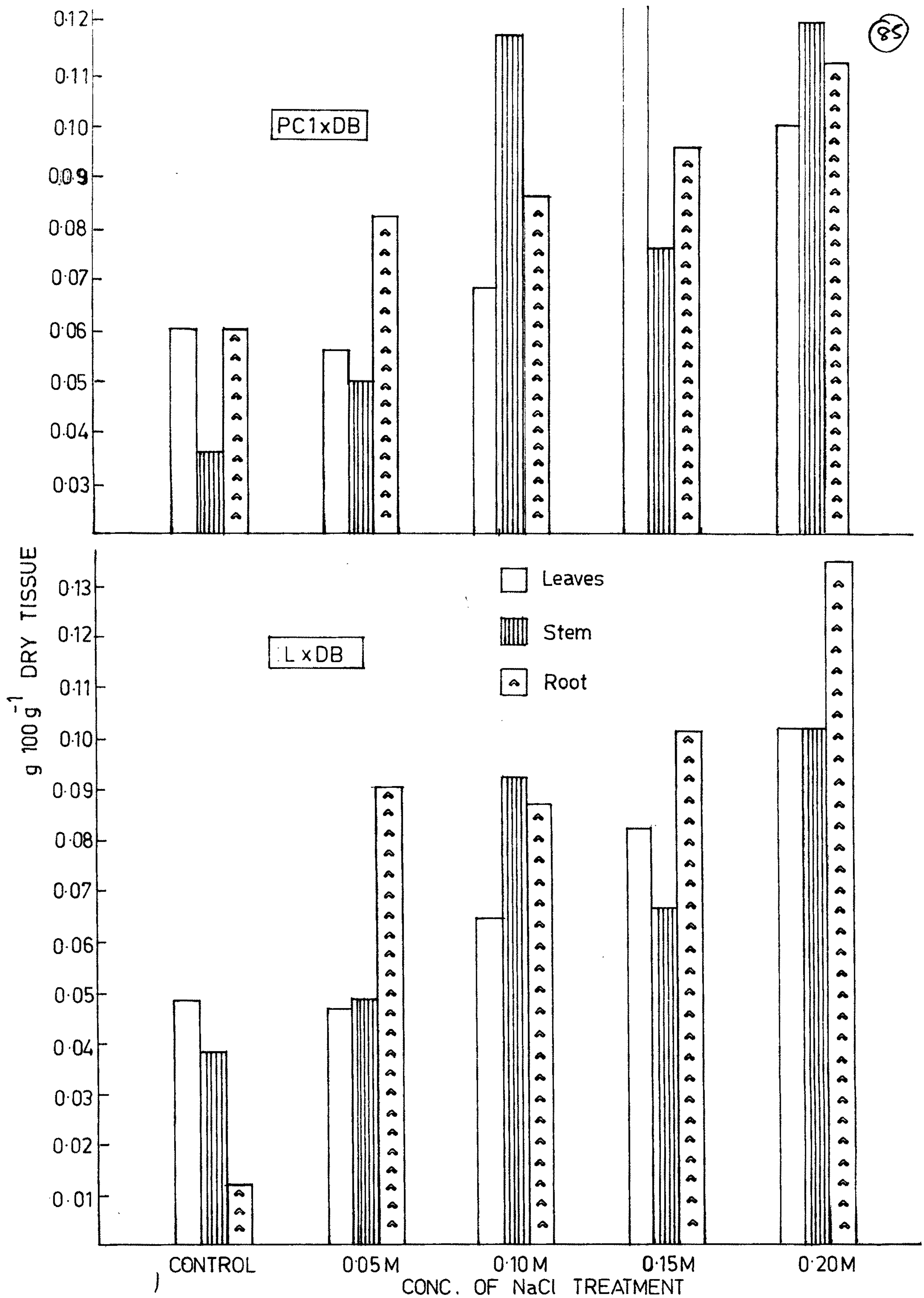

Fig.No. 24 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON SODIUM CONTENT OF *Capsicum annuum* HYBRID VARIETIES dry matter production of Triticum aestivum L, Hordeum vulgare l and oryza sativa l. and observed decreased potassium content and markedly increased the sodium content in the seedlings although the potassium-sodium ratio was better under salinity conditions, Salim et al., (1990) studied effect of salinity stress and varietal resistance in rice and observed Na^+ content increased. Hashim et al., investigated salt tolerance in Lycopersicon esculentum II and and observed decrease in Na^+ in roots but increase in Na^+ in leaves. Increase in Na^+ content under saline conditions was observed by Rajmane (1984) in Psophocarpus tetragonolobus in leaves, stem and roots.

There are also some results which suggest that less accumulation of Na^+ may help the plant to tolerate the salinity. In Atriplex hortensis an increase in growth, dry matter production and leaf size was due to low accumulation of Na^+. There are species which are able to tolerate low salinity levels by excluding Na^+ from leaves. It occurs in beans and corn (Jacoby and Ratner, 1974).

From the present investigation it is evident that under NaCl salinity, sodium uptake increases and its content is more in the leaves than in roots and stem in both the hybrid varieties of Capsicum annuum. PC1xDB and LxDB, which indicates that the roots transfer the Na^+ from stem to leaves rapidly.

Na^+ is toxic for plant growth and both the varieties accumulate higher Na^+ content. These results indicate that the plants show a sensitive nature towards salinity.

2. Potassium

K^+ has been regarded as one of the major solutes in plants and always plays a important role in the maintainance of cell turgor (Cram, 1972).

K^+ is a very essential element for respiratory metabolism in plants. The universal occurence of K^+ in growth and metabolism makes it difficult to trace a specific and casual relationship between K^+ nutrition and the response mechanism. It is very useful element in respiration and Photo-synthetic processes. K^+ is a monovalent cation. It has some indispensable role in the plant life. Broyer and Stout (1959) have indicated that K^+ is linked with carbohydrate metabolism. It is distributed all over the plant under saline conditions. Sargassum illcifolium (Gowda, 1971) accumulates K^+ more than Na^+ even though it grows in Na^+ rich environment. This indicates an absolute requirement of K^+.

In our present investigation the effect of NaCl salinity observed is shown in Table 10 Fig no 25,26

The results observed are contradictory results in both the varieties of Capsicum annuum PC1xDB and LxDB. In PC1xDB in leaves there is a increase in K^+ content at lower levels of salinity and decrease at higher levels of salinity while in LxDB leaves there is decrease in K^+ content at lower levels of salinity but it increases as the level of salinity increases.

In stem of both the hybrid varieties there is decrease in K content at all the levels of salinity, except at 0.05 M in PC1xDB and 0.10 M in LxDB where it increases slightly.

In roots there is decrease in K^+ content as the salinity level increases in both the hybrid varieties, except at 0.15 M salinity level it decreases slightly in LxDB hybrid variety.

There are many reports about decrease in K^+ content due to salinity. Gauch and Wadleigh (1944) in bean, Sarin (1962) in Cicer arientum Nieman and Poulsen (1967) in bean, Hasson-Porath et al., (1972) in pea seedlings, Mata et al., (1975) in spinach and lettuce, Lessani and Marschner (1978), D Arrigo et al., (1979), El Hamid et al., (1983), Imam ul Huq and Larher (1983) in Phaseolus aureus, and Kawathe (1986) in safflower.

Bhandari (1988) observed a decrease in K^+ content at all the levels of NaCl salinity in Capsicum annuum cultivars Pant C1 and NP46A. There are many reports about adverse effect of NaCl salinity on K^+ content. Hasson-Porath et al., (1972), Nimbalkar and Joshi (1975) in sugarcane var.co.740, Lal and Bharadwaj (1984) in Zea Mays, Paliwal and Maliwal (1972 and 1975) in Abelmoschus esculentus, Luffa cylindrica and Brassica oleraceae, Iyengar et al.,(1974, 1978) in sugarcane, cotton, tomato, Chavan and Karadge (1980) in Arachic hypogea, Despande (1981) in cajanus cajan. According to these workers the very severe depressive effect of NaCl on K^+ absorption might be caused by the competative relation between monovalent cations in addition to lowering or osmotic potential due to high concentrations of NaCl. Decreased K^+ content level in cowpeas under salt stress has attributed to the accumulation of Na at the expense of K^+ thereby creating a condition of K^+ deficiency.

There are reports about accumulation of K^+ under saline conditions, Aphale in Setaria italica (1978) observed that the accumulation of K^+ is more than in Oryza sativa, Zea mays and Saccharam officinarum.

Accumulation of K^+ is also reported by Rajmane (1984) in Psophocarpus tetragonolobus. He observed that increase in salinity caused a very slight effect on the uptake of K. Similar results are also observed by Koshtee (1992) in Curcuma longa species (Personal communication). She observed increase in K^+ uptake in leaves, rhizome with increasing salinity level.

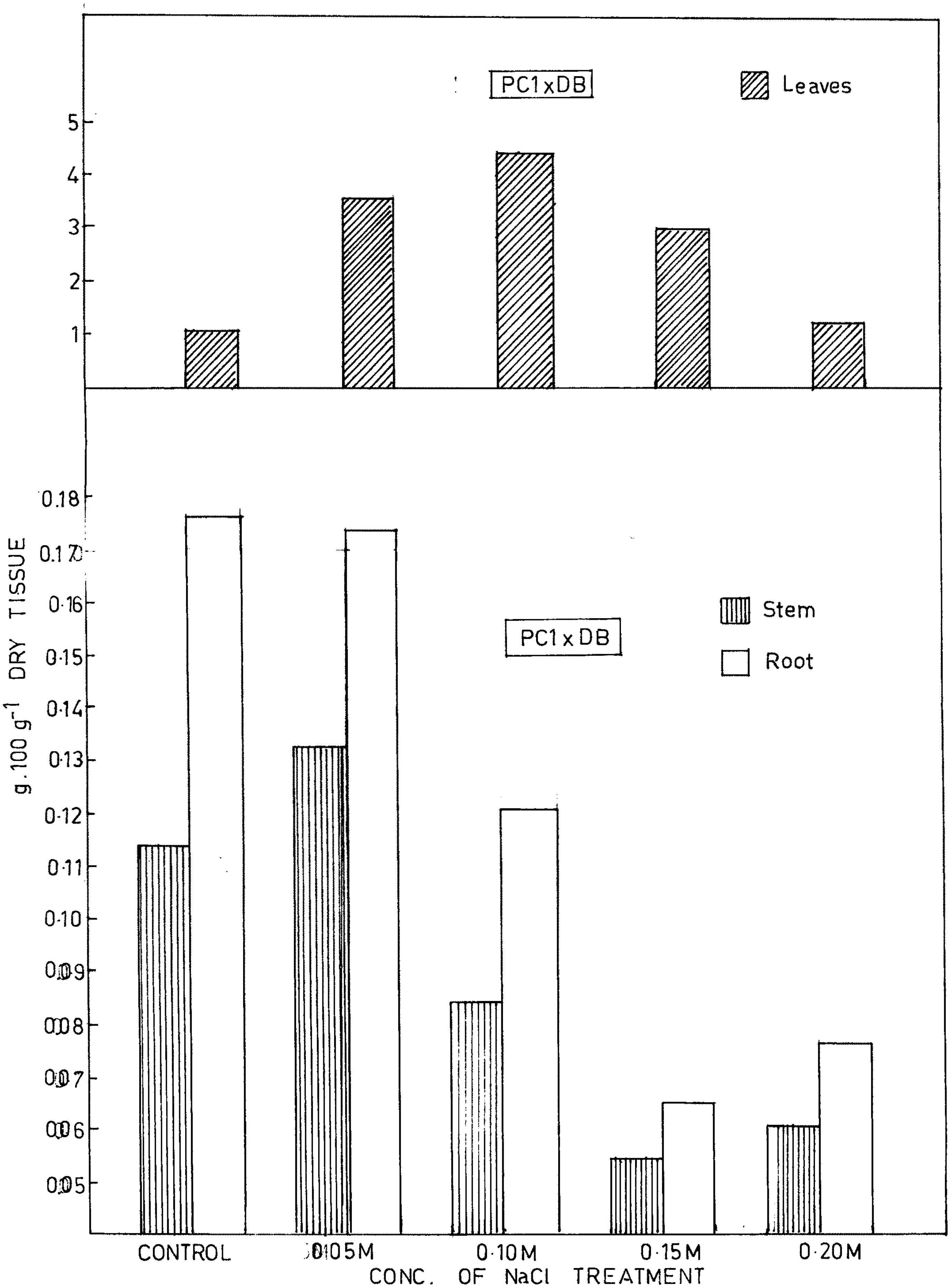

Fig No 25 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON POTASSIUM CONTENT OF *Capsicum annuum* HYBRID VARIETY

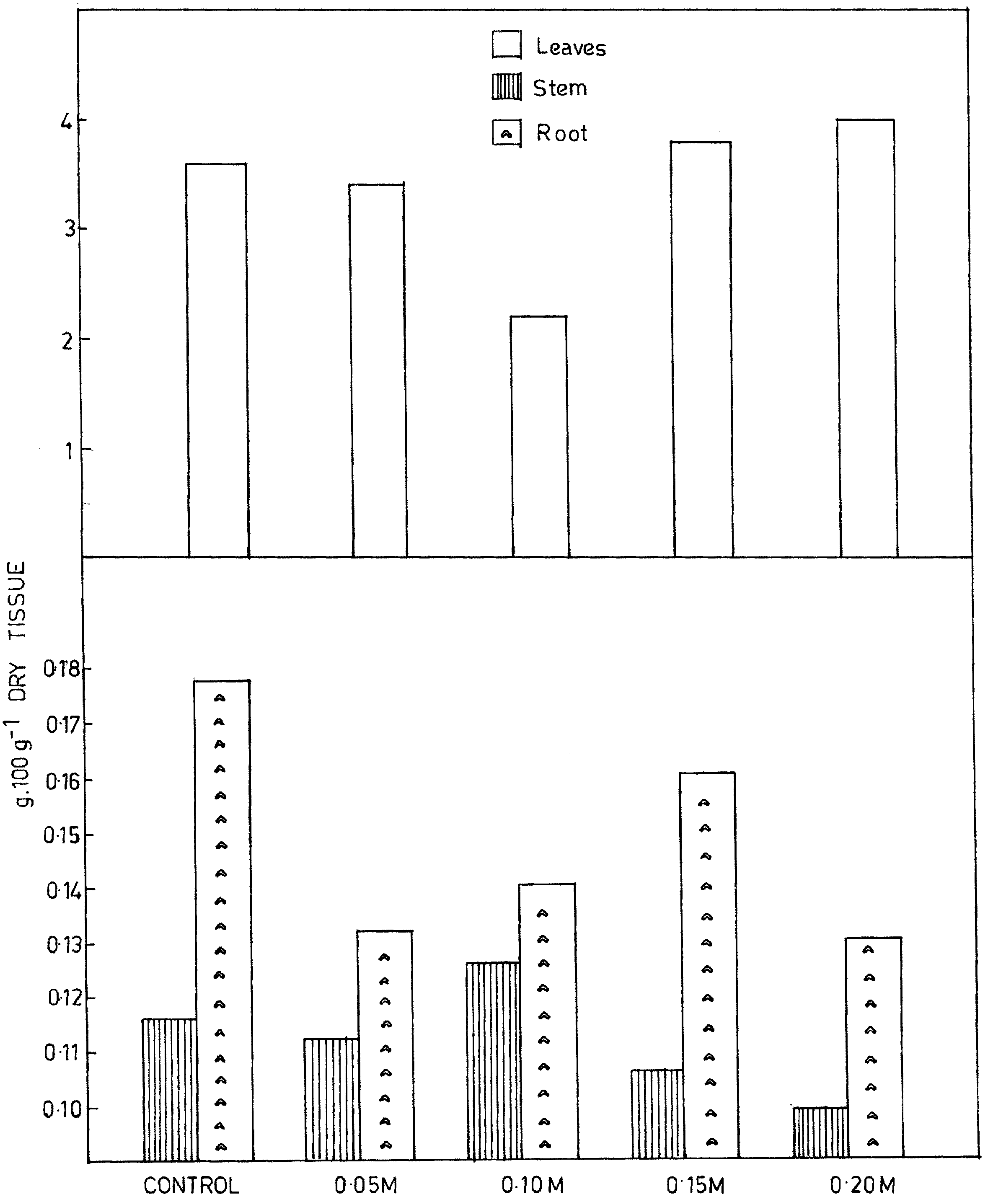

Fig No 26 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON POTASSIUM CONTENT OF *Capsicum annuum* HYBRID VARIETY L x DB

Controversial results are seen for K^+ absorption in different cases by different workers Rains and Epstein (1967) observd that lower concentration of chloride have little influence on K^+ uptake, while higher concentrations of chloride salts affect K^+ uptake.

From the present investigation it is clear that there is more accumulation of K^+ content in the leaves of the two hybrid varieties of <u>Capsicum</u> <u>annuum</u> PC1xDB and LxDB. There is decrease in K content in stem and roots in both the varieties, except at 0.05 and 0.10 as the level of salinity increases which indicates that there is a rapid translocation of K^+ from the roots to the leaves where they accumulate maximum. It also indicates that there is efficient K^+ uptake mechanism under saline condition in LxDB hybrid variety than in PC1xDB hybrid variety. This may be the important factor for the LxDB hybrid variety which can grow better than, the PC1xDB variety in saline environment.

3. **<u>Calcium</u>**

Calcium is important to the plant for its growth. Organic acid metabolism is intimately cor-related with Ca^{2+} metabolism. Iijin (1938) has observed that when plants grow in Ca^{2+} rich soil, there is a cor-relation between Ca^{2+} content and organic acids of plants. Ekdahi (1957) observed that in the absence of Ca^{2+}, roots do not elongate. Tadeno <u>et al.</u>, (1969) have studied effects of Ca^{2+} salts on K^+ uptake by excised barley roots. Cl^- as well as K^+ uptake was increased when Ca^{2+} and Cl^- conc in culture solutions were increased. Recently the role of Ca^{2+} and Calmodulin in regulating protein phosphorylation in plants has been demonstrated (Hetherington and Trewavas, 1982; Poyla and Davies, 1982; Ranjeva <u>et al.</u>, 1983; Salimath and Marme 1983; Veluthambi and Poviah 1984).

In our present investigation we have observed the results as shown in Table 10 - Fig 27 in <u>Capsicum annuum</u> hybrid varieties PC1xDB and LxDB.

In the leaves of PC1xDB the calcium content is less than control at all the levels of salinity except at 0.15 M NaCl salinity level where it increases slightly.

In LxDB, there is increase in Ca^{2+} content in leaves at all the levels of salinity. The highest value recorded was 4.8 gm/100gm dry matter at 0.15 M salinity level.

In the stem, in PC1xDB there is decrease in Ca^{2+} content as the level of salinity increased, whereas in LxDB there is increase in Ca^{2+} content at all the levels of salinity.

In the roots there is increase in Ca^{2+} content at lower levels of salinity but there is decrease at the higher conc. But in LxDB variety there is a gradual decrease at all the levels of salinity.

Similar results are observed by Bhandari in (1988) in <u>Capsicum annuum</u> cultivars. Pant C1 and NP46A.

There are reports about increasing salinity supresses Ca^{2+} uptake (Strogonov 1964, Osmond 1967, Laszlo and Kuiper 1979, Paliwal and Maliwal 1980, Divate and Pandey 1981; Kawasaki <u>et al</u>, 1983, Imam ul Huq and Larher, 1984).

Most of the workers have noticed Ca^{2+} uptake due to salinity Meiri <u>et al</u>,(1971) in bean plants have observed a redn in calcium uptake due to NaCl and Na_2SO_4 salinization. Chavan (1980) in ragi found a decrease in calcium content in the plant parts. Adams, Rachel holder (1992) have studied the effect of humidity, calcium and salinity on the accumulation of dry matter and calcium by the leaves and fruits of tomato (<u>Lycopersicon</u>

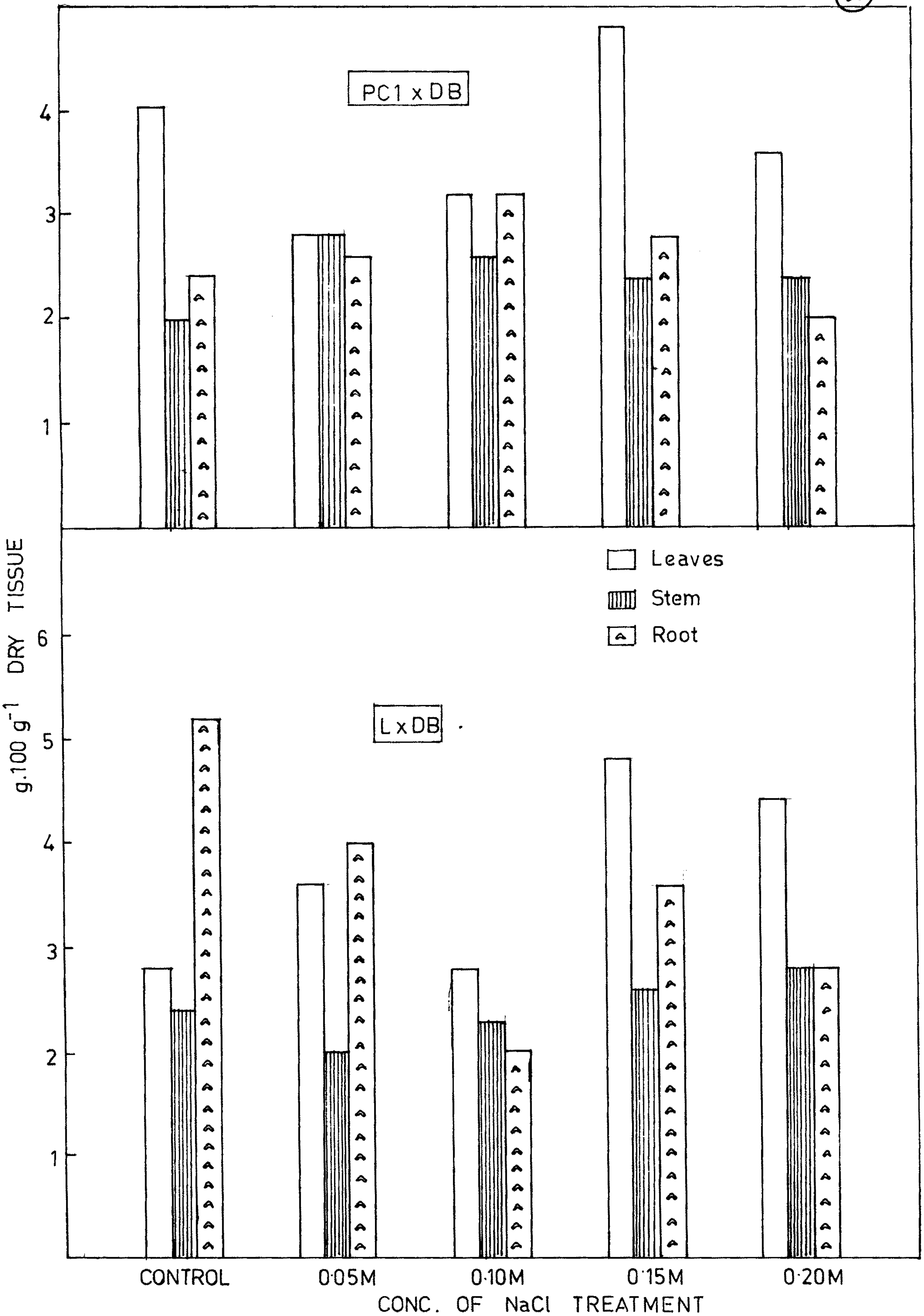

Fig No. 27 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON CALCIUM CONTENT OF Capsicum annuum HYBRID VARIETIES *esculentum*) and observed that accumulation of Ca^{2+} by the fruits was markedly reduced by high salinity.

From the present investigation it is evident that there is increase in Ca^{2+} accumulation in LxDB than in PC1xDB variety.

In PC1xDB variety there is increase in Ca^{2+} at lower levels of salinity in the roots, stem and leaves. While in LxDB there is increase in Ca^{2+} in leaves and stem at all the levels of salinity. However the roots showed a decrease in Ca^{2+} content in LxDB variety which may be due to the rapid translocation of Ca^{2+} through stem to leaves.

All these results indicate that there is efficient Ca^{+} uptake in LxDB variety where as in PC1xDB variety ~~where as~~ in ~~PC1xDB variety~~ there is more Ca^{+} uptake at lower levels only.

4. **Magnesium**

Magnesium is an important element because it is a constituent of Chlorophyll. It is a major constitutent of all green plants. it is a part of chlorophyll a and b molecules and hence present in all autotrophic plants. It is required in large number of physiological reactions where ATP is involved. Mazelis and stumpf (1955) have found that Mg^{2+} is involved along with adenine nucleotide and a krebs cycle intermiediate, in the esterification of P^{5+} into ATP. Arnon (1958) has shown that Mg^{2+} plays an important role in photosynthetic phosphorylation. Lorimer et al; (1976), Atkinson et al., (1969) have speculated that this element maintains the salt balance in the leaves of Aegitalitis, a mangroove species. Bernstein (1975) has postulated that the tolerance of a species for particular salt reflects the ability of the species to absorb nutritionally adequate levels of Ca^{2+} and Mg^{2+} from the soil. In this respect the report of konigshofer (1983), that non-halophytic species of plantago tended to exclude sodium from leaf tissue by enhancing Mg^{2+} uptake for charge balance under saline conditions appears quite interesting.

Form the present Investigation it is clear that Mg^{2+} content increases under lower levels of salinity and decreases at higher levels of salinity in the leaves of PC1xDB hybrid variety which is shown in Fig 28. Table 10 –

Where as in leaves of LxDB there is linear increase and decrease at higher and lower levels of salinity. The highest value recorded in both the varieties is 3.41 gm/100 gm dry matter at 0.1 M salinity level in LxDB variety.

In the stem and roots of both the varieties of *Capsicum annuum* var. PC1xDB and LxDB, there was increase in Mg^{2+} content as the level of salinity increase. The values of Mg^{2+} are higher than control at all the levels of salinity in roots stem and leaves in both the hybrid, varieties, except at 0.15M salinity level in both hybrids. Many workers have reported the higher accumulation of Mg^{2+} by plants in saline condition. The increase of Mg^{2+} due to salinity have been reported by Hassan et al., (1970) in barley and corn; syed and Swaify (1973) in sugarcane, Aslam, (1975) in safflower and Siegel et al., (1980) in corn reported an increase in Mg^{2+} content under saline conditions. Recently Bhandari (1988) has also reported increase in the Mg^{2+} content in *Capsicum annuum* cv. pant C1

The suppression or decrease in Mg^{2+} content due to Nacl salinity has been recorded by matar et al., (1975); Paliwal and Maliwal

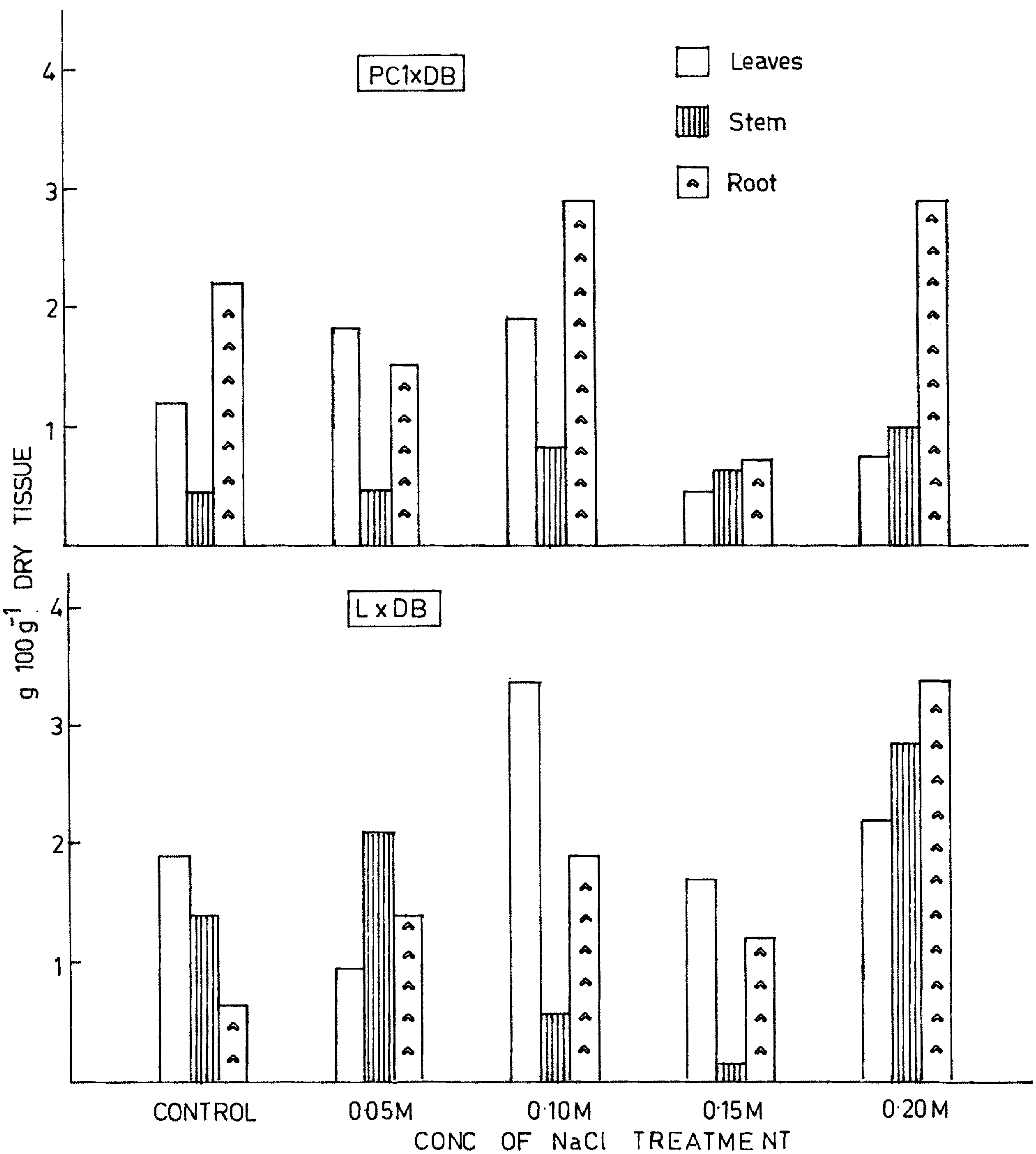

Fig No 28 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON MAGNESIUM CONTENT OF *Capsicum annuum* HYBRID VARIETIES

(1980); El-Hadim et al.,(1982) Bigot et al.,(1983) Heikal (1977) and Patil and Bhambota (1980) Lal and Bharadwaj (1984) have noticed a decrease in Mg^{2+} in bean and pea plant subjected to salt stress. Nimbalkar and Joshi (1975) reported that lower concentrations of NaCl reduced the Mg^{2+} content of sugarcane leaves while higher conc. cause an increase. Chavan (1980) reported that Mg^{2+} uptake was considerably increased in NaCl treated plants.

From the above observations in 2 hybrid varieties of *Capsicum annuum* PC1xDB and LxDB it can be clearly stated that these plants have a effecient mechanism of Mg^{2+} uptake under saline conditions. In the 2 hybrids of *Capsicum annuum* L x DB seems to be more efficient in Mg^{2+} uptake as the highest value is recorded in its leaves.

5. Chlorides

Plant need chlorides in very less quantities for their growth. But higher concentrations prove to be toxic to the plant growth and development (Boyer et al., 1954 In (1938) Lipman has shown that chlorides are beneficial ion for plants, Yamasaki (1964) has shown that rice needs Cl^- ion for its normal growth in quantity less than 0.5%. If it increases above 0.8% it is toxic to rice.

* Effect of various levels of salinity on chlorides content in *Capsicum annuum* hybrid varieties PC1xDB and L x DB is shown in Table 10 . Fig. 29 .

In our present investigation chloride uptake by the leaves is more in both the hybrid varieties PC1xDB and L x DB over stem and roots. It is clear from table and figure that in the leaves, stem and roots chloride content is more than control at all the levels of salinity. Increase in salinity increases the chloride content. It is further evident from table that in leaves chloride content increases from 5.25 'g' to 7.1 'g' where as in stem and roots it ranges from 1.28 'g' to 2.03 g / 100 g dry plant material.

There are results about increase in chlorides by Bhandari (1988) in Capsicum annumm cultiver Pant C1 where she observed that there is increase in chloride content in leaves, stem and roots with increasing salinity level.

According to Meiri and Poljakolf - Mayber (1969) the accumulation of chloride in leaves is related to the rate of salinization. They observed that rapid rather than slow salinization of the medium enhanced the chloride accumulation in bean leaves.

Harris *et al.*, (1924, 1925) have noted different lines of cotton, showed considerable specificity in their selective accumulation of chlorides vs S04 and according to them this specificity is directly inheritable pertaining the effect of salinity on bean crop.

Gauch and Wadleigh (1943, 1945) observed higher accumulation of chlorides in leaves, than stem and roots of salinized plants. Greenway *et al.*,(1966) observed accumulation of chlorides in bean plants in a ascending order from root (minimum) stems and leaves (maximum) due to salinity. Neiman and Poulsen (1967) also noted increased Cl^- accumulation in leaf blade followed by stem and petiole due to NaCl salinization. They observed that rapid rather than slow salinization of the medium enhanced the chloride accumulation in bean leaves. Lessani and Marschner (1978) observed that chloride content was more than Na^+ in salt treated maize cv. veloy, cress, sunflower, pepper, bean cv. saxa.

Aly, Atta, El beltagy and Jones (1988)89 studied the salt tolerance in Lycopersicon esculentum III and post harvest quality of lycopersicon Esculentum has been conducted on a salt sensitive and a salt tolerant cultivar grown oven a range of salinity treatment and observed a increased chloride content in fruits from saline treated plants.

Sharma (1989) investigated the effect of salinity ongrowth, ionic and water relations of 3 wheat Spps differing in salt tolerance were evaluated for salt tolerance and Physiological responses in sand culture under natural conditions. Higher salt tolerance of Kharchia 65 was indicated by its lower slope, lower conc of Na^+ and Cl^- higher potassium selectivity and better maintainance of tissue hydration. Salt sensitivity of HD 4502 was due to higher Na^+ and Cl^- lower K^+ and lower degree of tissue hydration while that of HD 2160 x Kharchia was due to higher Cl^- concentration.

Liu K-B and S- x Li (1991) studied the effect of sodium chloride on element balance peroxidase isoenzyme and protein banding patterns of lycopersicon leaf cultures and regenerated shoots and observed that addition of NaCl to the medium affected the balance of sodium, chloride, potassium and calcium significantly in regenerated shoots of two species of lycopersicon.

From present investigation we can say that there is more accumulation of chlorides in the leaves rather than roots and stem. The chlorides are more than the control at all the levels of salinity. This indicates that chlorides which are absorbed by the roots are translocated to the leaves rapidly through stem where they accumulate maximum and there is no mechanism which

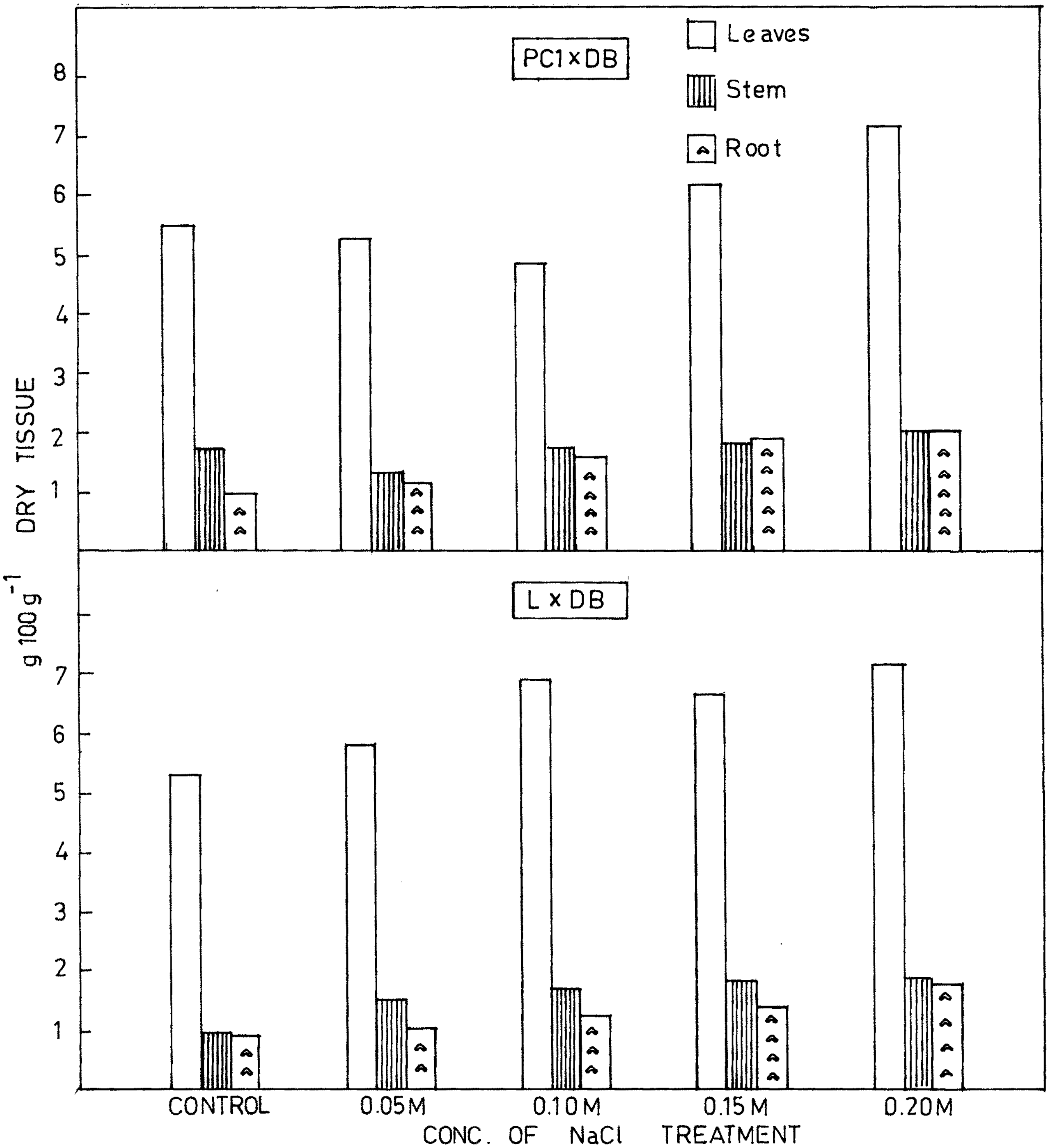

Fig No. 29 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON CHLORIDE CONTENT OF *Capsicum annuum* HYBRID VARIETIES stores toxic salts in roots in both the hybrid varieties.

The above observation indicates that chlorides are responsible for the inhibition of plant growth, as they are accumulated in higher contents in the leaves of the 2 hybrid varieties of *Capsicum annuum* PC1xDB and L x DB.

6. Phosphorus

P^{5+} is a constituent of many compounds in plants. Its involvement in metabolism is covered in detail by Mc Elory and Glass (1951, 1952). It is a constituent of phospholipids and one of these, Lecithin is believed to be present in cell membranes and to be of universal occurance in all living cells. It is also a constituent of the unique, high energy compounds ADP and ATP. High energy phosphate bond provide energy for synthesis of compounds such as Sucrose, Starch and proteins.

Phosphorus has long been known to be involved in Photosynthesis in connection with phosphorylation of various intermediates in CO_2 assimilation. P is involved in the conversion of light into physiologically useful chemical energy by the formation of NADPH and ATP. Effect of various level of NaCl salinity is shown in Table 10 and Fig 30 in *Capsicum annuum* hybrid varieties PC1xDB and LxDB.

In our present investigation we have observed that in leaves there is a increase in phosphorus at lower levels of salinity in PC1xDB variety but there is a decrease at higher levels. While in L x DB variety there is increasein phosphorus at all levels of salinity.

But the roots and stem showed a decrease in phorphorus content at all the levels of salinity as compared to the control in PC1xDB and L x DB hybrid varieties.

There are results about decrease in phosphorus by Bhandari (1988) in *Capsicum annuum* cultivers Pant C1 and NP46A. She observed a linear decrease, increase of phosphorus in leaves where as roots and stem showed a total decrease as the level of salinity increased.

There are many reports about increase in phosphorus at different saline conditions. According to Maas and Nieman (1978) salinity damages mechanisms controlling intracellur Pi concentrations. As much as 100% increase in P^{5+} content of salt stressed *Glycine Javanica* leaves was evident in the experiment of Gates *et al.*, (1966).

An increase in P^{5+} content under saline conditions is recorded by several workers like Ansari (1972); Karadge and Chavan (1980) in peanut Lal and Bharadwaj (1980) and Nukaya *et al.*, (1982).

Contrary to above observations there are several reports where reduced P^{5+} uptake due to salt stress has been observed Udovenko *et al.*, (1976) Paliwal and Maliwal (1972); Zhukhovskaya (1973); Singh *et al.*,(1974), Nanawati and Maliwal (1973) Kleinkopf *et al.*, (1975); Dahiya and Singh (1976); Tindal *et al.*,1979; Starch and Kozinska 1980; Karadge *et al.*, (1983).

Effect of various concentrationsof NaCl on phosphorus is depicted in the table 10 Figure 30.

From our present observation it is clear that in leaves phosphorus is inhibited at higher levels of salinity in PC1xDB hybrid variety while there is increase in phosphorus at all the levels of salinity in L x DB hybrid variety. These results indicate that the leaves of L x DB hybrid varieties have a better accumulation capacity than the PC1xDB hybrid variety.

In the roots and stem of both the varieties there is decrease in

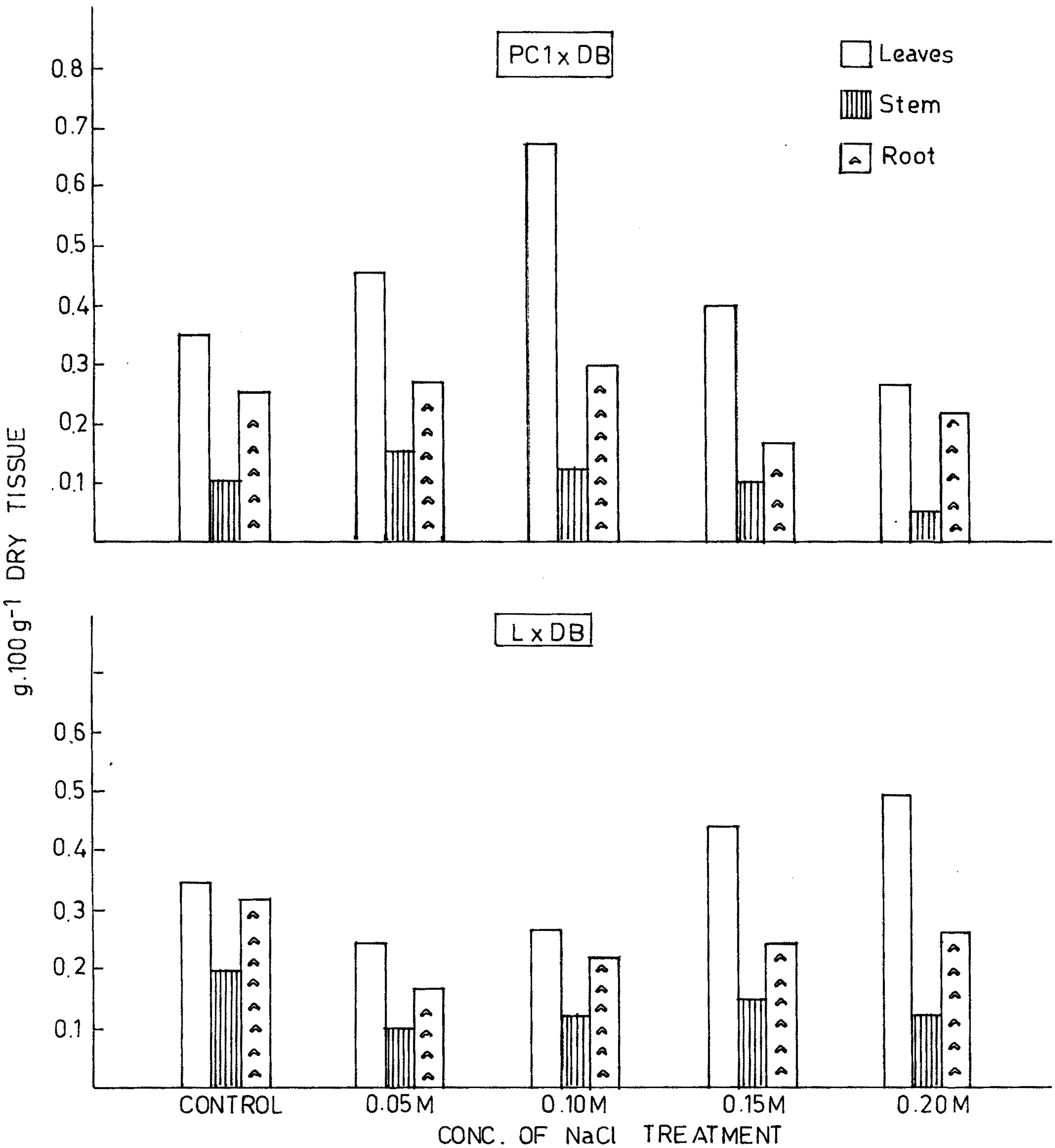

Fig No 30 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON PHOSPHORUS CONTENT OF *Capsicum annuum* HYBRID VARIETIES PC1 x DB AND L x DB phosphorus at all the levels of salinity as compared to the control which suggests that Phosphorus is affected greatly due to salinity in stem and roots.

As leaves are important and due to the increase in phosphorus in L x DB leaves in saline conditions it may help the plant for growth and development. So it can be said that L x DB hybrid variety is more tolerant to salt than PC1xDB hybrid variety.

7. <u>Iron</u>

Fe^{3+} is present in traces in plants. It participates in many metabolic activities. Iron is a very essential micronutrient Bogorad (1966) showed that iron is essential for chlorophyll synthesis. As its major portion is present in chloroplast (1968).

Though Fe^{3+} is considered as a microelement, Fe^{3+} is very essential for enzyme systems where it performs haem or haemin function as prosthetic groups. (Losada *et al*, 1983) There are reports of both iron chlorosis as well as toxicity in crop plants raised under different field conditions. Generally a larger proportion of Fe^{3+} is in a soluble state in acidic soils also some Fe^{3+} may be absorbed by plants as a result of ultimate contact between the root surface and the soil particle. Effect of NaCl on Iron content is shown in Table 10 -Fig 31

In our present investigation the effect of NaCl on Iron is different in the 2 hybrid varieties PC1xDB and L x DB. In PC1xDB hybrid variety in leaves there is a gradual decrease of Iron at all the levels of salinity except at 0.05 M salinity level where it is more than control where as in L x DB hybrid variety at all the levels of salinity there is a decrease in Iron except at 0.15 M salinity level where it showed a slight increase. Even though the Iron content is less than control at all the levels of salinity in both the hybrid varieties in leaves.

As compared in stem the iron content is less than control in both the hybrid varieties at all the level of salinity.

In roots, however stimulation of Fe^{3+} takes place. In PC1xDB variety Iron content is less than control at lower levels of salinity whereas at higher levels Iron content increased (at 0.2 M NaCl level) while in L x DB hybrid variety iron content is increased at 0.05 M salinity level. Further it decreased at all the levels of salinity.

Bhandari (1988) observed in cv Pant C1 and cv NP46A of Capsicum annuum that the Fe^{3+} in leaves decreased linearly over control with increase in levels of chloride salinity. In stem there is increase in Fe^{3+} over control as salinity increases. In roots however there is decrease in Fe^{3+} at all levels of salinity.

There are attempts made to study the effect of salinity on iron nutrition. Based on experiment on barley, wheat and Asparagus, Shimose (1972) has concluded that the pattern of iron uptake differs from species to species under salt rich environment.

There are also results about increase in roots and tops of tomato, squash and soyabean with increasing salinity. Similarly increase in iron content has been reported in some crops like Pea (Dahiya and Singh 1976), bean (Pandey and Kannan 1979 D'Arrigo et al. 1983) and Peanut (Karadge and Chavan 1980).

There are some workers who investigated that under saline condition iron decreases as the level of salinity increases. Sarin (1961); Strogonov (1964); Rahman et al., (1972); Shimose (1972). Medium levels of salinity resulted in highest content of Fe^{3+} while higher levels of salinity decreased Fe^{3+} content of

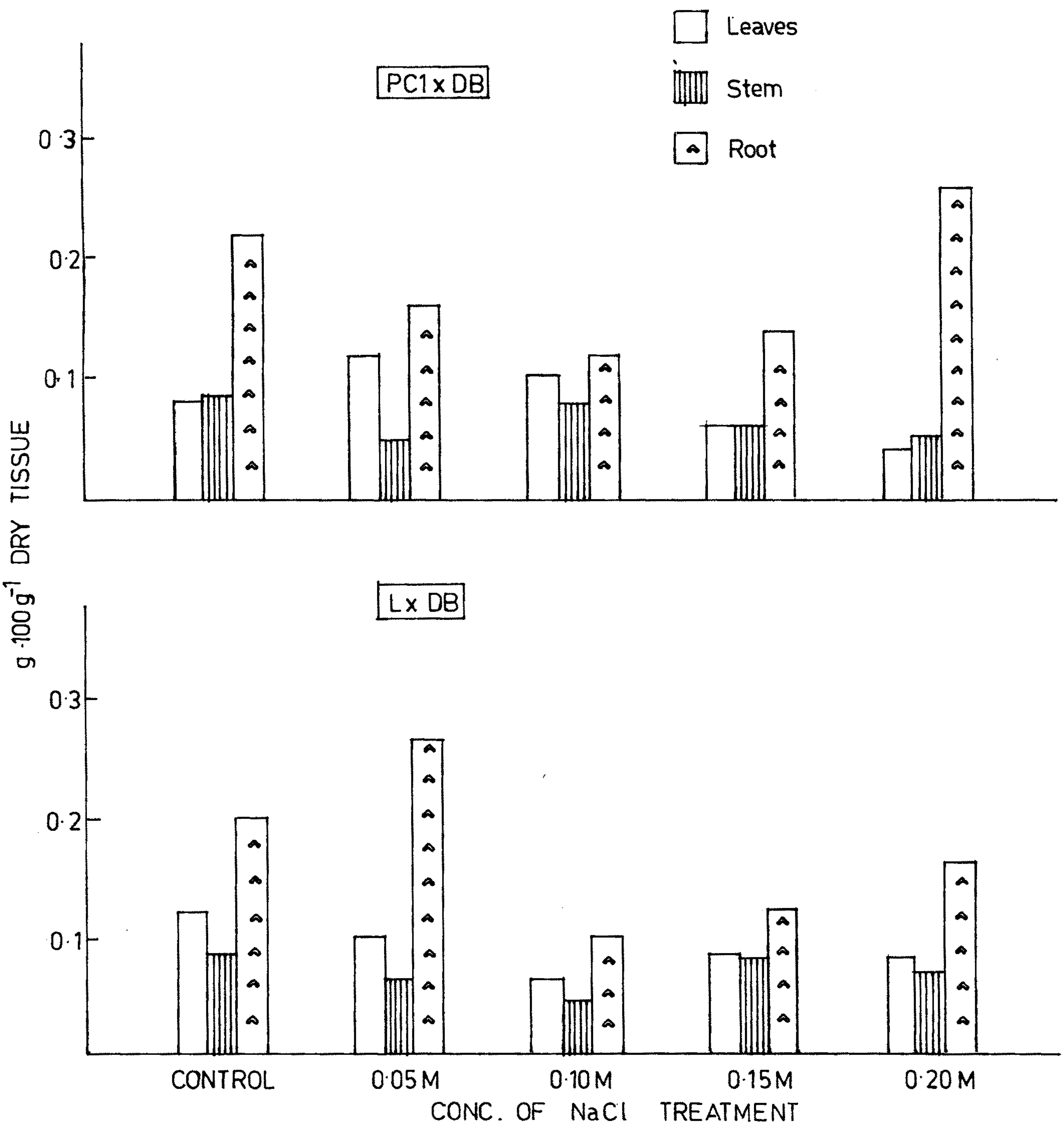

Fig No. 31 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON IRON CONTENT OF Capsicum annuum HYBRID VARIETIES PC1 x DB AND L x DB

Table : 10 Effect of various concentrations of NaCl salinity on Mineral composition of *Capsicum annuum* hybrid variety - PC1xDB

Mineral Element	NaCl treatment (M) — Leaf				
	C	0.05M	0.1 M	0.15M	0.2 M
Na^{+}	0.06	0.056	0.068	0.128	0.1
Cl^{-}	5.57	5.25	4.82	6.22	7.1
K^{+}	1.6	3.6	4.4	3.0	1.2
Ca^{2+}	4.0	2.8	3.2	4.8	3.6
Mg^{2+}	1.21	1.82	1.9	0.48	0.73
P^{5+}	0.35	0.45	0.67	0.4	0.27
Fe^{3+}	0.08	0.12	0.1	0.06	0.04
Mn^{2+}	0.0066	0.0064	0.0056	0.0044	0.0028
Cu^{2+}	0.0124	0.0164	0.0138	0.0136	0.011
Zn^{2+}	0.0146	0.0164	0.0167	0.0134	0.0106

Values are expressed as g 100^{-1} g dry matter

Table : 10 Effect of various concentrations of NaCl salinity on Mineral composition of *Capsicum annuum* hybrid variety - PC1xDB

Mineral Element	NaCl treatment (M) — Stem				
	C	0.05M	0.1 M	0.15M	0.2 M
Na^{+}	0.05	0.118	0.076	0.12	0.06
Cl^{-}	1.28	1.6	1.82	2.03	
K^{+}	0.132	0.088	0.054	0.06	0.176
Ca^{2+}	2.8	2.6	2.48	2.4	2.4
Mg^{2+}	0.48	0.85	0.68	0.97	2.19
P^{5+}	0.15	0.125	0.10	0.05	0.25
Fe^{3+}	0.052	0.08	0.06	0.056	0.22
Mn^{2+}	0.002	0.004	0.0016	0.0014	0.0012
Cu^{2+}	0.0102	0.0104	0.021	0.0158	0.012
Zn^{2+}	0.0076	0.008	0.0126	0.0098	0.0082

Values are expressed as g 100^{-1} g dry matter

Table : 10 Effect of various concentrations of NaCl salinity on Mineral composition of *Capsicum annuum* hybrid variety - PC1xDB

Mineral Element	NaCl treatment (M)				
	Root				
	C	0.05M	0.1 M	0.15M	0.2 M
Na^{+}	0.06	0.082	0.086	0.096	0.112
Cl^{-}	1.0	1.1	1.6	1.9	2.0
K^{+}	0.176	0.174	0.12	0.064	0.076
Ca^{2+}	2.4	2.6	3.2	2.8	2
Mg^{2+}	2.19	1.58	2.92	0.73	2.92
P^{5+}	0.25	0.27	0.3	0.17	0.22
Fe^{3+}	0.22	0.16	0.12	0.14	0.26
Mn^{2+}	0.0086	0.0096	0.0076	0.006	0.0046
Cu^{2+}	0.016	0.0166	0.0172	0.0168	0.0118
Zn^{2+}	0.014	0.013	0.0116	0.011	0.009

Values are expressed as g 100^{-1} g dry matter

Table : 10 Effect of various concentrations of NaCl salinity on Mineral composition of <u>Capsicum annuum</u> hybrid variety – L x DB

Mineral Element	NaCl treatment (M) — Leaf				
	C	0.05M	0.1 M	0.15M	0.2 M
Na^{+}	0.048	0.046	0.064	0.082	0.118
Cl^{-}	5.36	5.89	6.97	6.75	7.29
K^{+}	3.6	3.4	2.2	3.8	4.0
Ca^{2+}	2.8	3.6	2.8	4.8	4.4
Mg^{2+}	1.94	0.97	3.41	1.70	2.19
P^{5+}	0.35	0.25	0.275	0.45	0.5
Fe^{3+}	0.12	0.1	0.06	0.088	0.08
Mn^{2+}	0.0054	0.0044	0.0054	0.0062	0.0084
Cu^{2+}	0.0134	0.0154	0.0148	0.0152	0.0162
Zn^{2+}	0.0136	0.0134	0.0024	0.0014	0.001

Values are expressed as g 100^{-1} g dry matter

Table : 10 Effect of various concentrations of NaCl salinity on Mineral composition of <u>Capsicum annuum</u> hybrid variety – L x DB

Mineral Element	NaCl treatment (M) — Stem				
	C	0.05M	0.1 M	0.15M	0.2 M
Na^{+}	0.038	0.048	0.092	0.066	0.114
Cl^{-}	0.858	1.5	1.71	1.82	1.93
K^{+}	0.116	0.112	0.126	0.106	0.088
Ca^{2+}	2.40	2.0	2.36	2.60	2.8
Mg^{2+}	1.46	2.19	0.51	0.12	2.68
P^{5+}	0.2	0.1	0.12	0.15	0.125
Fe^{3+}	0.08	0.064	0.04	0.08	0.076
Mn^{2+}	0.0014	0.0016	0.002	0.0022	0.0024
Cu^{2+}	0.017	0.0186	0.0164	0.0152	0.0118
Zn^{2+}	0.01	0.011	0.0106	0.0104	0.0088

Values are expressed as g 100^{-1} g dry matter

Table : 10 Effect of various concentrations of NaCl salinity on Mineral composition of *Capsicum annuum* hybrid variety - L x DB

Mineral Element	NaCl treatment (M)				
	Root				
	C	0.05M	0.1 M	0.15M	0.2 M
Na^{+}	0.012	0.090	0.086	0.114	0.134
Cl^{-}	0.9	1.0	1.2	1.4	1.8
K^{+}	0.178	0.132	0.14	0.16	0.13
Ca^{2+}	5.21	4.0	2.0	3.6	2.8
Mg^{2+}	0.73	1.46	1.94	1.21	3.41
P^{5+}	0.32	0.17	0.22	0.25	0.27
Fe^{3+}	0.2	0.26	0.12	0.14	0.16
Mn^{2+}	0.008	0.0116	0.0084	0.008	0.009
Cu^{2+}	0.0152	0.01	0.0128	0.014	0.013
Zn^{2+}	0.012	0.008	0.0108	0.0124	0.0128

Values are expressed as g 100^{-1} g dry matter

different parts(leaves, stem and root) of this plant.

1. Na^+ (Sodium)

Na^+ is present in large amounts on this earth. It is useful for the plants in very less quantities, but its abundance causes the inhibition of plant growth. Kratz and Mayers (1955) have shown that both Na^+ and K^+ are required for better growth in many members of cyanophyceae. The work of Joham (1955 and 1957) and Whittenberg and Joham (1964) showed tht sodium can partially substitute ca^{2+} in maintaining carbohydrate translocation (Greenway (1962) has found tht Hordeum vulgaris leaves attained high dry wt during NaCl treatment that after sodium chloride removal).

In our present investigation we have observed the following results as shown in the Table no 10 Fig no 24

It is clear in our present investigation that Na^+ content in both the hybrid varieties of Capsicum annuum. L. PC1xDB and LxDB increases as the salinity level increases in leaves, stem and roots.

In leaves there is a increase in Na^+ content at all the levels of salinity except at 0.05M salinity level where it slightly decreases in both the varieties PC1xDB and LxDB.

In the stem there is increase in Na^+ content at all the levels of salinity.

The roots showed a increase in Na^+ content at all the levels of salinity. As the salinity level increases the Na^+ content also increases in both the varieties.

Increased accumulation of sodium has been reported by many workers (Ansari et al., 1978; Downton; 1978, Laszlo and Kuiper, 1979; Chavan and Karadge 1980)

With increasing chloride salinity, Na^+ uptake as well as dry matter productivity increased in *Lippia nudiflora* (Karadge *et al.*, 1983) These results indicate that with internal high Na^+, barley variety Vijay and *Lippia nudiflora* maintained their normal growth.

There are many reports about increase of Na^+ content under saline conditions (Strogonov (1972) in pea plants, Meiri *et al.*,(1971) in bean plants, Ayoub (1975) in Phaseolus bean, Akerson and Youngner (1975) in bean, Lessani and Marschner (1978) in various crops, D'Arrigo *et al.*, (1983) in bean, West and Taylor; (1980) in *Phaseolus vulgaris*, Rathert *et al.*,(1983) in bush bean and sugarcane, Abdel Rahaman (1987) in cowpea. Bhandari (1988) also observed an increase in Na^+ contents in two *Capsicum annuum* cultivars. Pant C1 and NP46A.

According to Hasson - Porath *et al.*, (1972) Sodium was restricted only to the roots and it was hardly transported to shoot in pea seedlings. Similar results have been observed by Marschner and Mix (1973) in beans. An increase in Na^+ content is also observed by Pakroo and Kashirad (1981) in sunflower from 0 to 1.5 ppm of NaCl. Yadav and Sharma (1980) observed an increased Na^+ content has decreased plant height, number of pods and seed yield per plant etc. in field experiment on gram. Kawasaki *et al.*, (1983) investigated the plant growth under both NaCl and PEG induced stress condition. These workers observed that in all 3 crops studied viz. beans, maize and sorghum. Sodium accumulated to a greater extent in shoot region than in root region with increasing salinity stress. Aly *et al.*, (1989) studied salt tolerance of *Lycopersicon esculentum* III and observed a increase in Na^+ content due to salinity. Roth, Hannelore (1989) studied the influence of sodium chloride or sodium sulphate on growth and

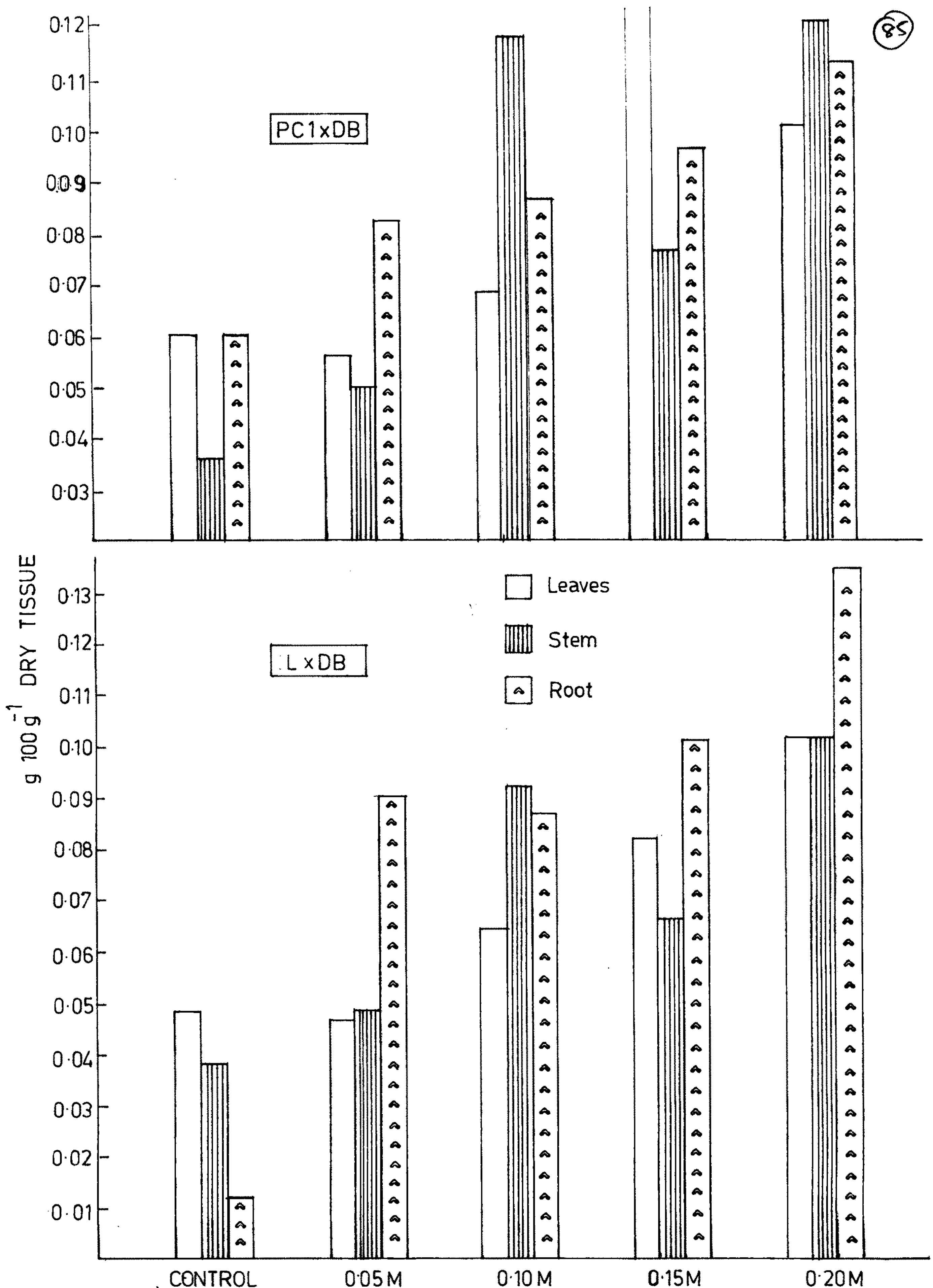

Fig.No. 24 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON SODIUM CONTENT OF *Capsicum annuum* HYBRID VARIETIES dry matter production of Triticum aestivum L, Hordeum vulgare l and oryza sativa l. and observed decreased potassium content and markedly increased the sodium content in the seedlings although the potassium-sodium ratio was better under salinity conditions, Salim et al., (1990) studied effect of salinity stress and varietal resistance in rice and observed Na^+ content increased. Hashim et al., investigated salt tolerance in Lycopersicon esculentum II and and observed decrease in Na^+ in roots but increase in Na^+ in leaves. Increase in Na^+ content under saline conditions was observed by Rajmane (1984) in Psophocarpus tetragonolobus in leaves, stem and roots.

There are also some results which suggest that less accumulation of Na^+ may help the plant to tolerate the salinity. In Atriplex hortensis an increase in growth, dry matter production and leaf size was due to low accumulation of Na^+. There are species which are able to tolerate low salinity levels by excluding Na^+ from leaves. It occurs in beans and corn (Jacoby and Ratner, 1974).

From the present investigation it is evident that under NaCl salinity, sodium uptake increases and its content is more in the leaves than in roots and stem in both the hybrid varieties of Capsicum annuum. PC1xDB and LxDB, which indicates that the roots transfer the Na^+ from stem to leaves rapidly.

Na^+ is toxic for plant growth and both the varieties accumulate higher Na^+ content. These results indicate that the plants show a sensitive nature towards salinity.

2. Potassium

K^+ has been regarded as one of the major solutes in plants and always plays a important role in the maintainance of cell turgor (Cram, 1972).

K^+ is a very essential element for respiratory metabolism in plants. The universal occurence of K^+ in growth and metabolism makes it difficult to trace a specific and casual relationship between K^+ nutrition and the response mechanism. It is very useful element in respiration and Photo-synthetic processes. K^+ is a monovalent cation. It has some indispensable role in the plant life. Broyer and Stout (1959) have indicated that K^+ is linked with carbohydrate metabolism. It is distributed all over the plant under saline conditions. Sargassum illcifolium (Gowda, 1971) accumulates K^+ more than Na^+ even though it grows in Na^+ rich environment. This indicates an absolute requirement of K^+.

In our present investigation the effect of NaCl salinity observed is shown in Table 10 Fig no 25,26

The results observed are contradictory results in both the varieties of Capsicum annuum PC1xDB and LxDB. In PC1xDB in leaves there is a increase in K^+ content at lower levels of salinity and decrease at higher levels of salinity while in LxDB leaves there is decrease in K^+ content at lower levels of salinity but it increases as the level of salinity increases.

In stem of both the hybrid varieties there is decrease in K content at all the levels of salinity, except at 0.05 M in PC1xDB and 0.10 M in LxDB where it increases slightly.

In roots there is decrease in K^+ content as the salinity level increases in both the hybrid varieties, except at 0.15 M salinity level it decreases slightly in LxDB hybrid variety.

There are many reports about decrease in K^+ content due to salinity. Gauch and Wadleigh (1944) in bean, Sarin (1962) in Cicer arientum Nieman and Poulsen (1967) in bean, Hasson-Porath et al., (1972) in pea seedlings, Mata et al., (1975) in spinach and lettuce, Lessani and Marschner (1978), D Arrigo et al., (1979), El Hamid *et al.*, (1983), Imam ul Huq and Larher (1983) in *Phaseolus aureus*, and Kawathe (1986) in safflower.

Bhandari (1988) observed a decrease in K^+ content at all the levels of NaCl salinity in *Capsicum annuum* cultivars Pant C1 and NP46A. There are many reports about adverse effect of NaCl salinity on K^+ content. Hasson-Porath *et al.*, (1972), Nimbalkar and Joshi (1975) in sugarcane var.co.740, Lal and Bharadwaj (1984) in *Zea Mays*, Paliwal and Maliwal (1972 and 1975) in *Abelmoschus esculentus*, *Luffa cylindrica* and *Brassica oleraceae*, Iyengar *et al.*,(1974, 1978) in sugarcane, cotton, tomato, Chavan and Karadge (1980) in *Arachic hypogea*, Despande (1981) in *cajanus cajan*. According to these workers the very severe depressive effect of NaCl on K^+ absorption might be caused by the competative relation between monovalent cations in addition to lowering or osmotic potential due to high concentrations of NaCl. Decreased K^+ content level in cowpeas under salt stress has attributed to the accumulation of Na at the expense of K^+ thereby creating a condition of K^+ deficiency.

There are reports about accumulation of K^+ under saline conditions, Aphale in *Setaria italica* (1978) observed that the accumulation of K^+ is more than in *Oryza sativa*, *Zea mays* and *Saccharam officinarum*.

Accumulation of K^+ is also reported by Rajmane (1984) in *Psophocarpus tetragonolobus*. He observed that increase in salinity caused a very slight effect on the uptake of K. Similar results are also observed by Koshtee (1992) in *Curcuma longa* species (Personal communication). She observed increase in K^+ uptake in leaves, rhizome with increasing salinity level.

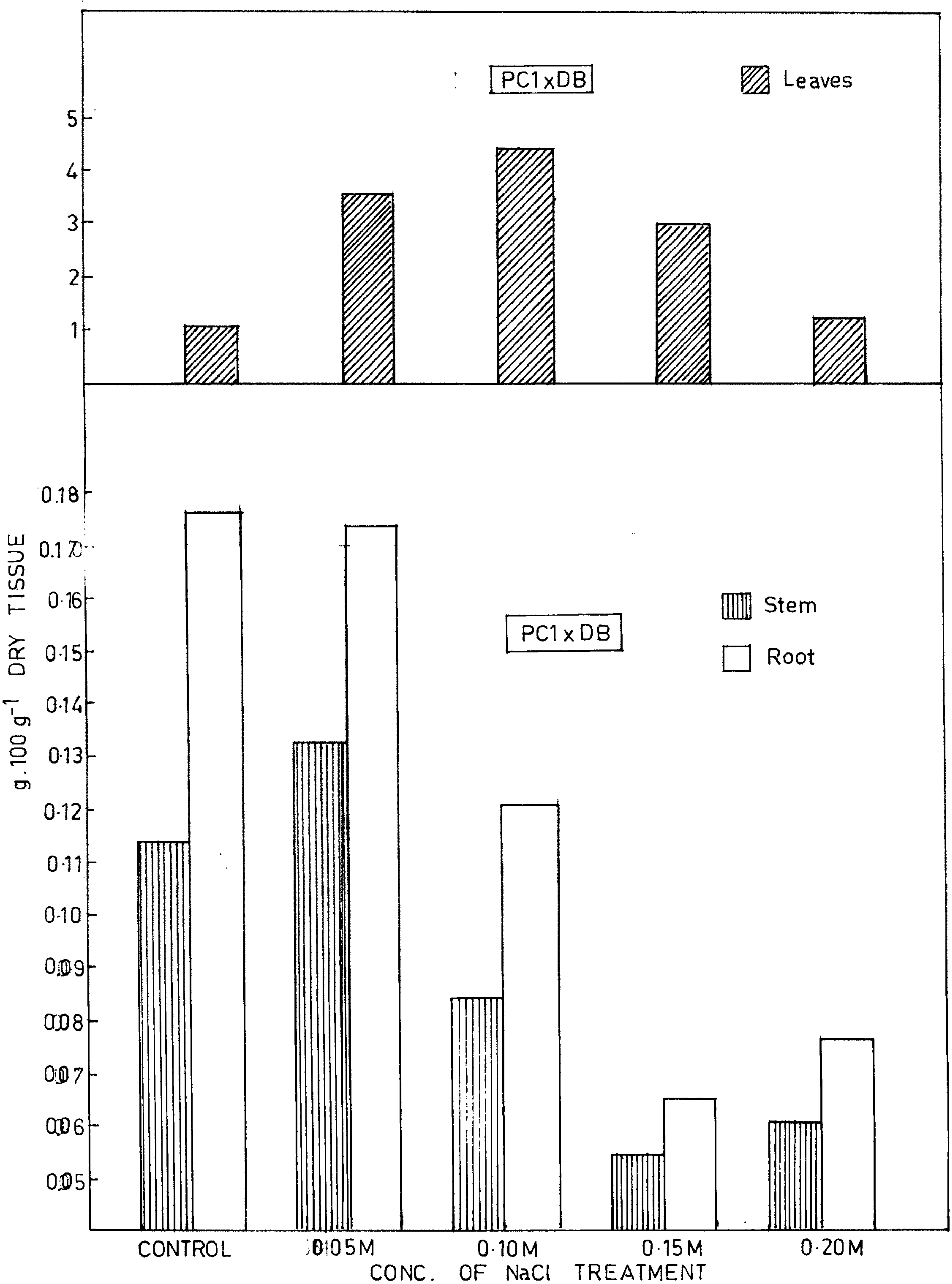

Fig No 25 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON POTASSIUM CONTENT OF Capsicum annuum HYBRID VARIETY

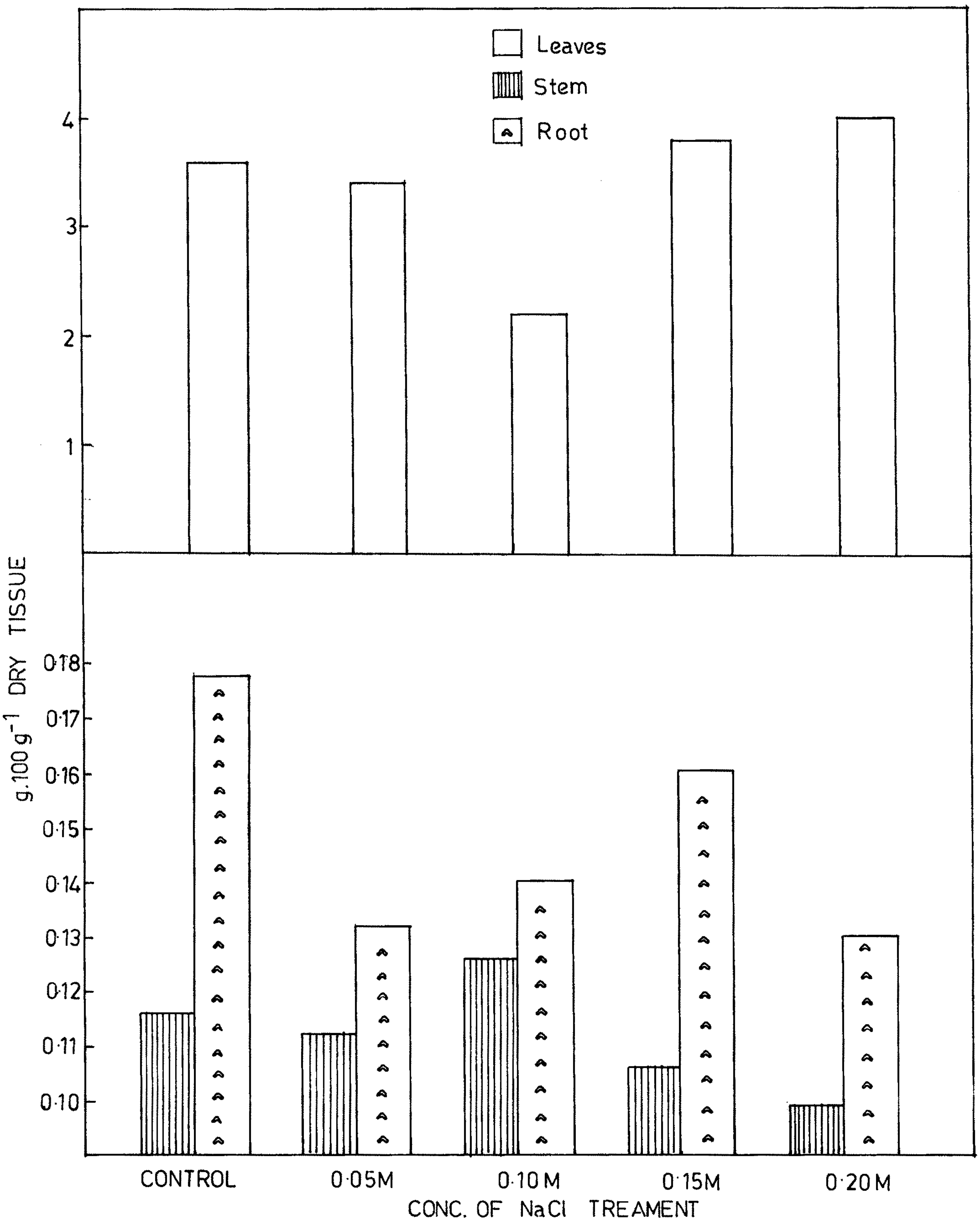

Fig No 26 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON POTASSIUM CONTENT OF *Capsicum annuum* HYBRID VARIETY LxDB

Controversial results are seen for K^+ absorption in different cases by different workers Rains and Epstein (1967) observd that lower concentration of chloride have little influence on K^+ uptake, while higher concentrations of chloride salts affect K^+ uptake.

From the present investigation it is clear that there is more accumulation of K^+ content in the leaves of the two hybrid varieties of <u>Capsicum annuum</u> PC1xDB and LxDB. There is decrease in K content in stem and roots in both the varieties, as the level of salinity increases which indicates that there is a rapid translocation of K^+ from the roots to the leaves where they accumulate maximum. It also indicates that there is efficient K^+ uptake mechanism under saline condition in LxDB hybrid variety than in PC1xDB hybrid variety. This may be the important factor for the LxDB hybrid variety which can grow better than, the PC1xDB variety in saline environment.

3. <u>Calcium</u>

Calcium is important to the plant for its growth. Organic acid metabolism is intimately cor-related with Ca^{2+} metabolism. Iijin (1938) has observed that when plants grow in Ca^{2+} rich soil, there is a cor-relation between Ca^{2+} content and organic acids of plants. Ekdahi (1957) observed that in the absence of Ca^{2+}, roots do not elongate. Tadeno <u>et al.</u> (1969) have studied effects of Ca^{2+} salts on K^+ uptake by excised barley roots. Cl^- as well as K^+ uptake was increased when Ca^{2+} and Cl^- conc in culture solutions were increased. Recently the role of Ca^{2+} and Calmodulin in regulating protein phosphorylation in plants has been demonstrated (Hetherington and Trewavas, 1982; Poyla and Davies, 1982; Ranjeva <u>et al.</u> 1983; Salimath and Marme 1983; Veluthambi and Poviah 1984).

In our present investigation we have observed the results as shown in Table 10 - Fig 27 in <u>Capsicum annuum</u> hybrid varieties PC1xDB and LxDB.

In the leaves of PC1xDB the calcium content is less than control at all the levels of salinity except at 0.15 M NaCl salinity level where it increases slightly.

In LxDB, there is increase in Ca^{2+} content in leaves at all the levels of salinity. The highest value recorded was 4.8 gm/100gm dry matter at 0.15 M salinity level.

In the stem, in PC1xDB there is decrease in Ca^{2+} content as the level of salinity increased, whereas in LxDB there is increase in Ca^{2+} content at all the levels of salinity.

In the roots there is increase in Ca^{2+} content at lower levels of salinity but there is decrease at the higher conc. But in LxDB variety there is a gradual decrease at all the levels of salinity.

Similar results are observed by Bhandari in (1988) in <u>Capsicum annuum</u> cultivars. Pant C1 and NP46A.

There are reports about increasing salinity supresses Ca^{2+} uptake (Strogonov 1964, Osmond 1967, Laszlo and Kuiper 1979, Paliwal and Maliwal 1980, Divate and Pandey 1981; Kawasaki <u>et al</u>, 1983, Imam ul Huq and Larher, 1984).

Most of the workers have noticed Ca^{2+} uptake due to salinity Meiri <u>et al</u>.,(1971) in bean plants have observed a redn in calcium uptake due to NaCl and Na_2SO_4 salinization. Chavan (1980) in ragi found a decrease in calcium content in the plant parts. Adams, Rachel holder (1992) have studied the effect of humidity, calcium and salinity on the accumulation of dry matter and calcium by the leaves and fruits of tomato (<u>Lycopersicon</u>

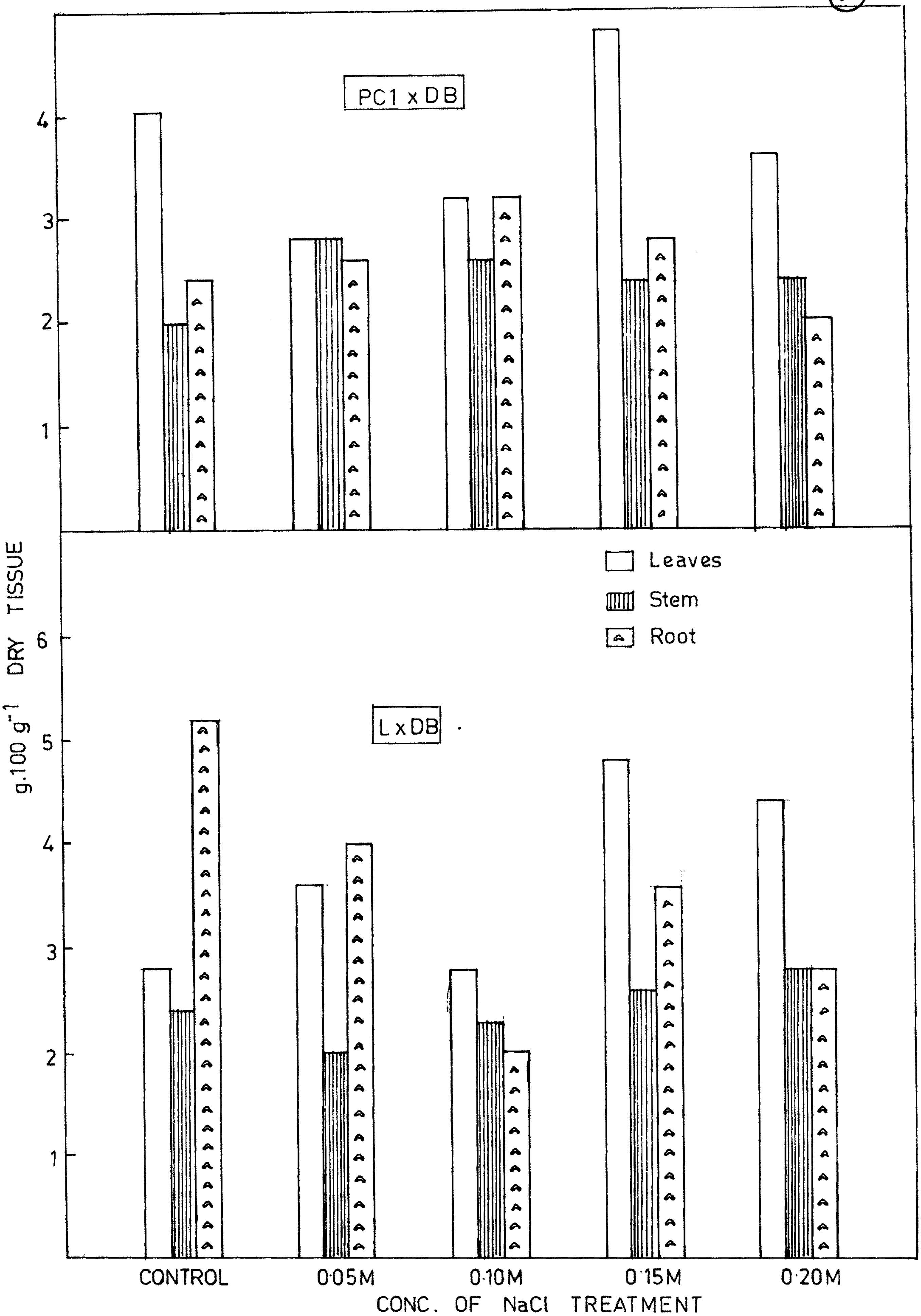

Fig No. 27 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON CALCIUM CONTENT OF *Capsicum annuum* HYBRID VARIETIES esculentum) and observed that accumulation of Ca^{2+} by the fruits was markedly reduced by high salinity.

From the present investigation it is evident that there is increase in Ca^{2+} accumulation in LxDB than in PC1xDB variety.

In PC1xDB variety there is increase in Ca^{2+} at lower levels of salinity in the roots, stem and leaves. While in LxDB there is increase in Ca^{2+} in leaves and stem at all the levels of salinity. However the roots showed a decrease in Ca^{2+} content in LxDB variety which may be due to the rapid translocation of Ca^{2+} through stem to leaves.

All these results indicate that there is efficient Ca^{+} uptake in LxDB variety where as in PC1xDB variety ~~where as~~ in ~~PC1xDB variety~~ there is more Ca^{+} uptake at lower levels only.

4. **Magnesium**

Magnesium is an important element because it is a constituent of Chlorophyll. It is a major constitutent of all green plants. it is a part of chlorophyll a and b molecules and hence present in all autotrophic plants. It is required in large number of physiological reactions where ATP is involved. Mazelis and stumpf (1955) have found that Mg^{2+} is involved along with adenine nucleotide and a krebs cycle intermiediate, in the esterification of P^{5+} into ATP. Arnon (1958) has shown that Mg^{2+} plays an important role in photosynthetic phosphorylation. Lorimer et al; (1976), Atkinson et al., (1969) have speculated that this element maintains the salt balance in the leaves of Aegitalitis, a mangroove species. Bernstein (1975) has postulated that the tolerance of a species for particular salt reflects the ability of the species to absorb nutritionally adequate levels of Ca^{2+} and Mg^{2+} from the soil. In this respect the report of konigshofer (1983), that non-halophytic species of plantago tended to exclude sodium from leaf tissue by enhancing Mg^{2+} uptake for charge balance under saline conditions appears quite interesting.

Form the present Investigation it is clear that Mg^{2+} content increases under lower levels of salinity and decreases at higher levels of salinity in the leaves of PC1xDB hybrid variety which is shown in Fig 28. Table 10 –

Where as in leaves of LxDB there is linear increase and decrease at higher and lower levels of salinity. The highest value recorded in both the varieties is 3.41 gm/100 gm dry matter at 0.1 M salinity level in LxDB variety.
In the stem and roots of both the varieties of Capsicum annuum var. PC1xDB and LxDB, there was increase in Mg^{2+} content as the level of salinity increase. The values of Mg^{2+} are higher than control at all the levels of salinity in roots stem and leaves in both the hybrid, varieties, except at 0.15M salinity level in both hybrids.
Many workers have reported the higher accumulation of Mg^{2+} by plants in saline condition. The increase of Mg^{2+} due to salinity have been reported by Hassan et al., (1970) in barley and corn; syed and Swaify (1973) in sugarcane, Aslam, (1975) in safflower and Siegel et al., (1980) in corn reported an increase in Mg^{2+} content under saline conditions. Recently Bhandari (1988) has also reported increase in the Mg^{2+} content in Capsicum annuum cv. pant C1

The suppression or decrease in Mg^{2+} content due to Nacl salinity has been recorded by matar et al., (1975); Paliwal and Maliwal

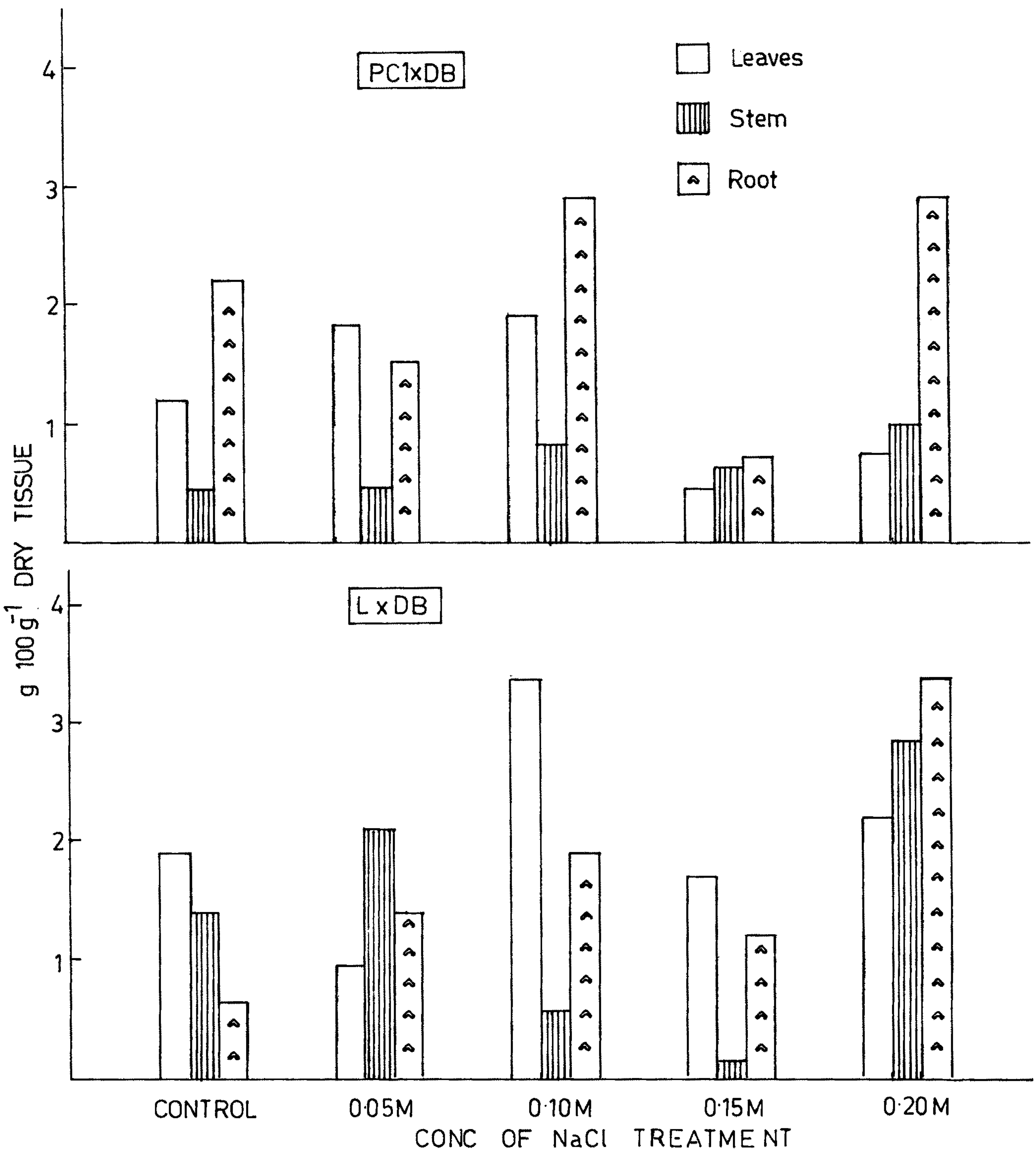

Fig No 28 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON MAGNESIUM CONTENT OF *Capsicum annuum* HYBRID VARIETIES

(1980); El-Hadim et al.,(1982) Bigot et al.,(1983) Heikal (1977) X and Patil and Bhambota (1980) Lal and Bharadwaj (1984) have noticed a decrease in Mg^{2+} in bean and pea plant subjected to salt stress. Nimbalkar and Joshi (1975) reported that lower concentrations of NaCl reduced the Mg^{2+} content of sugarcane leaves while higher conc. cause an increase. Chavan (1980) reported that Mg^{2+} uptake was considerably increased in NaCl treated plants.

From the above observations in 2 hybrid varieties of Capsicum annuum PC1xDB and LxDB it can be clearly stated that these plants have a effecient mechanism of Mg^{2+} uptake under saline conditions. In the 2 hybrids of Capsicum annuum L x DB seems to be more efficient in Mg^{2+} uptake as the highest value is recorded in its leaves.

5. Chlorides

Plant need chlorides in very less quantities for their growth. But higher concentrations prove to be toxic to the plant growth and development (Boyer et al., 1954 In (1938) Lipman has shown that chlorides are beneficial ion for plants, Yamasaki (1964) has shown that rice needs Cl^- ion for its normal growth in quantity less than 0.5%. If it increases above 0.8% it is toxic to rice.

* Effect of various levels of salinity on chlorides content in Capsicum annuum hybrid varieties PC1xDB and L x DB is shown in Table 10 . Fig. 29 .

In our present investigation chloride uptake by the leaves is more in both the hybrid varieties PC1xDB and L x DB over stem and roots. It is clear from table and figure that in the leaves, stem and roots chloride content is more than control at all the levels of salinity. Increase in salinity increases the chloride content. It is further evident from table that in leaves chloride content increases from 5.25 'g' to 7.1 'g' where as in stem and roots it ranges from 1.28 'g' to 2.03 g / 100 g dry plant material.

There are results about increase in chlorides by Bhandari (1988) in *Capsicum annumm* cultiver Pant C1 where she observed that there is increase in chloride content in leaves, stem and roots with increasing salinity level.

According to Meiri and Poljakolf - Mayber (1969) the accumulation of chloride in leaves is related to the rate of salinization. They observed that rapid rather than slow salinization of the medium enhanced the chloride accumulation in bean leaves.

Harris *et al*., (1924, 1925) have noted different lines of cotton, showed considerable specificity in their selective accumulation of chlorides vs S04 and according to them this specificity is directly inheritable pertaining the effect of salinity on bean crop.

Gauch and Wadleigh (1943, 1945) observed higher accumulation of chlorides in leaves, than stem and roots of salinized plants. Greenway *et al*.,(1966) observed accumulation of chlorides in bean plants in a ascending order from root (minimum) stems and leaves (maximum) due to salinity. Neiman and Poulsen (1967) also noted increased Cl^- accumulation in leaf blade followed by stem and petiole due to NaCl salinization. They observed that rapid rather than slow salinization of the medium enhanced the chloride accumulation in bean leaves. Lessani and Marschner (1978) observed that chloride content was more than Na^+ in salt treated maize cv. veloy, cress, sunflower, pepper, bean cv. saxa.

Aly, Atta, El beltagy and Jones (1988)89 studied the salt tolerance in Lycopersicon esculentum III and post harvest quality of lycopersicon Esculentum has been conducted on a salt sensitive and a salt tolerant cultivar grown oven a range of salinity treatment and observed a increased chloride content in fruits from saline treated plants.

Sharma (1989) investigated the effect of salinity ongrowth, ionic and water relations of 3 wheat spps differing in salt tolerance were evaluated for salt tolerance and Physiological responses in sand culture under natural conditions. Higher salt tolerance of Kharchia 65 was indicated by its lower slope, lower conc of Na^+ and Cl^- higher potassium selectivity and better maintainance of tissue hydration. Salt sensitivity of HD 4502 was due to higher Na^+ and Cl^- lower K^+ and lower degree of tissue hydration while that of HD 2160 x Kharchia was due to higher Cl^- concentration.

Liu K-B and S- x Li (1991) studied the effect of sodium chloride on element balance peroxidase isoenzyme and protein banding patterns of lycopersicon leaf cultures and regenerated shoots and observed that addition of NaCl to the medium affected the balance of sodium, chloride, potassium and calcium significantly in regenerated shoots of two species of lycopersicon.

From present investigation we can say that there is more accumulation of chlorides in the leaves rather than roots and stem. The chlorides are more than the control at all the levels of salinity. This indicates that chlorides which are absorbed by the roots are translocated to the leaves rapidly through stem where they accumulate maximum and there is no mechanism which

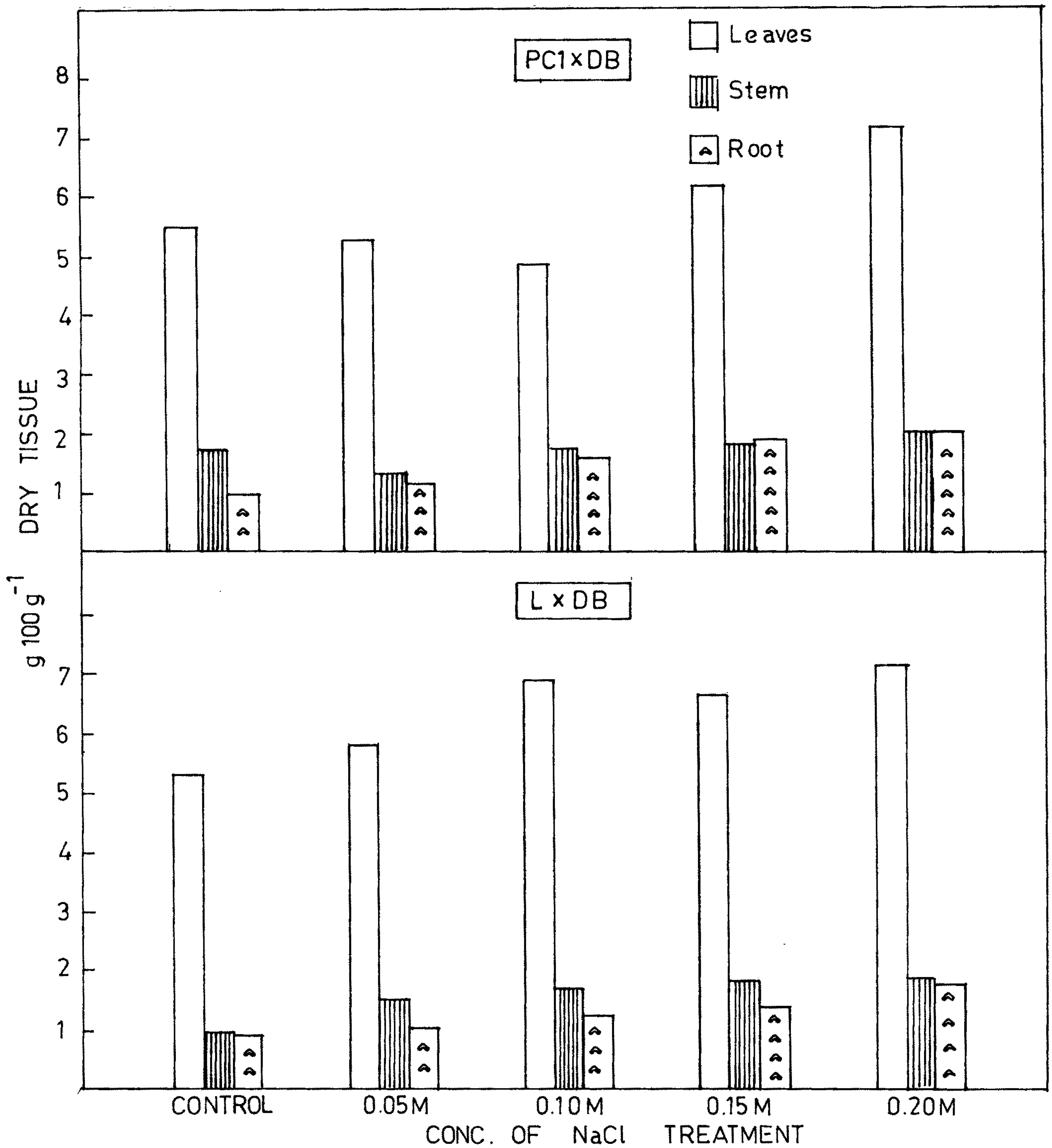

Fig No. 29 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON CHLORIDE CONTENT OF *Capsicum annuum* HYBRID VARIETIES stores toxic salts in roots in both the hybrid varieties.

The above observation indicates that chlorides are responsible for the inhibition of plant growth, as they are accumulated in higher contents in the leaves of the 2 hybrid varieties of *Capsicum annuum* PC1xDB and L x DB.

6. Phosphorus

P^{5+} is a constituent of many compounds in plants. Its involvement in metabolism is covered in detail by Mc Elory and Glass (1951, 1952). It is a constituent of phospholipids and one of these, Lecithin is believed to be present in cell membranes and to be of universal occurance in all living cells. It is also a constituent of the unique, high energy compounds ADP and ATP. High energy phosphate bond provide energy for synthesis of compounds such as Sucrose, Starch and proteins.

Phosphorus has long been known to be involved in Photosynthesis in connection with phosphorylation of various intermediates in CO_2 assimilation. P is involved in the conversion of light into physiologically useful chemical energy by the formation of NADPH and ATP. Effect of various level of NaCl salinity is shown in Table 10 and Fig 30 in *Capsicum annuum* hybrid varieties PC1xDB and LxDB.

In our present investigation we have observed that in leaves there is a increase in phosphorus at lower levels of salinity in PC1xDB variety but there is a decrease at higher levels. While in L x DB variety there is increase in phosphorus at all levels of salinity.

But the roots and stem showed a decrease in phorphorus content at all the levels of salinity as compared to the control in PC1xDB and L x DB hybrid varieties.

There are results about decrease in phosphorus by Bhandari (1988) in *Capsicum annuum* cultivers Pant C1 and NP46A. She observed a linear decrease, increase of phosphorus in leaves where as roots and stem showed a total decrease as the level of salinity increased.

There are many reports about increase in phosphorus at different saline conditions. According to Maas and Nieman (1978) salinity damages mechanisms controlling intracellur Pi concentrations. As much as 100% increase in P^{5+} content of salt stressed *Glycine Javanica* leaves was evident in the experiment of Gates *et al*., (1966).

An increase in P^{5+} content under saline conditions is recorded by several workers like Ansari (1972); Karadge and Chavan (1980) in peanut Lal and Bharadwaj (1980) and Nukaya *et al*., (1982).

Contrary to above observations there are several reports where reduced P^{5+} uptake due to salt stress has been observed Udovenko *et al*., (1976) Paliwal and Maliwal (1972); Zhukhovskaya (1973); Singh *et al*.,(1974), Nanawati and Maliwal (1973) Kleinkopf *et al*., (1975); Dahiya and Singh (1976); Tindal *et al*.,1979; Starch and Kozinska 1980; Karadge *et al*., (1983).

Effect of various concentrationsof NaCl on phosphorus is depicted in the table 10 Figure 38.

From our present observation it is clear that in leaves phosphorus is inhibited at higher levels of salinity in PC1xDB hybrid variety while there is increase in phosphorus at all the levels of salinity in L x DB hybrid variety. These results indicate that the leaves of L x DB hybrid varieties have a better accumulation capacity than the PC1xDB hybrid variety.

In the roots and stem of both the varieties there is decrease in

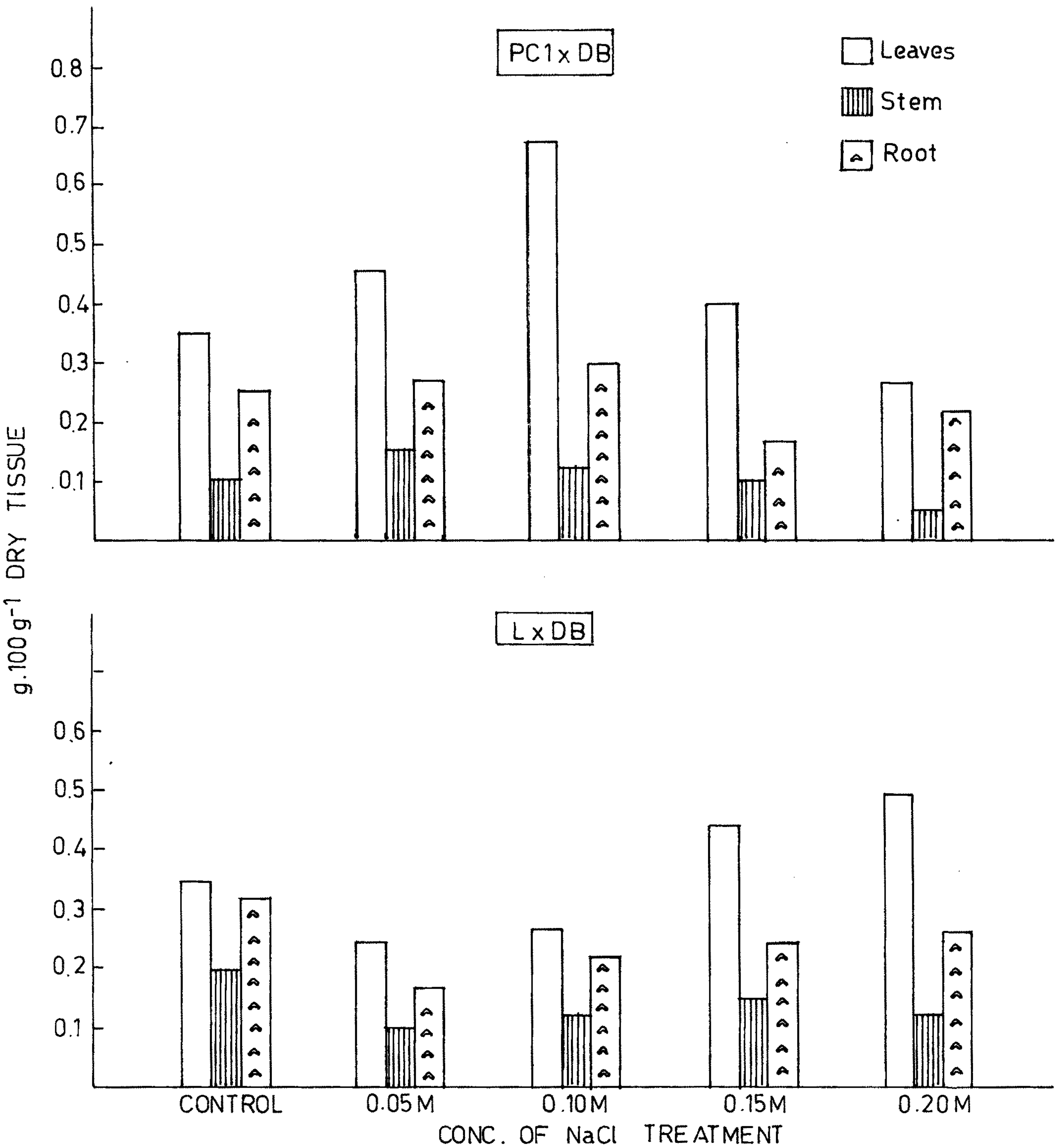

Fig No 30 EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON PHOSPHORUS CONTENT OF <u>Capsicum annuum</u> HYBRID VARIETIES PC1 x DB AND L x DB phosphorus at all the levels of salinity as compared to the control which suggests that Phosphorus is affected greatly due to salinity in stem and roots.

As leaves are important and due to the increase in phosphorus in L x DB leaves in saline conditions it may help the plant for growth and development. So it can be said that L x DB hybrid variety is more tolerant to salt than PC1xDB hybrid variety.

7. <u>Iron</u>

Fe^{3+} is present in traces in plants. It participates in many metabolic activities. Iron is a very essential micronutrient Bogorad (1966) showed that iron is essential for chlorophyll synthesis. As its major portion is present in chloroplast (1968).

Though Fe^{3+} is considered as a microelement, Fe^{3+} is very essential for enzyme systems where it performs haem or haemin function as prosthetic groups. (Losada et al, 1983) There are reports of both iron chlorosis as well as toxicity in crop plants raised under different field conditions. Generally a larger proportion of Fe^{3+} is in a soluble state in acidic soils also some Fe^{3+} may be absorbed by plants as a result of ultimate contact between the root surface and the soil particle. Effect of NaCl on Iron content is shown in Table 10 -Fig 31

In our present investigation the effect of NaCl on Iron is different in the 2 hybrid varieties PC1xDB and L x DB. In PC1xDB hybrid variety in leaves there is a gradual decrease of Iron at all the levels of salinity except at 0.05 M salinity level where it is more than control where as in L x DB hybrid variety at all the levels of salinity there is a decrease in Iron except at 0.15 M salinity level where it showed a slight increase. Even though the Iron content is less than control at all the levels of salinity in both the hybrid varieties in leaves.

As compared in stem the iron content is less than control in both the hybrid varieties at all the level of salinity.

In roots, however stimulation of Fe^{3+} takes place. In PC1xDB variety Iron content is less than control at lower levels of salinity whereas at higher levels Iron content increased (at 0.2 M NaCl level) while in L x DB hybrid variety iron content is increased at 0.05 M salinity level. Further it decreased at all the levels of salinity.

Bhandari (1988) observed in cv Pant C1 and cv NP46A of Capsicum annuum that the Fe^{3+} in leaves decreased linearly over control with increase in levels of chloride salinity. In stem there is increase in Fe^{3+} over control as salinity increases. In roots however there is decrease in Fe^{3+} at all levels of salinity.

There are attempts made to study the effect of salinity on iron nutrition. Based on experiment on barley, wheat and Asparagus, Shimose (1972) has concluded that the pattern of iron uptake differs from species to species under salt rich environment.

There are also results about increase in roots and tops of tomato, squash and soyabean with increasing salinity. Similarly increase in iron content has been reported in some crops like Pea (Dahiya and Singh 1976), bean (Pandey and Kannan 1979 D'Arrigo et al. 1983) and Peanut (Karadge and Chavan 1980).

There are some workers who investigated that under saline condition iron decreases as the level of salinity increases. Sarin (1961); Strogonov (1964); Rahman et al., (1972); Shimose (1972). Medium levels of salinity resulted in highest content of Fe^{3+} while higher levels of salinity decreased Fe^{3+} content of

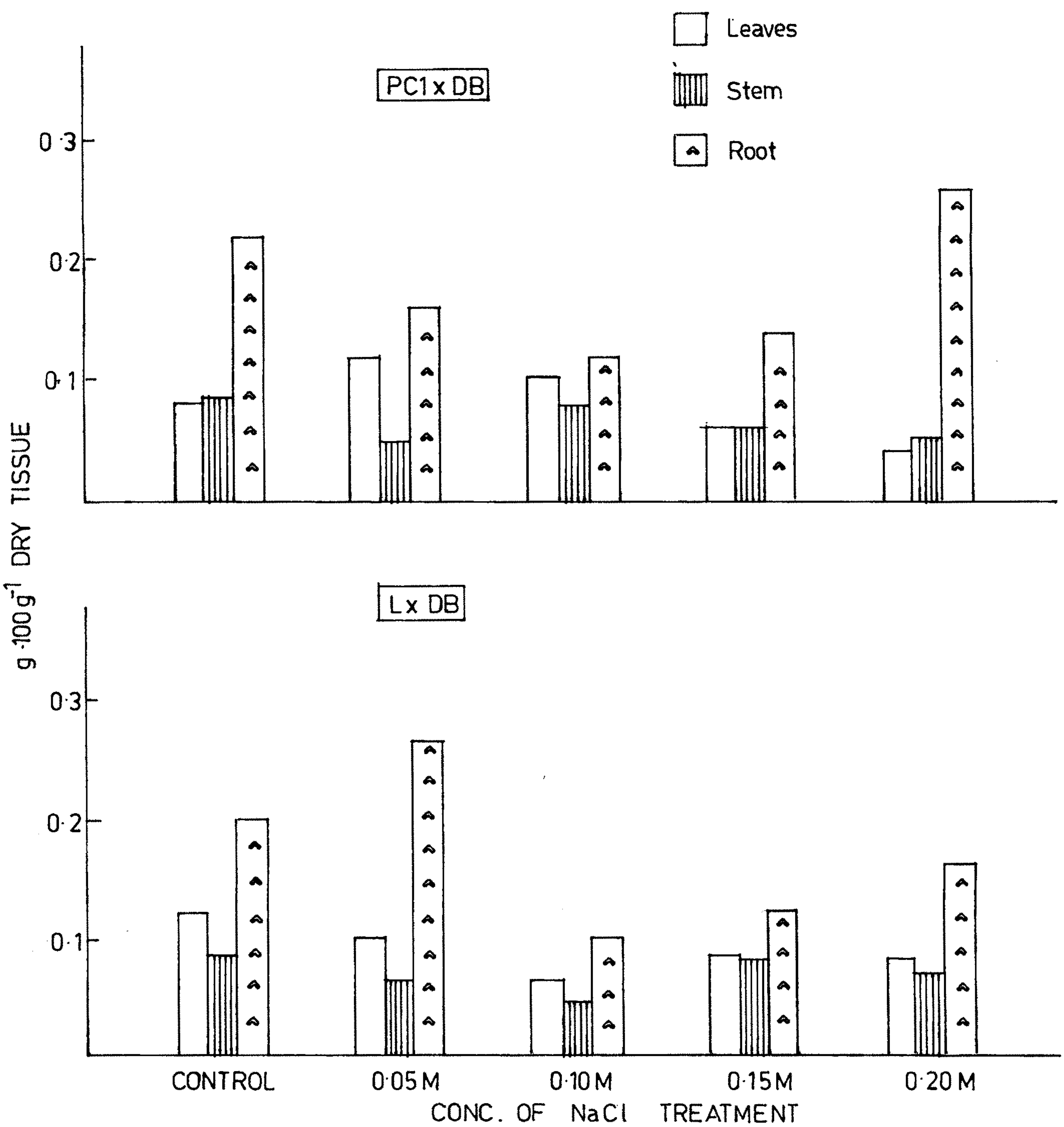

Fig No.**31** EFFECT OF VARIOUS CONC. OF NaCl SALINITY ON IRON CONTENT OF *Capsicum annuum* HYBRID VARIETIES PC1 x DB AND LxDB shoots of Sankha 8, Sonalika, Sakha 3 and Soltane cultivars of wheat (El-Sherbiesy et al, 1986).

According to Maas et al.,(1972) increase in Fe^{+3} content under saline conditions may be due to abrupt changes in membrane permeability.

From the present investigation it is clear that Fe^{3+} content is inhibited more in leaves and stem of both the hybrid varieties. Fe^{3+} is inhibited due to increase in salinity, as the leaves are the main source of chlorophyll and Fe^{3+} is essential for chlorophyll estimation, the decrease in Fe^{3+} content in leaves affect the productivity and growth of the plant.

But it is different in roots where Fe^{3+} uptake increases at higher levels of salinity in PC1xDB variety which indicates that translocation of Fe^{3+} is very slow from roots to stem and leaves, so it accumulates more in roots. While in L x DB hybrid variety there is increase in Fe^{3+} at 0.05M salinity level only, further higher levels of salinity showed a decrease in Fe^{3+} content.

8. Copper

Copper is essential for growth and reproduction of green plants, in very less quantity (Sommer, 1930). Sommer (1931) demonstrated a decline of more than 90% yield in tomato plant, sunflower and flax when copper was not added.

Hasson et al.,(1970) and Bhatti and Sarwar (1977) who reported a decrease in Cu^{2+} content in barley and corn respectively due to NaCl treatment. Singh (1966) has shown that nitrogen content of leaves bear a direct relation to the rate of Cu^{2+} application. Neish (1939) suggested that Cu^{2+} functions in photosynthesis.

In our present investigation we have observed results about increase in Cu^{2+} content in leaves, stem and roots of PC1xDB and

L x DB hybrid varities are shown in Table 10

In leaves of PC1xDB hybrid variety there is initial increase in Cu^{2+} at lower levels of salinity where as at higher levels of salinity the Cu^{2+} content decreases. While in L x DB hybrid variety there is increase in Cu^{2+} content at all the levels of salinity.

In the stem of PC1xDB there is increase in Cu^{2+} at all the levels of salinity except at 0.20M NaCl salinity level where it slightly decreases over control.

In the stem of L x DB hybrid variety there is slight stimulation of Cu^{2+} at 0.05M salinity level further it decreased as the salinity level increased.

The roots show increase in Cu^{2+} content in PC1xDB hybrid variety at all the levels of salinity except at 0.20M salinity level whereas in L x DB hybrid variety there is decrease in Cu^{2+} content at all the levels of salinity except at 0.15M salinity level where it is more than control.

There are many workers who have reported about increase in Cu^{2+} in saline conditions. Smith and Oobrenz (1981) have noticed increased Cu^{2+} uptake under saline condition in alfa alfa. Increase in Cu^{2+} content is also reported by Khot (1978) in root, stem, leaves of Phaseolus aureus. Rajmane (1984) in Psophocarpus tetragonolobus, Bhandari (1988) in Capsicum annuum cultivars Pant C1 and NP46A.

There are adverse reports about decrease in Cu^{2+} by many workers. Hassan et al., (1970) and Bhatti and Sarwar (1977) who reported a reduced Cu^{2+} content in barley and corn due to NaCl treatment. (The Cu^{2+} content is reduced mainly in leaves of fresh bean cultivar Vaghya under the influence of both the salts.) Similar observations were made by D'Arrigo et al.,(1983) in bean. Cu^{2+} increases with increase in salt conc. in the root medium of salt sensitive plants while it decreases or remains stable in salt tolerant plants (Townseno 1980).

It is clear from our investigation that there is higher accumulation of Cu^{2+} in the leaves of L x DB hybrid variety than the leaves of PC1xDB. The stems show greater accumulation of Cu^{2+} in PC1xDB hybrid variety while the L x DB hybrid variety shows less accumulation of Cu^{2+} in the stem. In roots there is increase in Cu^{2+} in PC1xDB hybrid variety at all the levels of salinity whereas there is decrease in Cu^{2+} content in roots of L x DB hybrid variety.

These observations suggest that in PC1xDB hybrid variety the roots and the stem accumulate more Cu^{2+} do not transfer to the leaves rapidly. Where as in L x DB hybrid variety there is rapid translocation of Cu^{2+} roots to stem and then leaves where it accumulates more.

Increased Cu^{2+} content is a significant feature under saline condition which may help the plants to survive.

9. **Zinc**

Zinc is required in very minute quantities by the plants. Lipman et al., (1926) and Sommer (1928) established that Zn^{2+} absolutely essential for the growth and development of green plants. Srivastava (1964) has reported its significant effect on greater extension of root system and more growth of leaves and others above ground tissues. Moghe (1965) reported that the zinc content of certain crops grown in India is as follows: Vegetables 28.2 ppm, pulses 34.8 ppm, cereals 27.8 ppm, cotton and sugarcane 36 ppm and grasses 18.5 ppm.

From the present investigation in the two hybrid varieties of <u>Capsicum annuum</u>. PC1xDB and L x DB the effect of NaCl salinity on Zn^{2+} content is shown in Table 10

In the leaves of PC1xDB Zn is less than control at higher levels of salinity and more than control at lower levels of salinity, while in L x DB hybrid variety the zinc content is less than control at all the levels of salinity.

In the stem there is increased Zn^{2+} content as the salinity level increased. Zn^{2+} is less than control at 0.05 M salinity level only. At all the other levels the Zn^{2+} content is more than control in PC1xDB hybrid variety while in L x DB hybrid variety there is increase in Zn^{2+} content at lower levels and decrease at higher levels of salinity.

In roots there is decrease in Zn^{2+} content at all the levels of salinity in PC1xDB hybrid variety where as in L x DB hybrid variety there is decrease in Zn^{2+} at the lower concentration of NaCl and increase at higher conc of NaCl.

Bhandari (1988) has also reported the increase in Zn^{2+} contents in all parts of the <u>Capsicum annuum</u> cultivars Pant C1 and NP46A. Increase in Zn^{2+} due to salinity is reported by Rajmane (1984) in <u>Psophocarpus tetragonolobus</u>. El Sharbiery <u>et al</u>., (1986) reported that Zn^{2+} content increases as the level of salinity increases.

On the other hand Patil and Patil (1983) have reported about a decline in Zn^{2+} content due to salt stress in Jamun tree and Monette (1978) observed a decrease in the Zn^{2+} content of Plant tissues and soil with increasing salinity.

From our investigation we can say that there is a linear decrease and increase in both the hybrid varieties PC1xDB and L x DB hybrid variety in leaves, stem and roots.

In PC1xDB leaves accumulate more Zn^{2+} than in L x DB hybrid variety where as the stems of PC1xDB hybrid variety show a decrease at low salinity level except in L x DB where there is increase in Zn^{2+} at higher levels of salinity.

In the roots of PC1xDB hybrid variety there is increase in Zn^{2+} at low levels and in L x DB hybrid variety there is increase in Zn^{2+} at higher levels of salinity.

All these results prove that Zn^{2+} uptake is better in PC1xDB than in L x DB hybrid variety.

10. **Manganese** (Mn^{2+})

Mn^{2+} is involved in the reactions of oxidation, reduction decarboxylation and hydrolysis as a cofactor. It is associated mostly with Photosynthesis, respiration and activation of enzymes of nitrogen metabolism.

In our present investigation in 2 hybrid varieties of *Capsicum annuum* PC1xDB and L x DB there are different results about the effect of salinity on Mn^{2+} content is shown in Table 10 . In leaves of PC1xDB hybrid variety, Mn^{2+} content decreased at all the levels of salinity, while in leaves of L x DB hybrid variety there is increase in Mn^{2+} at low levels of NaCl salinity.

In stem, roots there is decrease in Mn^{2+} content as the salinity level increases in PC1xDB hybrid variety, while in stem and roots of L x DB hybrid variety the Mn^{2+} content increased at all the levels of salinity.

Decrease in Mn^{2+} content have been reported by many workers like

Maas *et al*., 1972 in tomato and soyabean, Pandey and Khanna (1979) in bean, Chavan and Karadge (1980) in Peanut and D'Arrigo *et al*., in *Phaseolus vulgaris* have reported stimulatory effect of salinity on Mn^{2+} content, while Shimose (1973) in barley, Despande (1981) in Pigeon pea and Pakroo (1980).

Bhandari (1988) has also observed decreased Mn^{2+} contents in *Capsicum annuum* L cultivars Pant C1 and NP46A under saline conditions.

The results observed in the present investigation in 2 hybrid varieties of *Capsicum annuum* PC1xDB and L x DB show contradictory results.

There is more accumulation of Mn^{2+} in leaves stem and roots of L x DB hybrid variety than the PC1xDB hybrid variety. These observations indicate that the absorption of Mn^{2+} under saline conditions is influenced by salinity in L x DB hybrid variety while it is affected in PC1xDB hybrid variety.