RESULTS AND DISCUSSION

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GROWTH

Saline substrates generally depress growth of plants. The effect of various concentrations of NaCl on growth and development of two varieties of Curcuma longa - Sugamdhum and Erode has been studied. The results are compared with control plants grown in absence of salts. The effect of NaCl on growth and development with respect to plant height, biomas (Fresh wt. and dry wt.) moisture percentage, leaf area and no. of leaves per plant, length of the roots, length of the rhizome and girth of the rhizome of Curcuma longa varieties are recorded in the table No

From our results it is observed that there is a decrease in plant height, no. of leaves and leaf area, as the level of NaCl salinity increases. The moisture percentage is also affected at different concentrations of NaCl. Length of the rhizome and girth of the rhizome is reduced with increasing level of the NaCl salinity. Root length is also reduced in both the varieties due to NaCl salinity.

From all these observations it is clear that the plant growth and development is severely affected by NaCl salinity in both the varieties.

Plant height is a good indicator in the process of growth and development (Strogonov, 1984). Leaf area is one of the most important growth parameters which is extensively studied by several investigators under different environmental stresses.

Reduction in leaf area is a common response to salinity which is proved in the experiments of Nieman (1965).

It is well known that there is a general stunting of plant growth due to salinity (Hayward, 1955); Berstein and Hayward, 1958; Riley, 1968; and Eaton et al., 1971). Strogonov (1964) reported a 50% inhibition of growth in tomatoes grown is soil containing 0.1% of NaCl. In case of glycophytes also there are few reports of plant growth stimulation by lower salt concentration, Nieman (1962) studied the salt tolerance of twelve crops and found a stimulation of growth in garden beet and spinach by NaCl.

There are some reports regarding decrease in plant height. Joshi (1976) in wheat and barley. Ansari (2972) in Brassica, Taha et al., (1972) in grape. guava and olive, Joolka and Singh (1979) in citrus; Hassan - Porath et al (1972), Uptrey and Sarin (1975) in Pea, Nukaya et al., (1980) and Lauter et al., (1981) in chick pea and Kawasaki et al., (1983) in bean concluded that with increase in salinity height of the plant decreases considerably.

There are some reports about the decrease in various growth parameters due to NaCl salinity. With an increase in salinity level leaf area and number get decreased (Kale, 1962; Ahmed, 1965 and Sharma et al., 1977). Strogonov (1964) has also recorded about 50% inhibition of growth in Tomatoes grown in soil containing 0.1 % salts. Meiri and Poljakoff mayber (1967) reported about 20-40 % reduction in leaf area of bean plants when grown under saline conditions.

A no. of workers have reported a reduction in plant growth and dry matter production due to salt stress (Taylor <u>et al</u>., 1975; Ahmed <u>et al</u>., 1979; Chavan and Karadge, 1989; Maliwal and Paliwal, 1984; Flowers <u>et al</u>., 1986).

Immul Huq and Larher (1983) have found that <u>Vigna sinensis</u> and <u>Phaseolus aureus</u> show differential behaviour under saline conditions. They found that <u>V.sinensis</u> grows better while <u>P.aureus</u> shows a decline in its growth even at the low salt concentrations. The response shown by the plants to salinity also varies from species to species.

Inhibitory effects of different salts on growth of <u>Pheaseolus vulgarise</u> CV Vaghya were studied by Bhivara and Nimbalkar (1984). The growth inhibition of <u>Aster tripolium</u>, in terms of both dry weight and leaf expansion due to high salinity was reported by Shennan <u>et al</u>., (1987). Okusanya and Ebong (1984) recorded that in <u>Luffa aegyptiaca</u> salinity significantly supressed the growth as measured by plant height, dry wt. similarly with increasing salinity level, plant growth is decreased observed by Setia and Narang (1985) in <u>Pisum sativum</u>; Murumkar (1986) in <u>Cicer arietinum</u> and Shennan <u>et al</u> (1987) in <u>Aster tripolium</u>.

A decrease in plant growth due to salinity is also reported by Huffman <u>et al</u> (1980) in <u>Capsicum annum</u>; Chavan (1980) in Ragi; Garg and Garg (1980) in <u>Pisum sativum</u>; Patil and Patil (1983) in <u>Syzygium cumini</u> and Mirza and Khalid (1986) in <u>Phaseolus aureus</u> CV 6601.

There were results about decrease in plant height by sadle (1989) in Crotolaria juncea plants as the salinity level in growth medium increases. Giridhar et al., (1989) have reported abnout the response of sunflower to saline water irrigation and changing zone salinity and observed plant height, no. of leaves and leaf area decreased at higher level of salinity.

Recently Charizoulakis, K.S. (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.

There are results about increase in plant height at lower levels of salinity and decrease at higher levels by Bhandari (1988) in Capsicum annum cultivars Farias et al. (1989) have reported about stimulation of growth at lower concentrations of salinity and decrease in growth at higher levels of salinity of Blutaparon portulacoides (SLH.I) Mears (Amaranthaceae).

From the present investigation it is clear that there is a decrease in plant height at all the levels of salinity except at 0.05 m salinity level where it is more than control in both the varieties of Curcuma longa - Sugamdhum and Erode.

The length of the rhizome showed a overall decrease at all the levels of salinity in both the varieties.

There was a decrease in the girth of the rhizome as the level of salinity increased in both the varieties.

Leaf Area :-

From our present observations it is evident that there is decrease in leaf area as the concentration of NaCl salinity increases.

PHOTOSYNTHETIC PIGMENTS

i) Chlorophyll

The effect of NaCl salinity on chlorophyll contents of the leaves of 2 varieties of *Curcuma longa* Sugamdhum and Erode is shown in fig No. 6 a,b. Table No. 2.... . As compared to control plants it is evident that in both the varieties, total chlorophyll content of the leaves decreased with increasing salinity. Chlorophyll 'a' and Chlorophyll 'b' also decreased with increasing salinity. It can also be seen that the rate of degradation of chlorophylls in the leaves of Sugamdhum variety is relatively more than that in the leaves of Erode variety, when both the plants are grown under saline conditions. The response shown by these plants also varies with respect to the influence of salinity on chlorophyll 'a' and 'b' separately. As compared to control plants the chlorophyll content is less in the salt treated plants. In both the varieties chlorophyll a : b ratio decreases with increasing salinity. This decrease in Chlorophyll a : b in ratio can be accounted for more damage to Chlorophyll 'a' then chlorophyll 'b' in both the varieties.

As early as 1936, Baslavaskaya has shown that in potato leaves the accumulation of Cl^- ions interferes with the photosynthetic mechanism by causing reduction in chlorophyll content. There are

Table No : 1A

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl SALINITY ON GROWTH PARAMETERS of Curcuma longa VARIETIES - SUGAMDHUM AND ERODE.

Variety	Conc.ns NaCl	Plant height (cm)	No. of leaves/ plant	Leaf length (cm)	Leaf breadth (cm)	Leaf area (cm^2) (LxB)x0.72
Sugamdhum	Control	87	9	43	15	464.40
	0.05M	88	8	37	14	372.96
	0.10M	85	9	41	14	413.28
	0.15M	83	7	30	14	224.64
	0.20M	80	8	26	12	302.40
Erode	Control	45	7	40	14	403.20
	0.05M	48	6	37	15	399.60
	0.10M	38	7	31	14	312.48
	0.15M	35	5	30	11	237.60
	0.20M	34	5	29	13	271.44

* Conversion factor suggested by Rao & Swamy (1984) for leaf area.

Table No. 1B

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl SALINITY ON GROWTH PARAMETERS OF Curcuma longa VARIETIES - SUGAMDHUM AND ERODE.

Variety	Conc.ns NaCl	Fresh wt. of rhizome gm	Dry wt. of rhizome gm	Length of the finger (cm)	Girth of rhizome (cm)	Root length
Sugamdhum	Control	22.800	5.000	6.2	5.9	13.5
	0.05M	22.500	4.500	6.1	6.0	14.0
	0.10M	20.100	4.000	5.2	5.0	12.6
	0.15M	15.500	3.100	4.5	4	10.5
	0.20M	13.200	2.500	4.0	3.4	9.7
Erode	Control	27.500	3.500	6.0	5.2	12.0
	0.05M	25.500	3.000	5.2	4.8	12.1
	0.10M	23.100	2.500	4.5	4.3	11.8
	0.15M	20.200	2.000	4.6	4.1	10.7
	0.20M	15.000	1.300	4.2	3.8	9.5

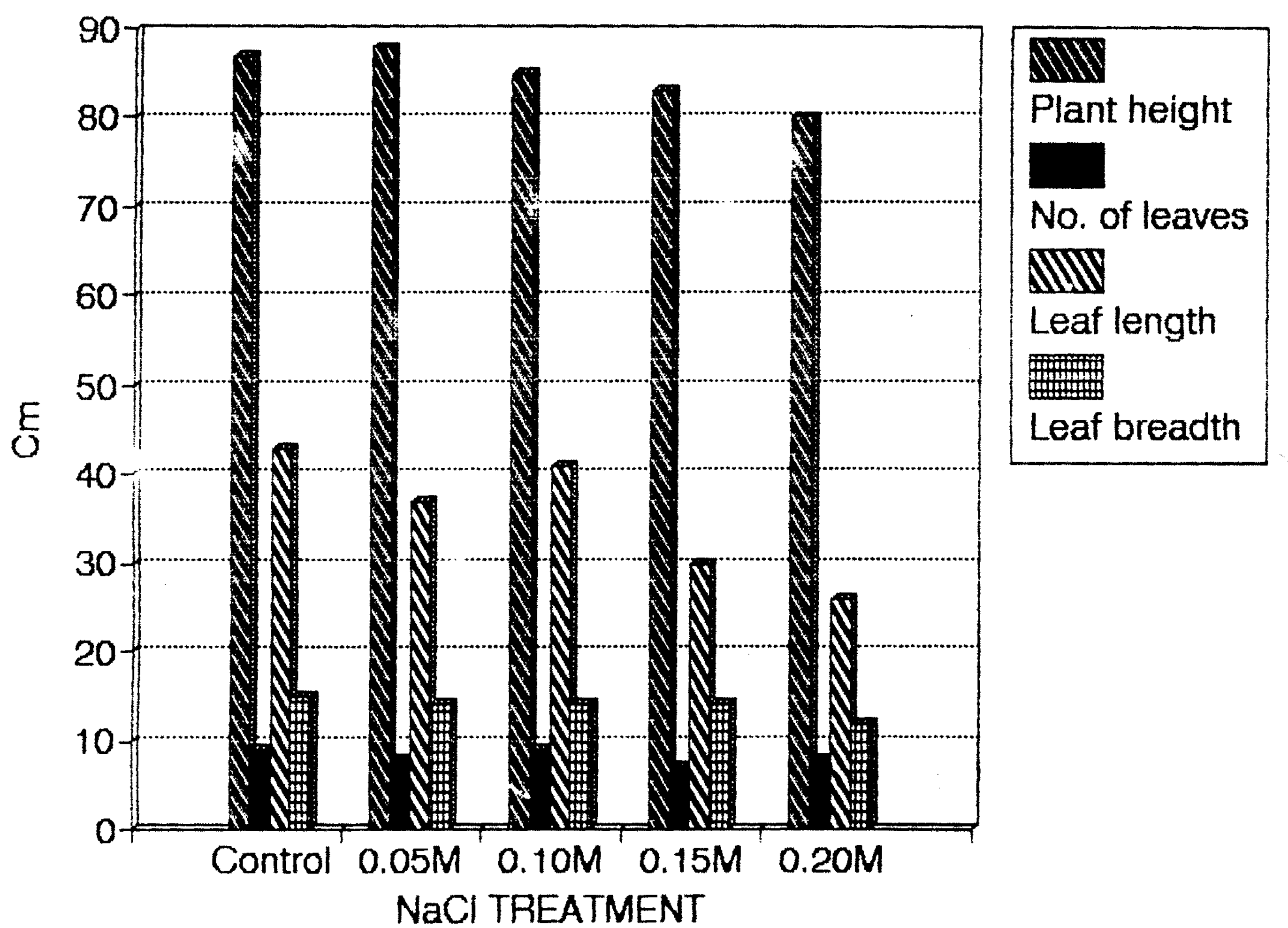

Fig.NO.1 Effect of various concentrations of NaCl salinity on various growth parameters (plant height, leaf length, leaf breadth, no.of leaves) of Curcuma longa - Sugamdhum variety.

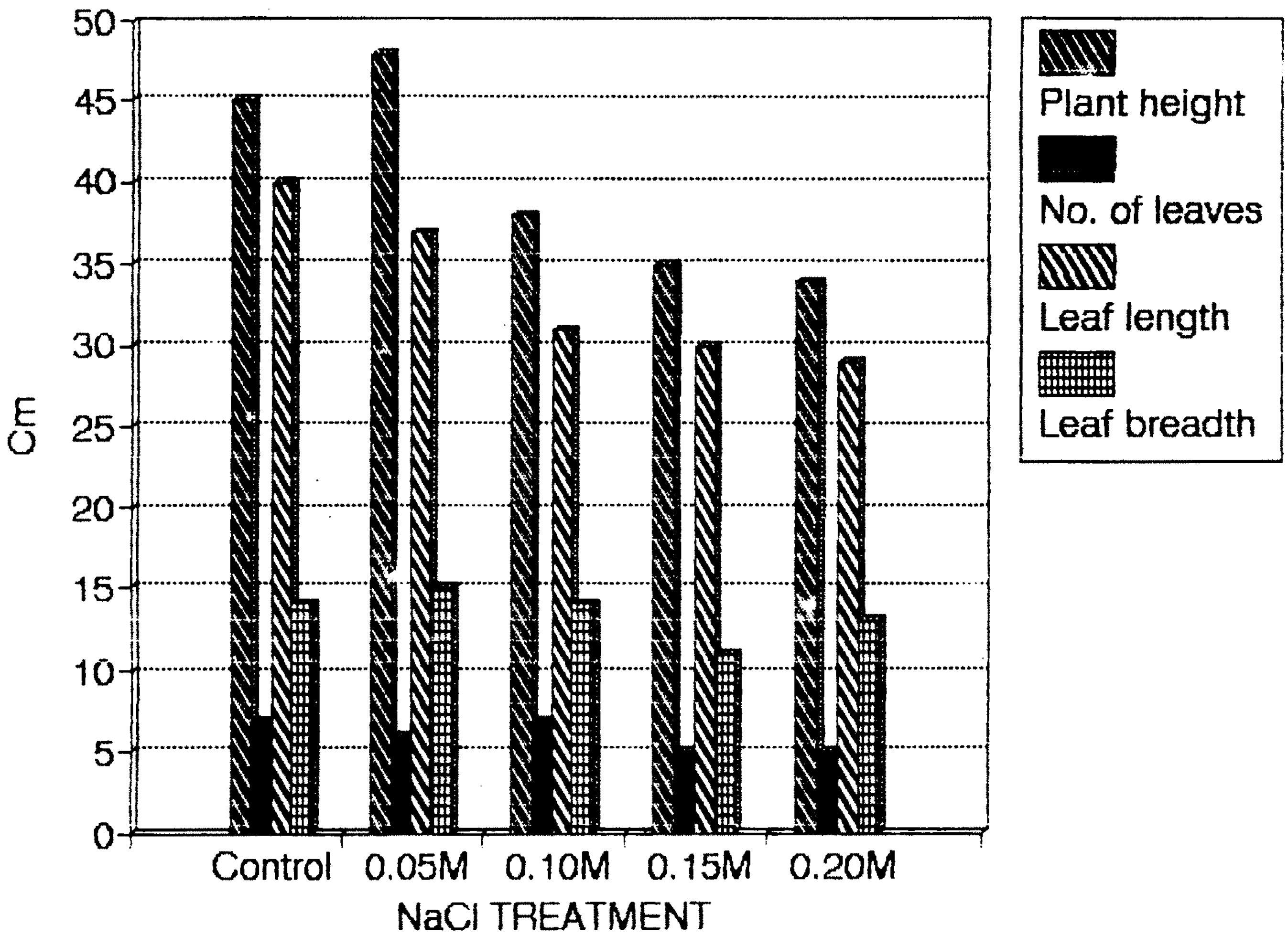

Fig.NO.2 Effect of various concentrations of NaCl salinity on various growth parameters (plant height, leaf length, leaf breadth, no.of leaves) of <u>Curcuma longa</u> - Erode variety.

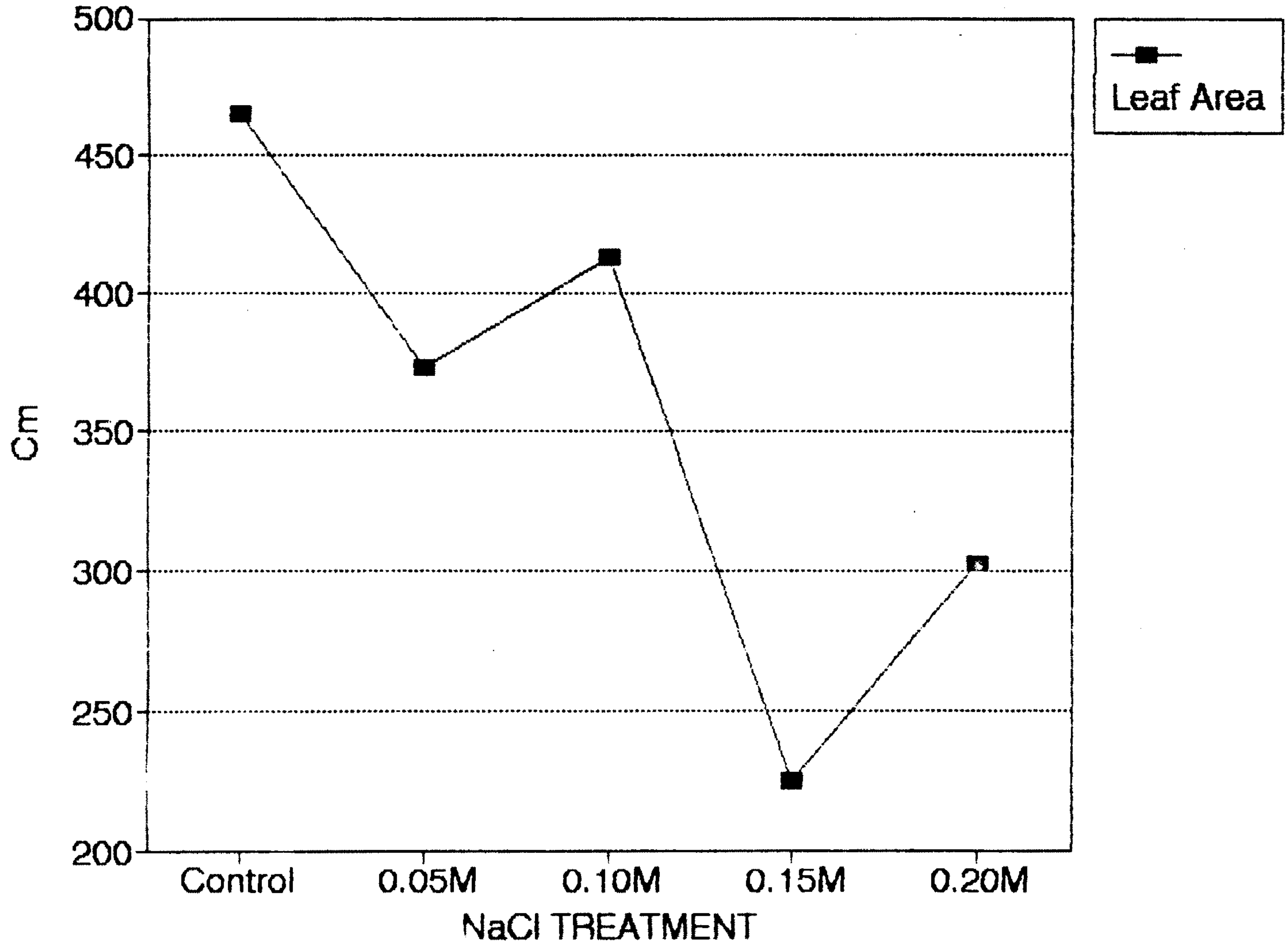

Fig.NO.3 Effect of various concentrations of NaCl salinity on leaf area of Curcuma longa - Sugamdhum variety.

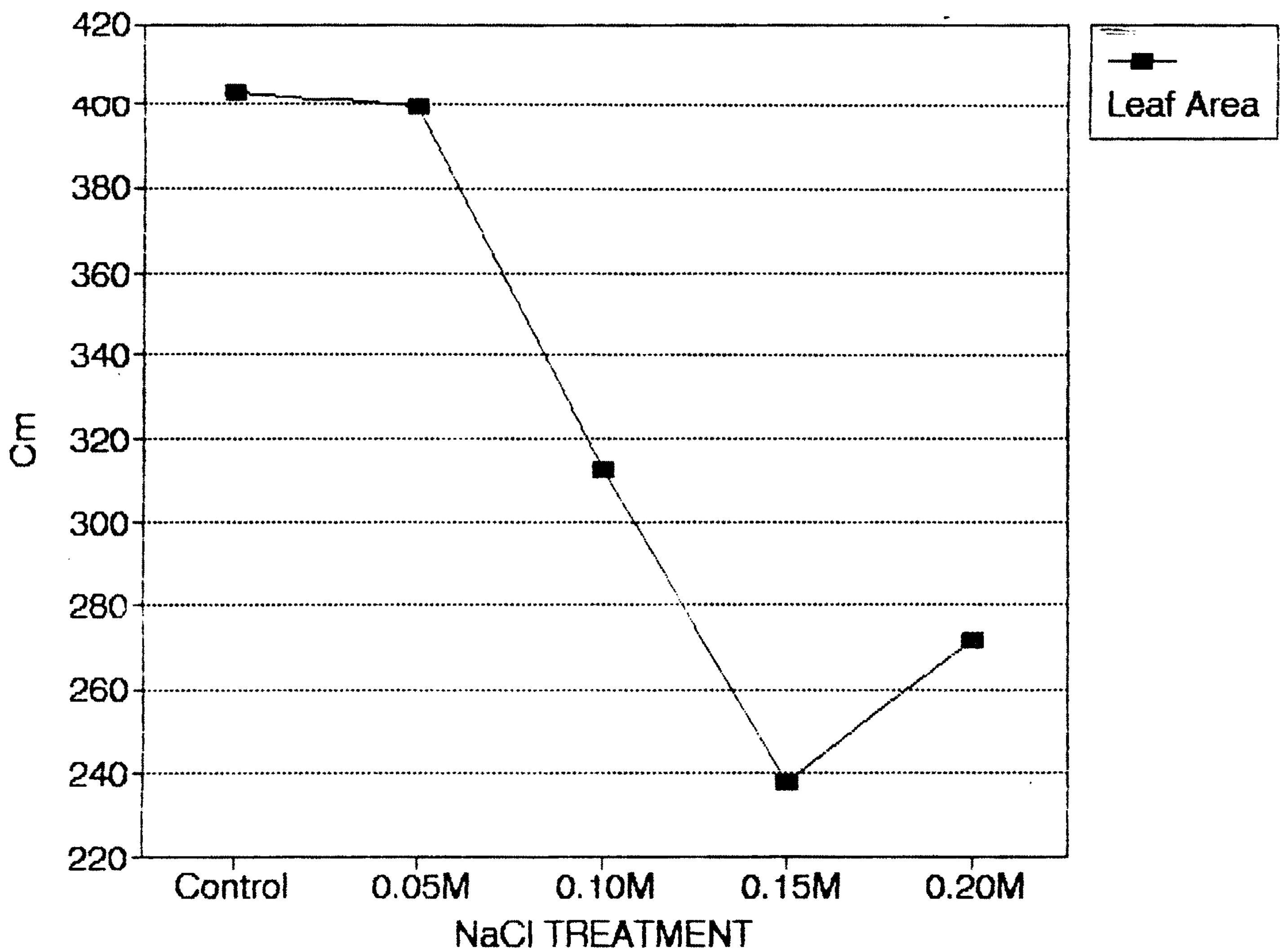

Fig.NO.4 Effect of various concentrations of NaCl salinity on leaf area of Curcuma longa - Erode variety.

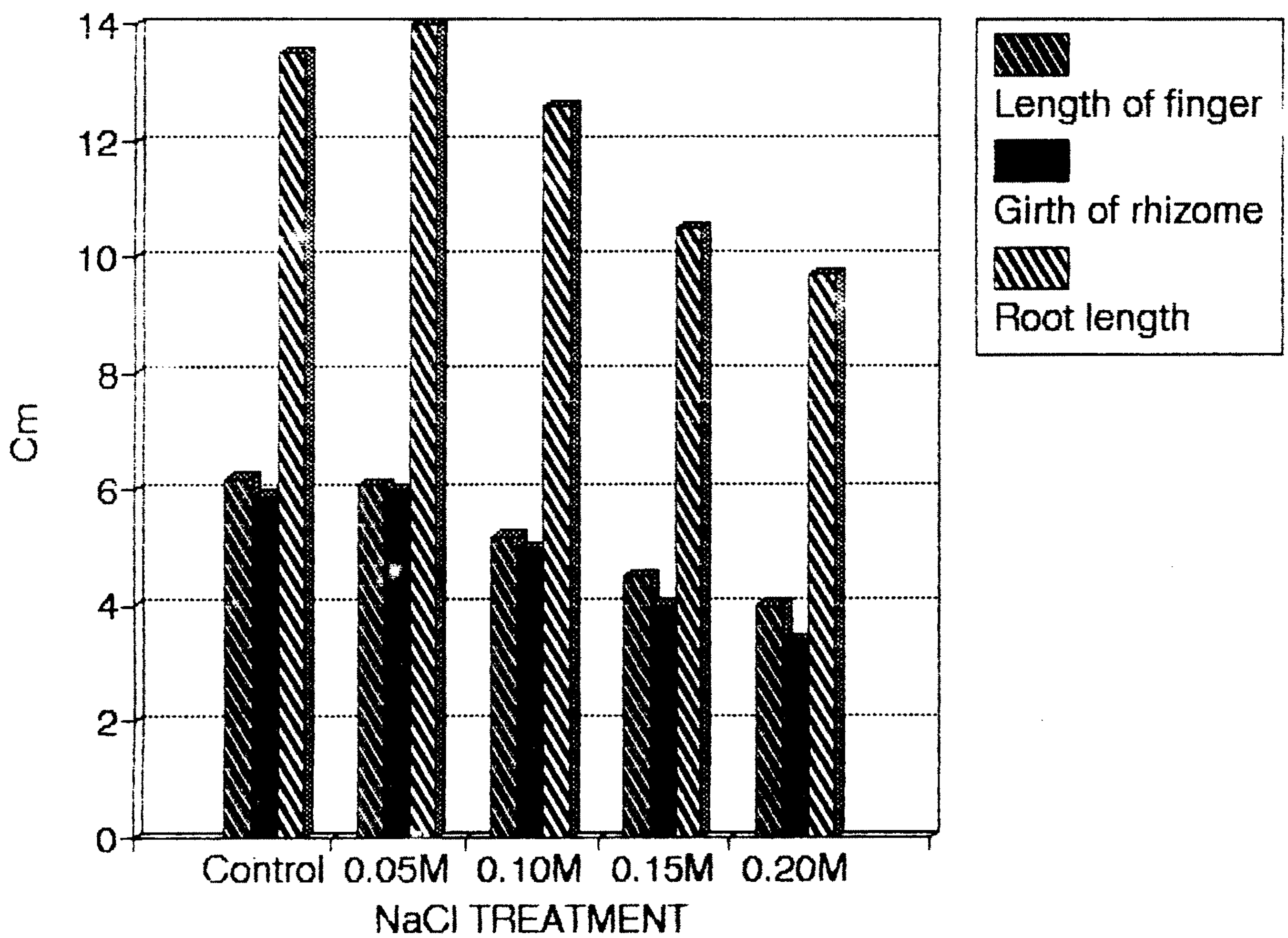

Fig.NO.4 Effect of various concentrations of NaCl salinity on varoius growth parameters (root length, length of finger, girth of finger) of Curcuma longa -Sugamdhum variety.

many reports where salinization decreases the chlorophyll content of plants (Ashour et al., 1977; Kleinkopf et al, 1975; Joshi and Karadge 1977; Chavan and Karadge, 1980; Petolino and Leone, 1988; Grant and Somers, 1981; Karadge, 1981). Sadale, (1989) also observed a decrease in chlorophyll content with increasing salinity levels in Crototaria juncea.

Various reasons have been attributed for the low chlorophyll contents under saline conditions. According to Strogonov (1970) salinity affects the strength of the forces binding the complex of pigment - protein - lipid in the chloroplast structure. This idea is supported by Udovenko, (1971) and Ponomareva et al., (1971), Svitsev et al., (1973) have reported that in tomato leaves the chlorophyll content decreases due to salinization. Similar observations have been made by Sudyina and Fomishyna (1974) in sugarbeet leaves. According to Ibrajimov and Azimov (1975) the effect of salinity on chlorophyll content depends on the stage of plant growth. They have noted that in cotton, salinity decreases the chlorophyll content before flowering while increases after flowering.

There are few reports of enhancement of chlorophyll synthesis by salinity in various plants such as bean (Helel et al., (1975); Panicum antidotal, Setaria sphacelata, Chloris gayana and Pennisetum pedicellatum (Varshney and Baijal, 1977); Triticum sestivum (Passera and Albuzio, 1978) and Eleusine coracana (Chavan 1980).

Table No : 2

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl SALINITY ON CHLOROPHYLL CONTENT OF <u>Curcuma longa</u> - VARIETIES - SUGAMDHUM AND ERODE.

Variety	Conc.n of NaCl	Chlorophyll 'a'	Chlorophyll 'b'	Total Chlorophyll
Sugamdhum	Control	94.38	54.88	149.26
	0.05M	90.23	52.25	142.48
	0.10M	52.20	44.28	96.48
	0.15M	44.28	32.25	76.53
	0.20M	50.34	30.42	80.76
Erode	Control	63.32	41.14	104.46
	0.05M	55.10	49.22	105.32
	0.10M	47.85	45.20	93.05
	0.15M	46.91	39.12	86.03
	0.20M	45.23	31.39	80.62

values are expressed in mg 100^{-1} g fresh tissue.

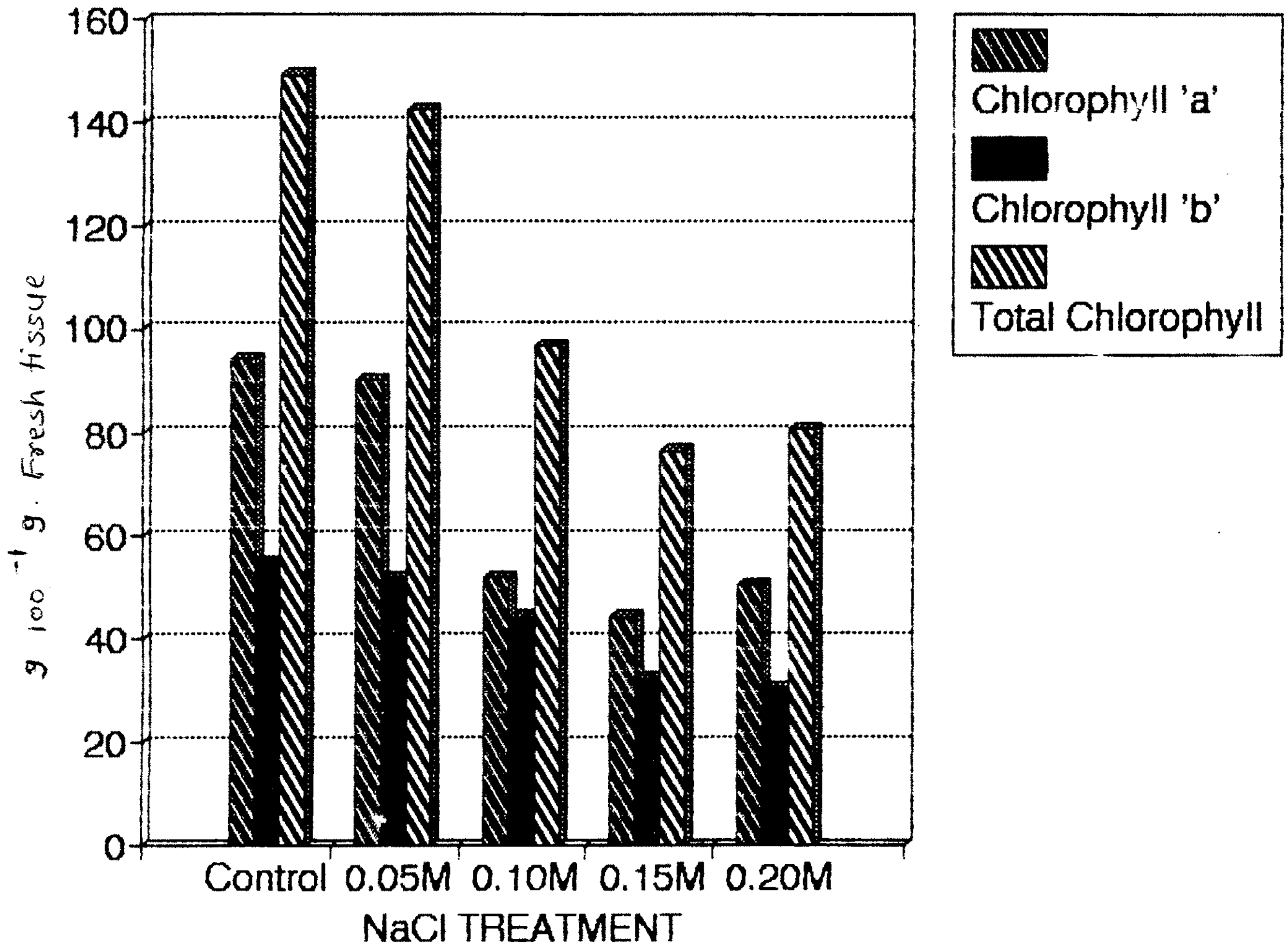

Fig.NO.6 Effect of various concentrations of NaCl salinity on chlorophyll content of Curcuma longa - Sugandhum variety.

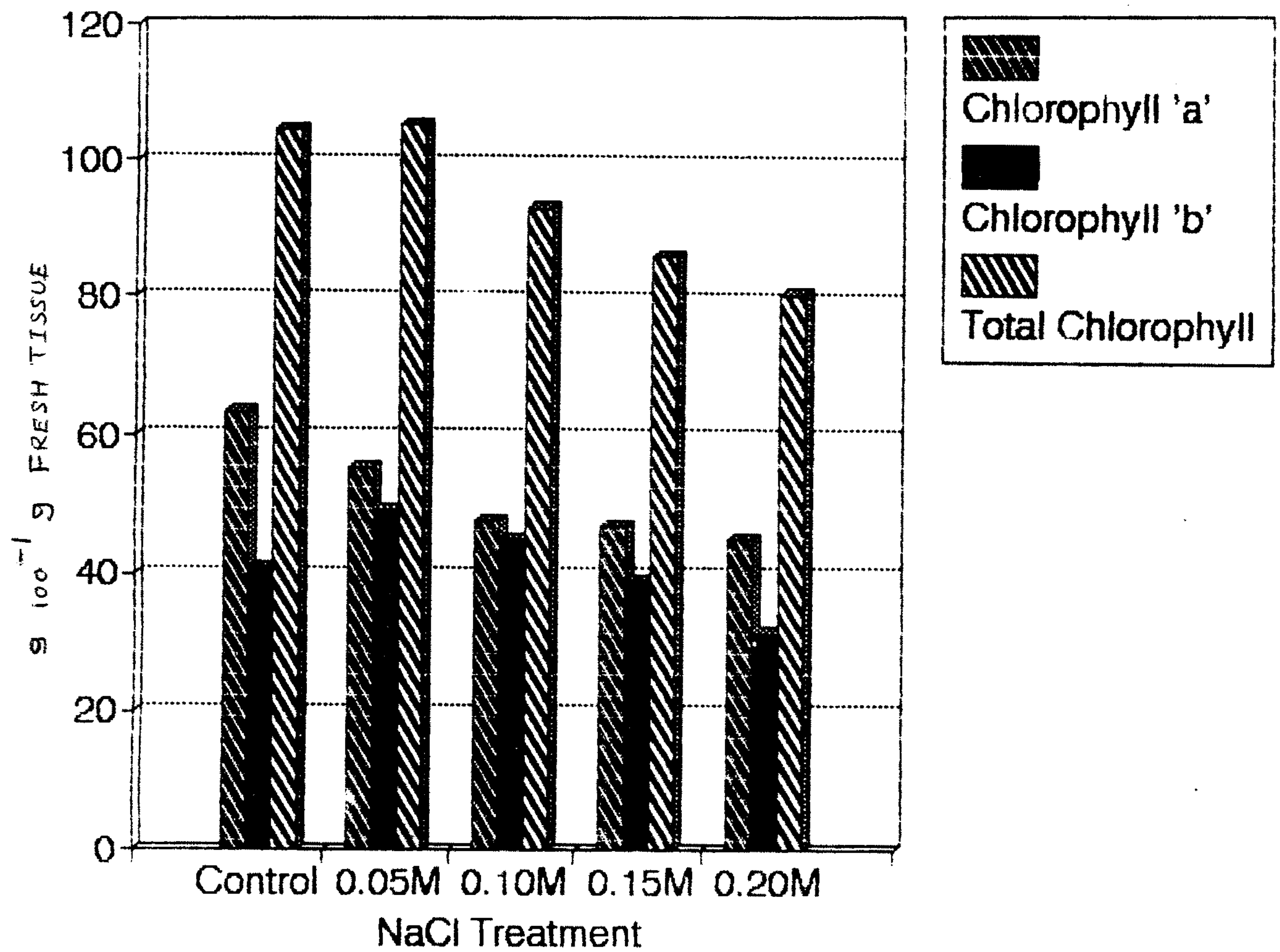

Fig.NO.6 Effect of various concentrations of NaCl salinity on chlorophyll content of __Curcuma longa__ - Erode variety

Helel et al., (1975), Heikal, (1976), Patil (1986), Deshpande, (1981) and Kulkarni, (1984) reported that salinity at low levels increases chlorophyll but higher concentrations had inhibitory effects.

From our results, it is clear that in both the varieties chlorophyll content decreases with increasing salinity indicating the salt sensitive nature of these varieties. According to some workers, in salt sensitive plant chlorophyll degradation is more rapid because of the fact that degradative enzyme chlorophyllase is found to be stimulated by salt. There is decrease in chlorophyll a : b ratio. This indicates that accumulation of chlorophyll 'a' is slower than that of chlorophyll 'b'. Therefore chlorophyll metabolism is distributed due to salinity in both the varieties of Curcuma longa.

5) **TITRATABLE ACID NUMBER** [TAN]

TAN (Titratable Acid number) represents the ml. of decinormal NaOH required to neutralize the acid contents from 100 gm of fresh material. The effect of NaCl on TAN in different parts of Curcuma longa varieties - Sugamdhum and Erode has been presented in Table No 3....... and Fig No 7 a, b .. . It is obvious from table and figure that as compared to control plants, TAN decreases in the leaves, rhizome and roots of both the varieties due to NaCl salinity. The rhizome of both the varieties accumulates more acids than the leaves.

Table No : 3

EFFECT OF VARIOUS NaCl CONCENTRATIONS OF NaCl SALINITY ON TAN OF *Curcuma longa* VARIETIES - SUGAMDHUM AND ERODE.

Variety	Conc.n of NaCl	Leaves	Rhizome	Root
Sugamdhum	Control	7.69	10.38	6.4
	0.05M	3.80	7.69	6.2
	0.10M	3.07	5.38	5.5
	0.15M	2.88	4.26	4.9
	0.20M	2.11	3.07	4.1
Erode	Control	10.76	9.23	5.8
	0.05M	8.53	7.8	5.7
	0.10M	5.38	5.38	5.1
	0.15M	4.60	3.07	4.3
	0.20M	3.46	4.60	3.2

values are expressed in ml/100^{-1} g fresh tissue.

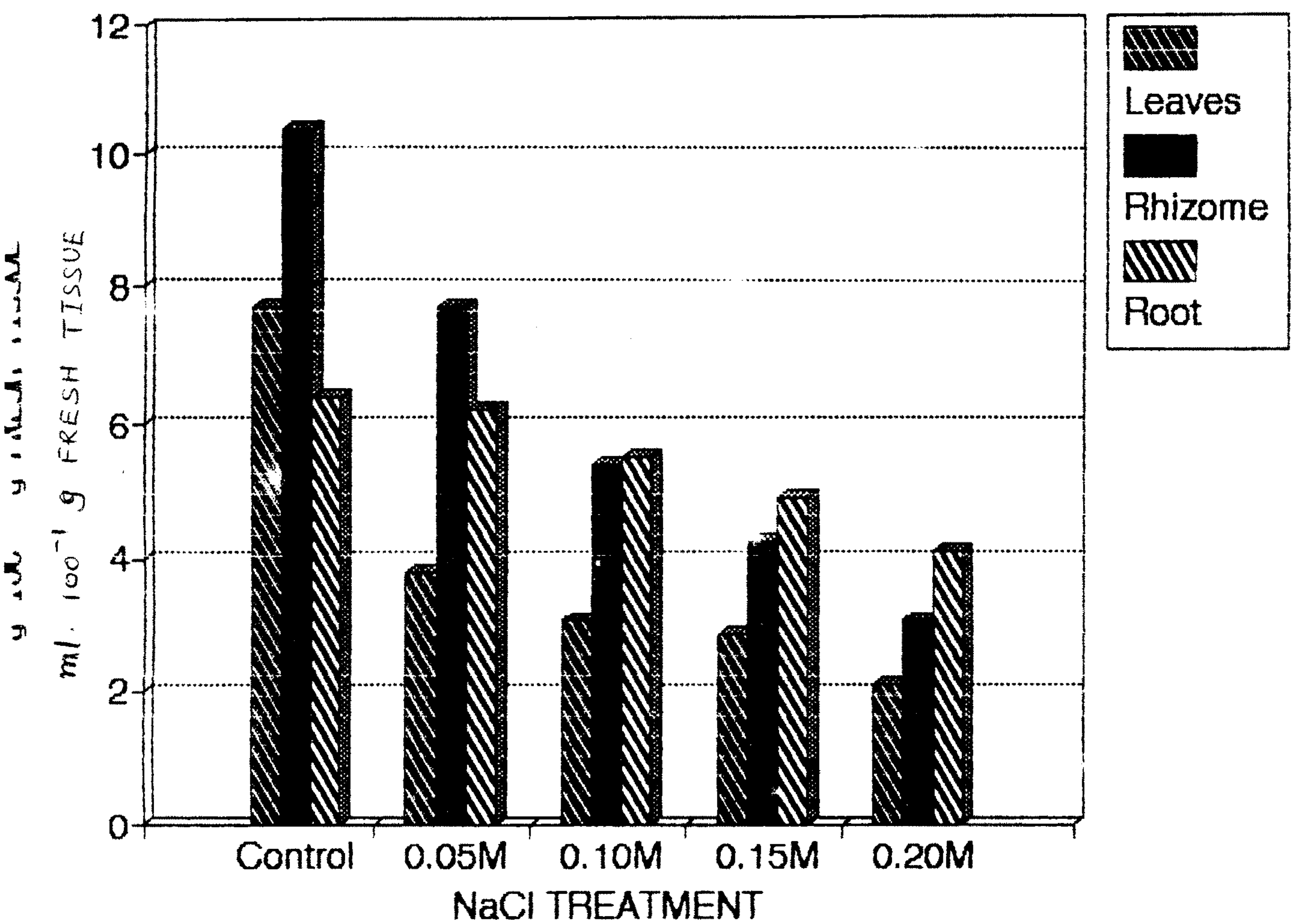

Fig.NO.7a Effect of various concentrations of NaCl salinity on TAN of Curcuma longa - Sugandhum variety.

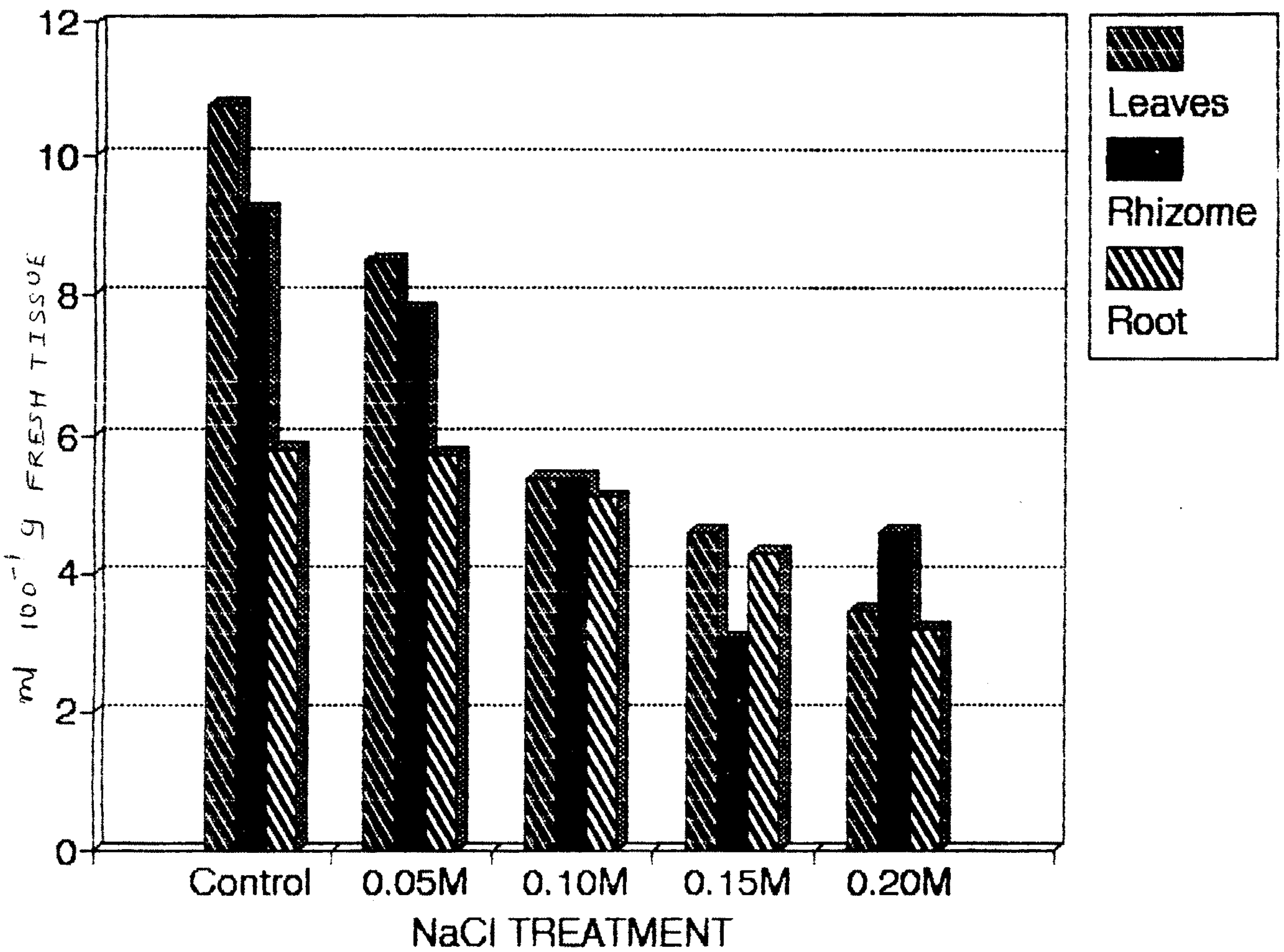

Fig.NO.7b Effect of various concentrations of NaCl salinity on TAN of *Curcuma longa* - Erode variety.

Similar results are observed by Bhandari (1988) in Capsicum annuum cultivar pant C1 and NP 46 A. She observed that there is ecrease in Titratable Acid Number value at all the Ece levels of salinity. There are some similar reports regarding the decrease in TAN observed by Azizbekova and Rasulova, (1972) in cotton, Flowers and Hall (1980) in Insuada maritima and Abdel - Rasoul et al., (1980) in Zea Mays.

There are some contradictory reports about the increase in TAN values under saline conditions. Rush and Epstein (1976) in tomato leaves, Downston and Loveys (1978) in grapeberry, Chavan (1980) in Ragi, Wallace et al., (1982) in Atriplex Polycarpa.

Our results indicates that there is decrease in TAN values due to NaCl salinity in Curcuma longa varieties. It is a causative factor for salt sensitive nature of these two varieties.

4) **POLYPHENOLS**

The influence of NaCl salinity on polyphenol content of Curcuma longa varieties - Sugamdhum and Erode leaves and rhizome is presented in the table No ...4... and Fig no. 8a,b . The table reveals that in the leaves of both the varieties salinity causes to decrease the polyphenol contents. As compared to control plants, in sugamdhum variety, the polyphenol content is slightly increased at 0.1M NaCl level. While in Erode variety the polyphenol content slightly increases at 0.2 M NaCl level.

As compared to control plants in the rhizome and roots of sugamdhum variety polyphenol content decreases due to NaCl salinity while in the rhizome and roots of Erode variety polyphenol content increases with increasing salinity level except at 0.05 M salinity level where it decreases slightly.

Very little attention has been paid towards the influence of salinity on the polyphenol metabolism in plants. Generally polyphenols are considered as aromatic compounds produced during secondary metabolism in plants.

Sadale (1989) in Crotolaria juncea and Walvekar (Personal communication, 1992) in Capsicum annuum hybrid varieties, observed a decrease in polyphenol content due to salinity.

Adverse effect of salinity on polyphenol contents of leaves is recorded by Karadge (1981) in Portulaca oleracea; Patil (1984) in groundnut and Krishnamoorthy and Siddique (1985) in cowpea. In salt sensitive cultivars of Panicum (MS - 1907) and Pennisetum (GHB - 81). Similar trend is observed by Gaikwad, (1989). Wadkar, (1989) observed a decrease in polyphenol content due to salt stress in C.Verrucosa and C.juncea leaves.
Jamale (1975) indicated that mangroves are rich in polyphenols. Similarly 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 the synthesis and

Table No : 4

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl SALINIITY ON POLYPHENOL CONTENT OF *Curcuma longa* - SUGAMDHUM AND ERODE.

Variety	Conc.n of NaCl	Leaves	Rhizome	Root
Sugamdhum	Control	2.25	1.9	1.50
	0.05M	2.15	1.6	1.20
	0.10M	2.60	1.1	1.60
	0.15M	2.35	1.3	1.68
	0.20M	2.00	1.7	1.73
Erode	Control	2.00	1.50	1.10
	0.05M	1.20	1.45	0.90
	0.10M	1.70	1.55	1.20
	0.15M	1.60	1.65	1.35
	0.20M	2.15	3.05	1.44

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

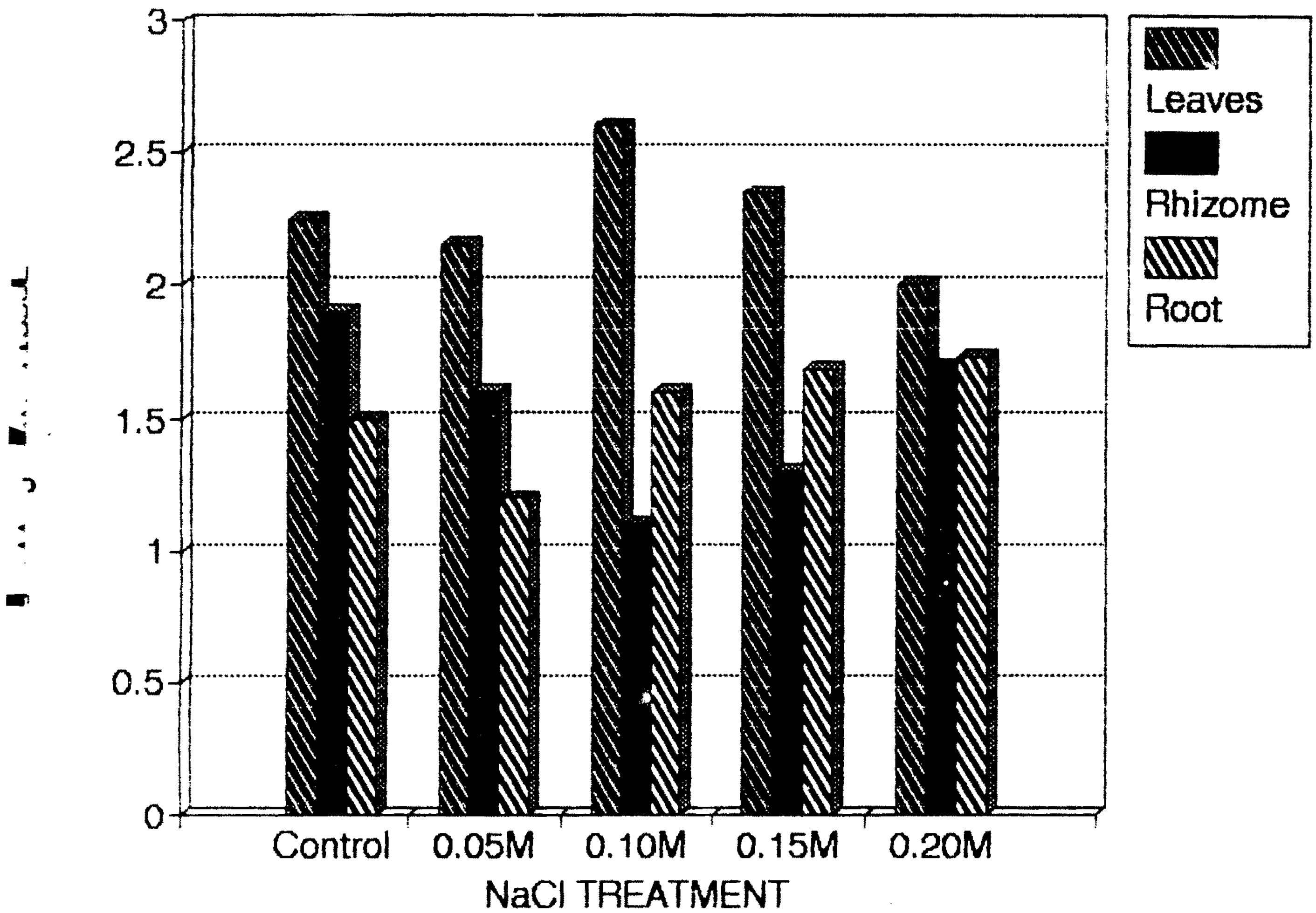

Fig.NO.8a Effect of various concentrations of NaCl salinity on polyphenol content of <u>Curcuma longa</u> - Sugandhum variety.

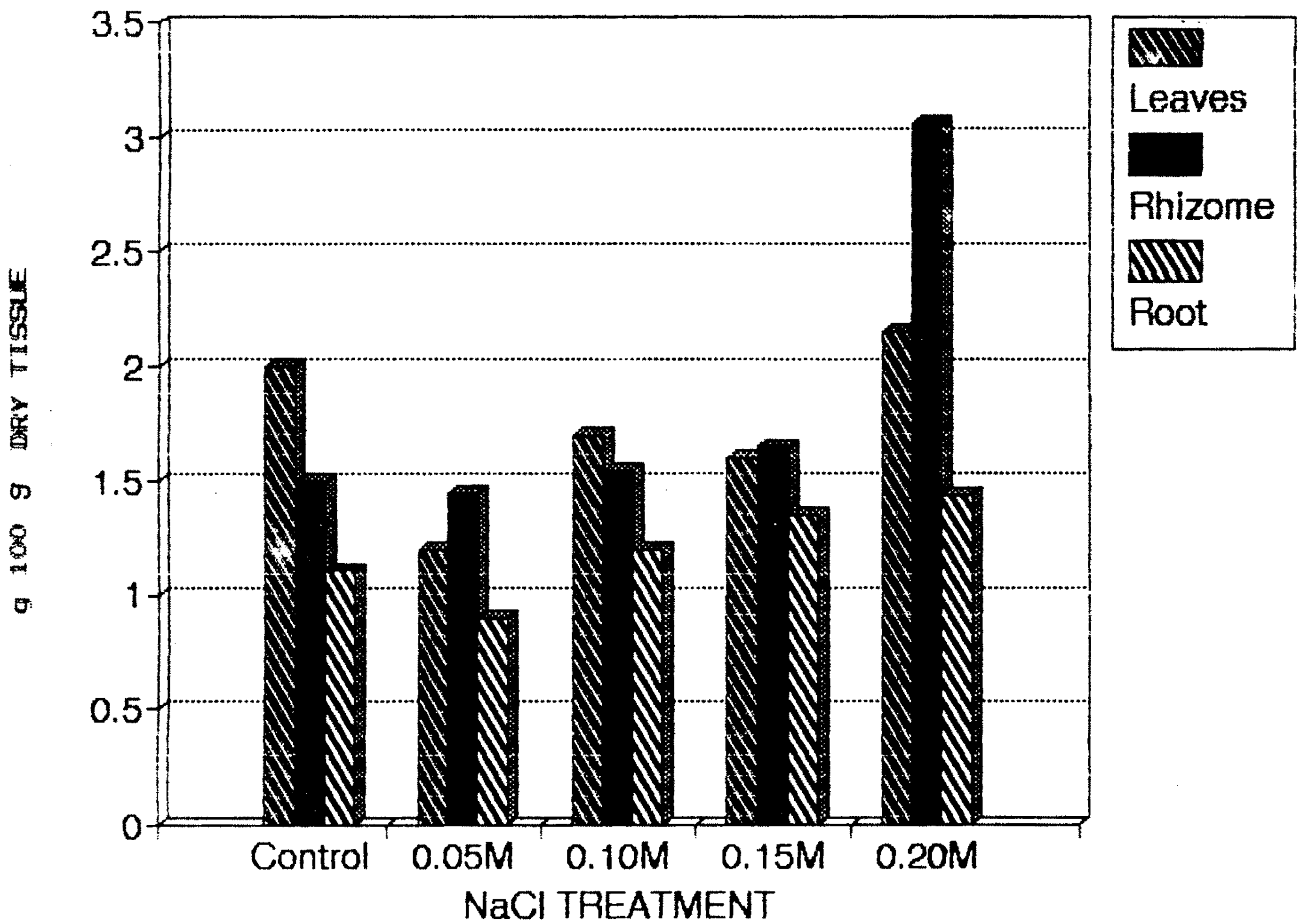

Fig.NO.8b Effect of various concentrations of NaCl salinity on polyphenol content of <u>Curcuma longa</u> - Erode variety.

accumulation of polyphenols in the leaves indicates, probably NaCl salinity induces the secondary metabolic changes which are apparently related to the salt tolerance capacity of the plants. Chavan (1980) observed considerable increase in polyphenol content of Eleusine coracana leaves due to chloride and sulphate salinities. Murumkar (1986) has also observed an increase in the level of polyphenols with salinity in chickpea.

From the present investigation, it is clear that decrease in polyphenol content due to salt stress is more pronounced in the leaves and rhizome of sugamdhum variety of Curcuma longa while in the rhizome of Erode variety, it is decreased. A slight increase in polyphenol content at 0.1 and 0.2 M NaCl in the leaves of Sugamdhum and Erode variety of Curcuma longa is observed. This indicates that the NaCl salinity induces the secondary metabolic changes in both the varieties.

5) **PROLINE**

The effect of NaCl salinity on proline content of Curcuma longa - varieties Sugamdhum and Erode is presented in the table No...5.... and fig no 9.a,.b. . As compared to control plants it is evident that the proline content is increased in the leaves and rhizome and roots of both the varieties due to increasing salinity levels. Only at the 0.15 M NaCl level it is slightly decreased in the rhizome of both the varieties.

A correlation between proline content and salt tolerance in Aster tripolium has been proposed by Goas (1968). In halophytic higher

Table No : 5

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl SALINITY ON PROLINE CONTENT OF *Curcuma longa* VARIETIES - SUGAMDHUM AND ERODE.

Variety	Conc.n of NaCl	Leaves	Rhizome	Root
Sugamdhum	Control	0.06	0.08	0.05
	0.05M	0.06	0.06	0.08
	0.10M	0.08	0.10	0.11
	0.15M	0.12	0.16	0.13
	0.20M	0.16	0.18	0.15
Erode	Control	0.06	0.08	0.05
	0.05M	0.08	0.08	0.06
	0.10M	0.10	0.12	0.08
	0.15M	0.10	0.16	0.13
	0.20M	0.12	0.26	0.19

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

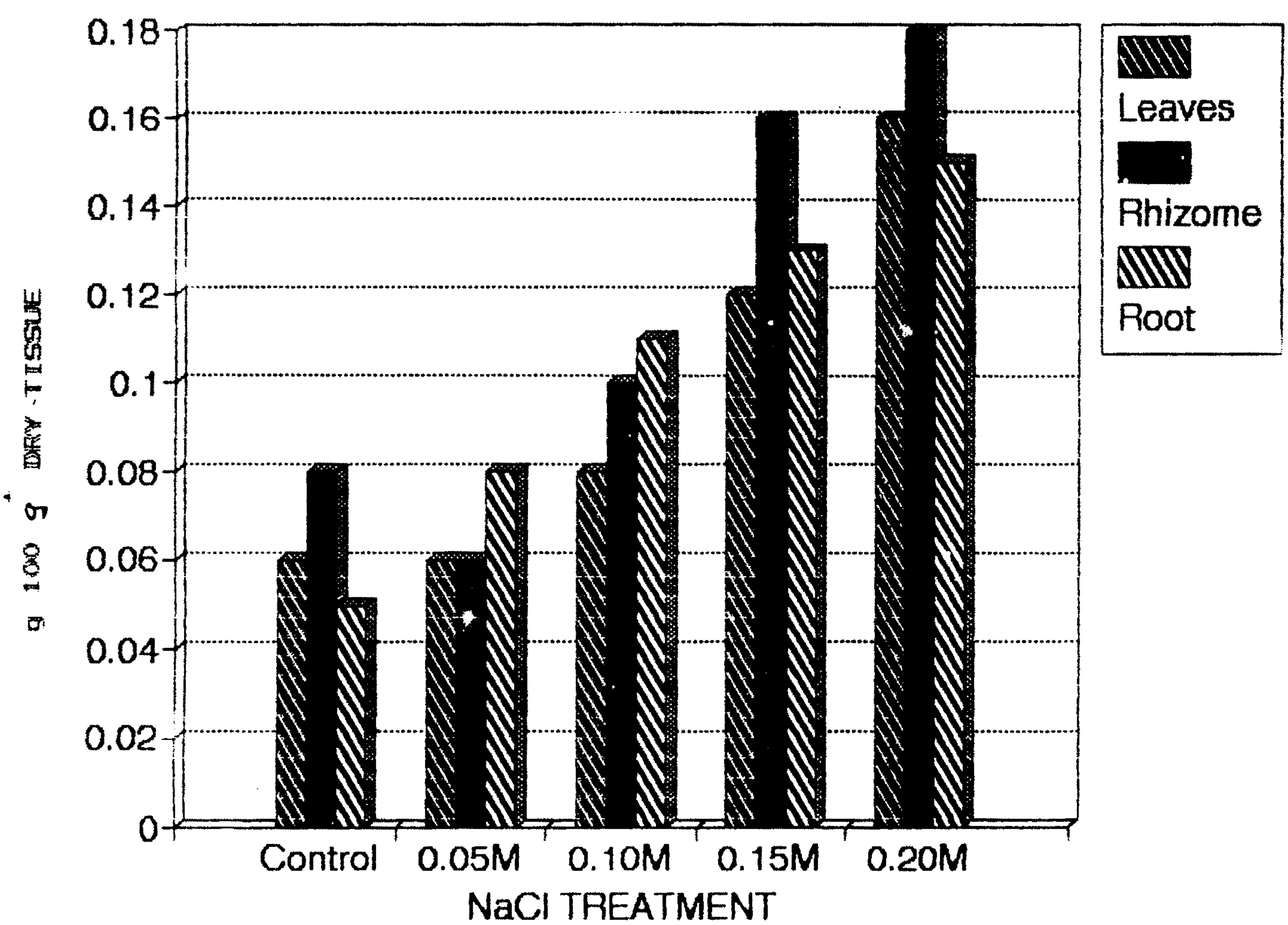

Fig.NO.9a Effect of various concentrations of NaCl salinity on proline content of <u>Curcuma longa</u> - Sugandhum variety.

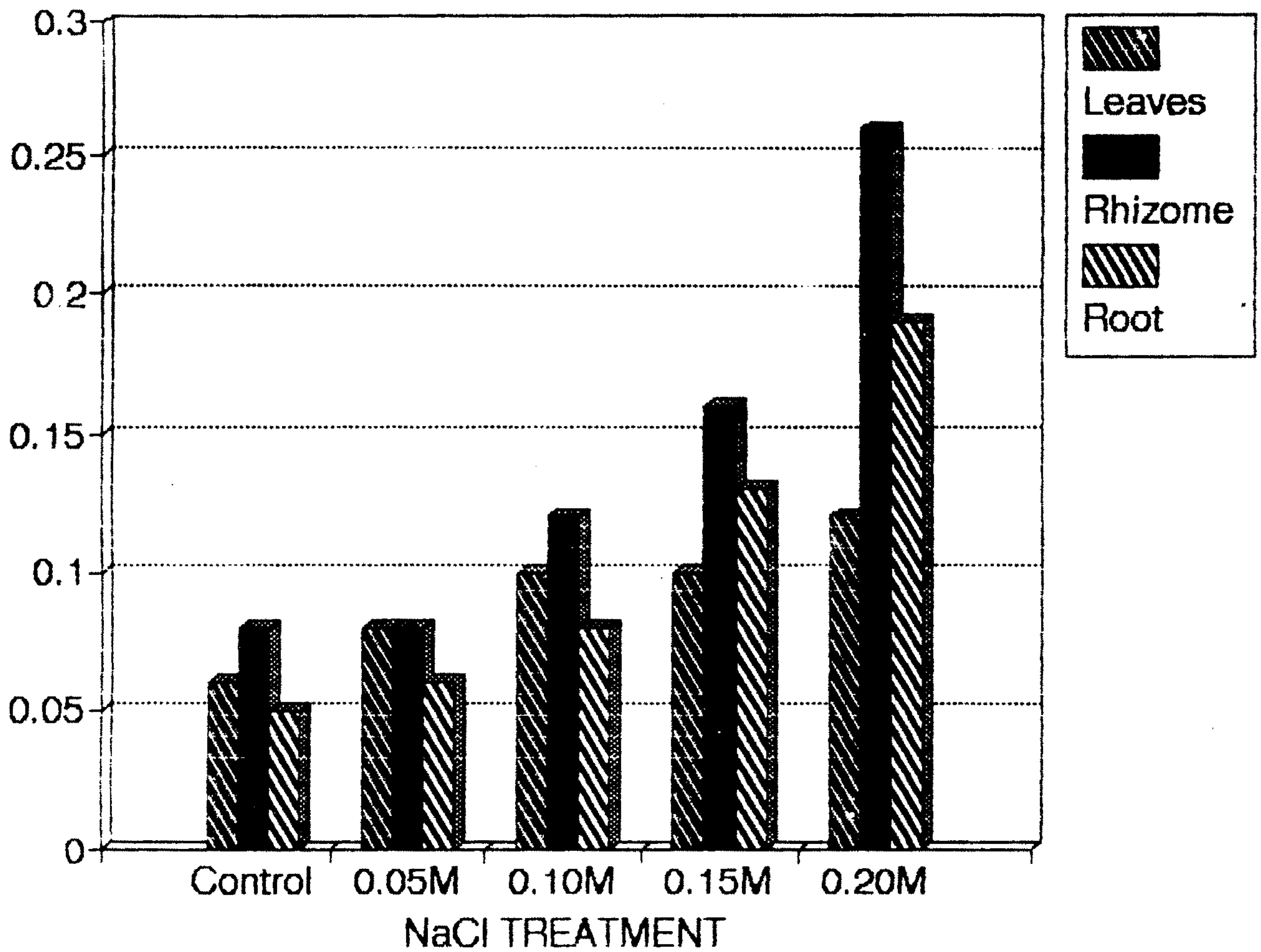

Fig.NO.9b Effect of various concentrations of NaCl salinity on proline content of *Curcuma longa* - Erode variety.

plants free proline has been found to vary with salt concentration (Stewart and Lee, 1974; Treichel, 1975). Although proline in glycophytes is usually negligible, the concentration increases in plants subjected to salinity (Palfi and Juhasz, 1970; Huber, 1974; Storey and Wyn Jones, 1975; chu et al., 1976).

Chauhan et al., (1980) noted that under salt stress conditions free proline accumulates in salt tolerant strains of barley and wheat, while in sensitive strains of both the crops it does not accumulate. Similarly proline accumulation due to salinity is also reported by Rajmane (1984) in Psophocarpus tetragonolobus; Chavan (1980) in Eleusine coracana and Karadge and Chavan, (1981) in groundnut.

Recently Ragab et al., (1988) noted that in Pisum sativum due to effect of soil salinity, plants which grown under relatively low saline condition, the proline content is affected and the response was greatly affected by the salt type. Pandey and Srivastava, (1990) reported that in paddy genotypes, proline content is significantly stimulated due to soil salinity and also an increase in leaf proline was greater in the tolerant genotypes of paddy than suceptible ones. Evidently proline accumulation may serve as one of the promising indices for breeding salt tolerant genotypes in rice.

There are some reports about the decrease in proline content due to salinity. A decrease in proline content under NaCl salinity is reported by Shevyukova and Kornizerko (1969) in callus of cabbege leaves, Totawat and Saxena (1971) in Phaseolus aureus, Stewart and Lee (1974) in Plantago and Joshi and Naik, (1980) in sugarcane.

From the present investigation it is clear that there is an increase in proline content in the leaves and rhizome of both the varieties of Curcuma longa. In the rhizome of both the varieties accumulation of proline is more than that in leaves. It is also found that eventhough proline content increases under saline conditions in both the varieties of Curcuma longa yet productivity decreases. These results suggest that increased proline due to NaCl salinity is for maintainance of growth as suggested by Greenway and Munn (1980).

6) NITROGEN METABOLISM

i) Total Nitrogen :-

The effect of NaCl salinity on total nitrogen content of the two varieties of Curcuma longa - Sugamdhum and Erode is presented in the Table No..6.... and fig No..10a.,b. . The table reveals that nitrogen content is linearly increased in the leaves of both the varieties grown in the medium at various concentrations. In the rhizome of Sugamdhum variety nitrogen content decreases due to NaCl salinity. While in the rhizome of Erode variety nitrogen content increases at all the levels of NaCl salinity. Except at 0.05 M salinity level it is slightly decreased. In the roots of Sugamdhum variety nitrogen content is decreased at all the levels of NaCl salinity. While in the Erode variety it increases due to salinity.

Table No : 6

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl SALINITY ON NITROGEN CONTENT OF *Curcuma longa* VARIETIES - SUGAMDHUM AND ERODE.

Varieties	Conc.n of NaCl	Leaves	Rhizome	Root
Sugamdhum	Control	0.25	1.4	0.90
	0.05M	0.70	0.7	0.88
	0.10M	1.00	1.2	0.81
	0.15M	0.50	1.3	0.72
	0.20M	1.00	1.4	0.64
Erode	Control	0.35	0.35	0.2
	0.05M	0.50	0.25	0.21
	0.10M	1.00	0.50	0.28
	0.15M	0.70	1.00	0.32
	0.20M	1.20	0.50	0.40

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

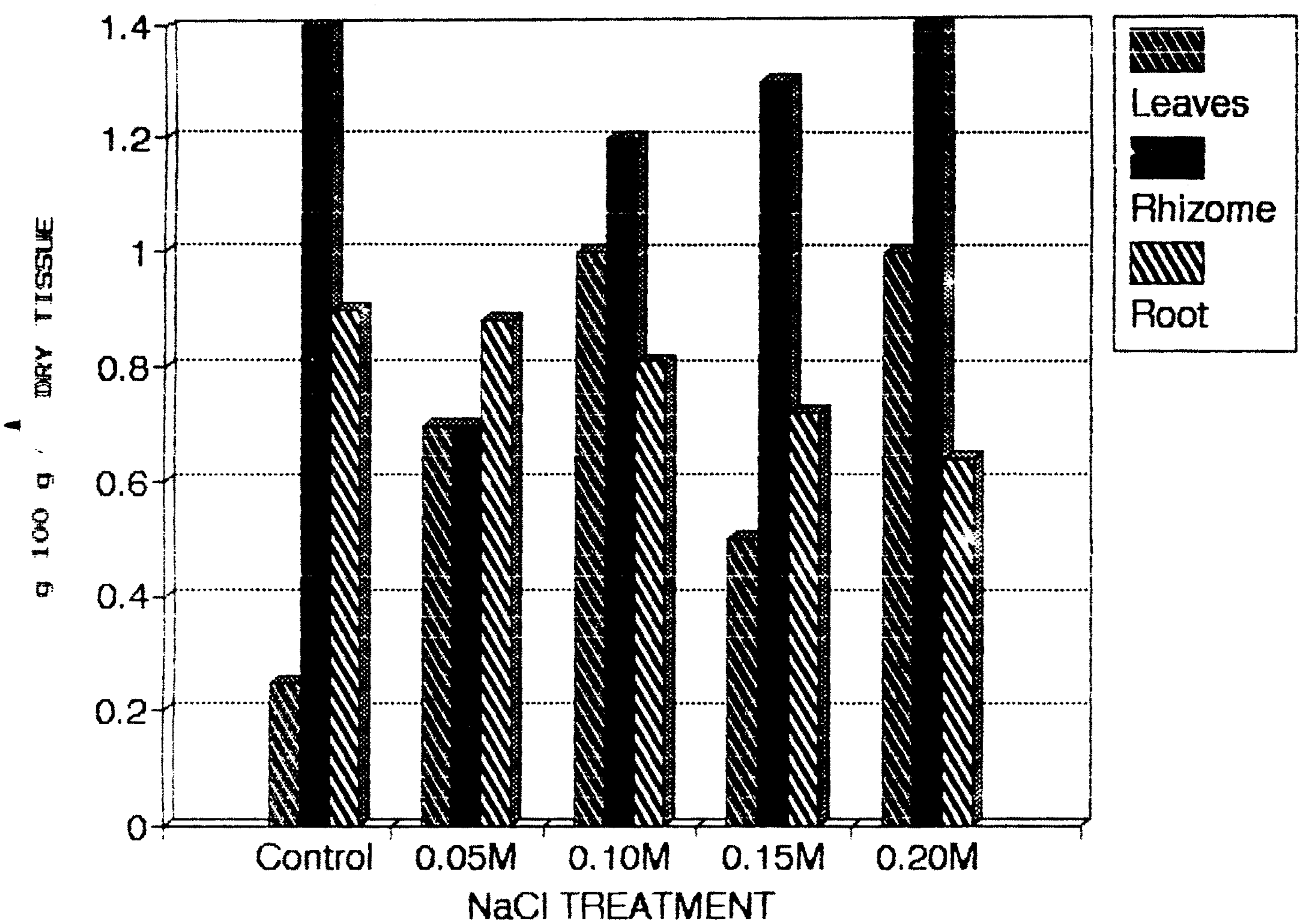

Fig.NO.10a Effect of various concentrations of NaCl salinity on nitrogen content of *Curcuma longa* -Sugandhum variety

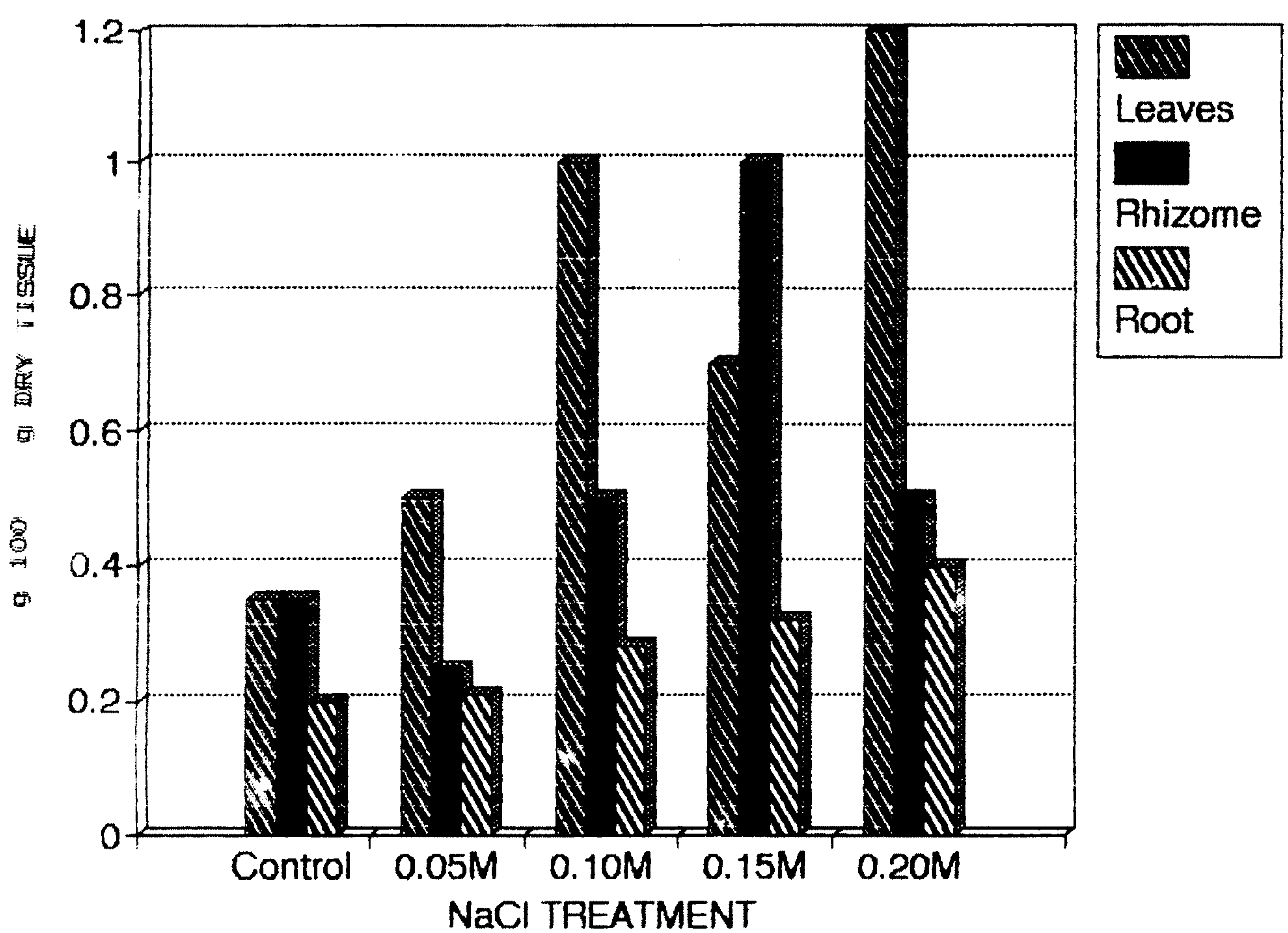

Fig.NO.10bEffect of various concentrations of NaCl salinity on nitrogen content of Curcuma longa -Erode variety.

Ravikovitch and Yoles (1975) have noticed that the nitrogen content rises with an increase in salinity level in Setaria italica sp., Orygopsis, miliace, Crotolaria aegyptiaca, Medicago sativa and Chloris gayara. Jadhav et al., (1976) noticed that total nitrogen content at maturity increases with salinity in wheat cultivar, sonora-64. Chavan (1980) has studied the effect of NaCl salinity on total nitrogen content of Eleusine coracana and found that total nitrogen content of the leaves and stem increased considerably due to NaCl salinity. Aphale (1978) in Setaria italica observed an increase in nitrogen content in the leaves.

There are many reports about increase in nitrogen content due to NaCl salinity. Ashour et al., (1977) also observed that chloride salinity causes to increase the concentrations of protein and total nitrogen in the wheat shoots. Similar observations were made by Abdel - Rahman et al., (1980) in some desert fodder plants, Smith et al., (1980) in rye grass and Phleum pratense, Rajmane (1984) in winged beans, Murumkar (1986) in Chickpea and Chippa and Lal (1985) in wheat.

There are many reports about decrease in nitrogen content. According to Strogonov (1964), nitrogen metabolism is the main target of salt injury in plants. A decrease in total nitrogen content due to salinity is reported by number of workers. Balasubramanian and Sinha (1976) studied the effect of salt stress on growth, nodulation and nitrogen fixation in Cowpea and mungbeans.

They observed that total nitrogen content of plant parts decreases due to salt treatment.

Lal and Bhardwaj (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 Uptrey and Sarin (1976) in Pisum sativum. Masshady et al., (1982) in wheat and triticales, Patil and Patil (1983) in Syzygium roots; Singleton and Bohool (1984) in the leaves of Sesbania and by Mahmoud and Abdel (1985) in soybean Cooper and Dumbroff (1973), Syed and Swaify (1973) Singh et al (1974) and content due to salinity in tomato, bean, sugarcane, rice and rhodes grass respectively. Similar observations have been made by Karadge (1981) in Portulaca oleracea and Bhivare and Nimbalkar (1983) in Phaseolus vulgaris cv. Vaghya.

From our present results it is observed that there is increase in nitrogen in the leaves at all the levels of salinity in both the varieties Sugamdhum and Erode.

In the rhizome of variety Erode there is slight decrease in nitrogen content only at 0.05 M NaCl salinity level and an increase at all other levels of NaCl salinity. While in Sugamdhum rhizome nitrogen content is decreased at all the levels of NaCl salinity.

In the roots of Sugamdhum variety it is decreased at all the levels of salinity while in Erode roots it is increased under the saline conditions.

From these results it indicates that the leaves and rhizome of Sugamdhum and Erode accumulate more nitrogen. Except in Sugamdhum rhizome where there is a decrease in nitrogen content at all the levels of salinity. In the roots of Sugamdhum nitrogen content decrease at all the levels of salinity while in Erode roots it increases at all the levels of salinity than the Erode variety. It is the adaptive feature towards the salt tolerance of the plant.

7) **CARBOHYDRATES**

The effect of various concentrations of NaCl on carbohydrate metabolism of Curcuma longa varieties - Sugamdhum and Erode has been recorded in the Table No ..7..... and fig No 11,10,15 . The table reveals that as compared to control plants in Sugamdhum leaves, there is a decrease in reducing sugars, total sugars and total carbohydrates at all the levels of NaCl salinity and starch content is linearly decreased at all the levels of salinity. In the Sugamdhum rhizome, reducing sugars and total sugars are decreased at lower levels of NaCl salinity. Except at 0.05 M level it is slightly increased.

In the Sugamdhum roots, total sugars, starch and total carbohydrates are increased with increasing levels of salinity. Reducing sugars are increased at all the levels of salinity.

In the Erode leaves, reducing sugars, total sugars, starch and total carbohydrates are decreased at all the levels of NaCl salinity. In the rhizome of Erode variety reducing sugars and

Table No :7

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl SALINITY ON CARBOHYDRATE CONTENT OF *Curcuma longa* VARIETIES - SUGAMDHUM AND ERODE.

Varieties	Conc.ns of NaCl (M)	Reducing Sugars	Total Sugars	Starch	Total Carbohydrate
Sugamdhum Leaves	Control	0.500	0.600	2.640	3.200
	0.05	0.168	0.246	2.400	2.640
	0.10	0.238	0.320	2.048	2.368
	0.15	0.240	0.410	2.528	2.910
	0.20	0.210	0.520	2.384	2.904
Sugamdhum Rhizome	Control	0.072	0.075	2.800	2.875
	0.05	0.062	0.068	2.960	3.028
	0.10	0.069	0.072	2.342	2.414
	0.15	0.128	0.150	1.803	1.953
	0.20	0.178	0.220	1.640	1.860
Sugamdhum Roots	Control	0.03	0.068	1.80	1.860
	0.05	0.034	0.065	1.71	1.770
	0.10	0.040	0.060	1.52	1.580
	0.15	0.048	0.056	1.44	1.490
	0.20	0.052	0.053	1.32	1.370
Erode Leaves	Control	0.312	0.426	2.544	2.970
	0.05	0.120	0.172	2.176	2.348
	0.10	0.190	0.250	2.064	2.314
	0.15	0.230	0.280	2.304	2.584
	0.20	0.270	0.320	2.368	2.400
Erode Rhizome	Control	0.023	0.280	2.80	3.080
	0.05	0.101	0.310	2.32	2.630
	0.10	0.096	0.350	2.64	2.990
	0.15	0.072	0.430	3.14	3.570
	0.20	0.066	0.480	3.30	3.780

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

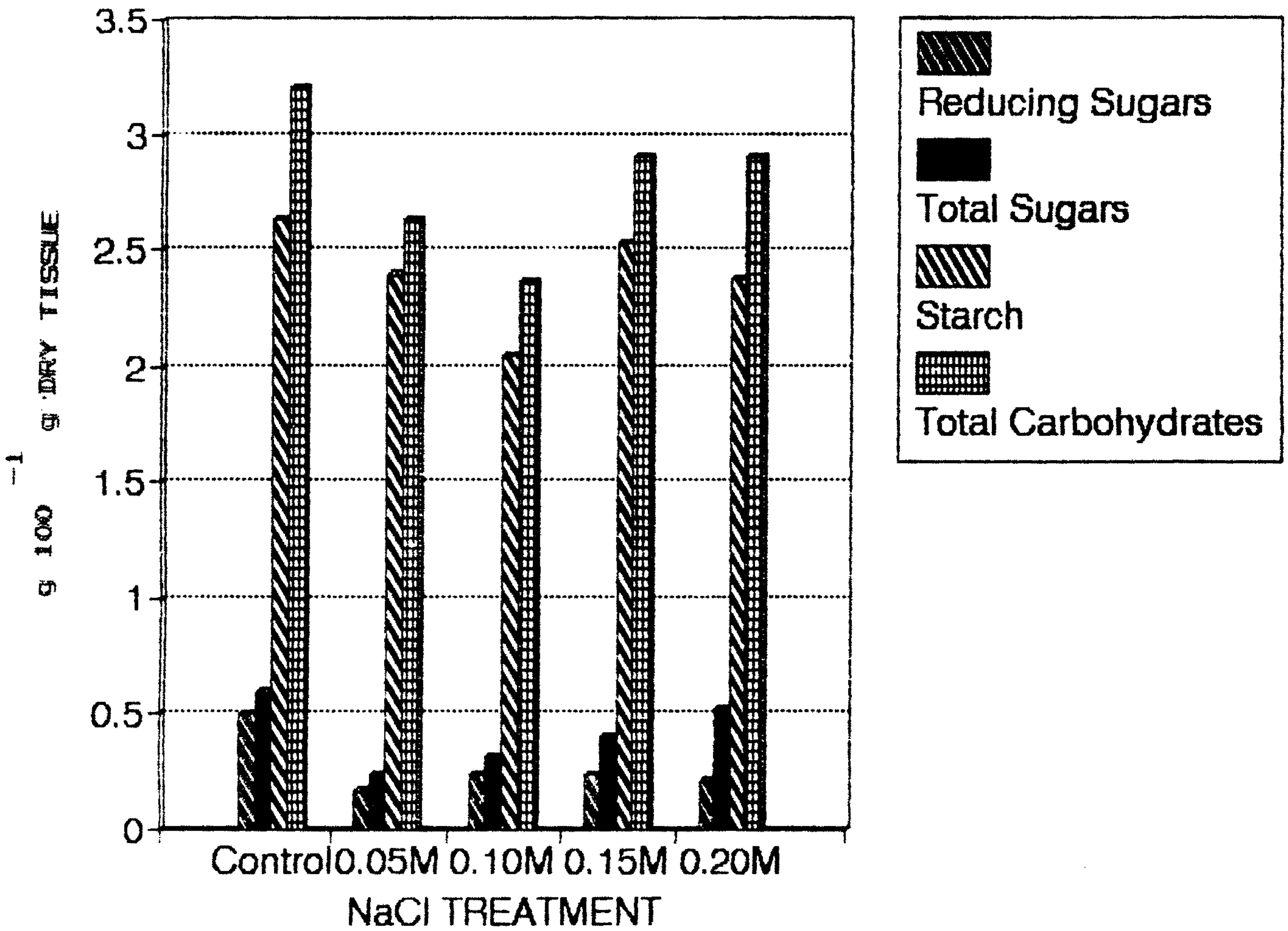

Fig.NO.11 **Effect of various concentrations of NaCl salinity on carbohydrate content** of *Curcuma longa* -variety Sugamdhum leaves.

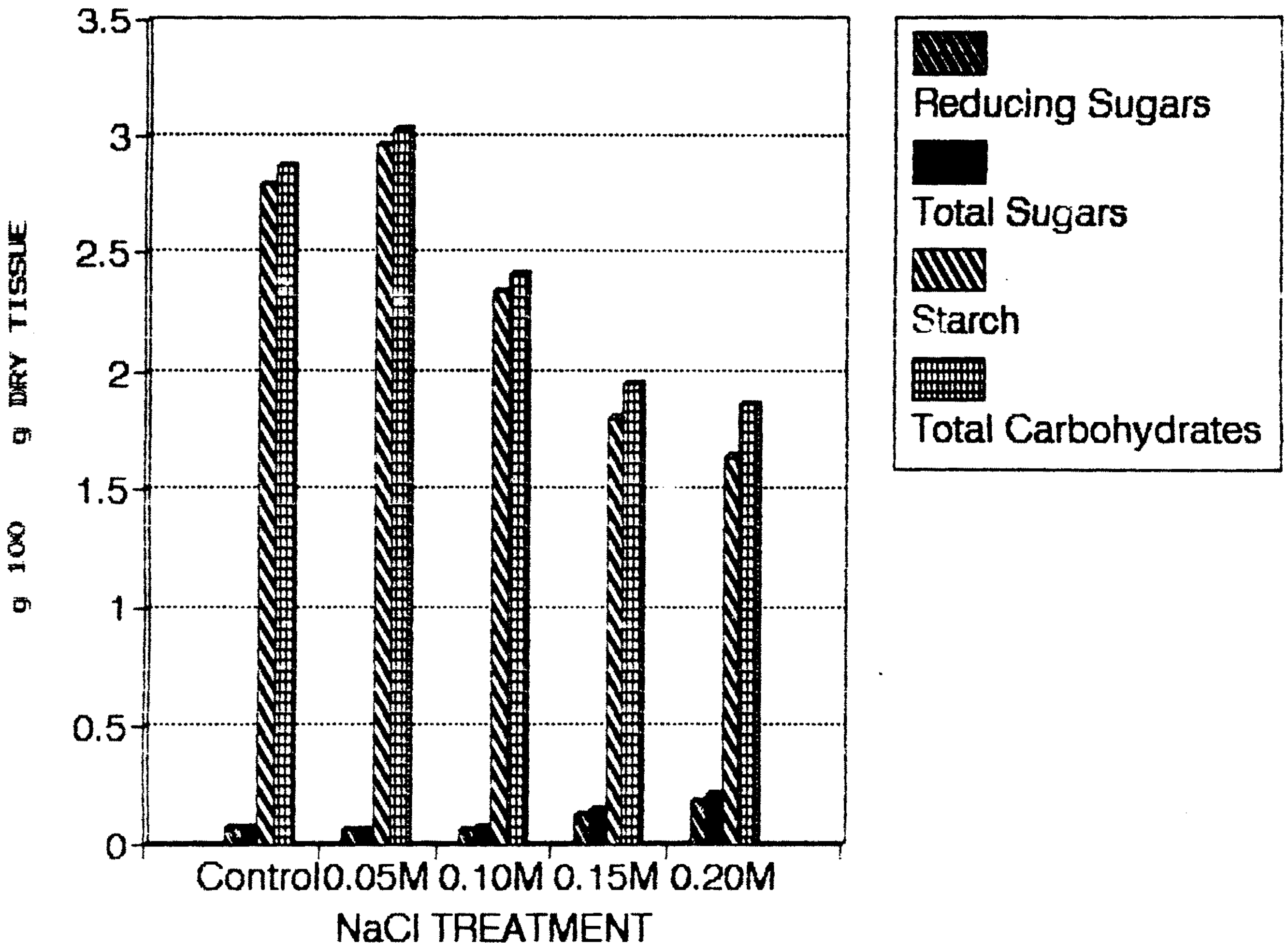

Fig.NO.12 Effect of various concentrations of NaCl salinity on carbohydrate content of *Curcuma longa* -variety Sugamdhum rhizome.

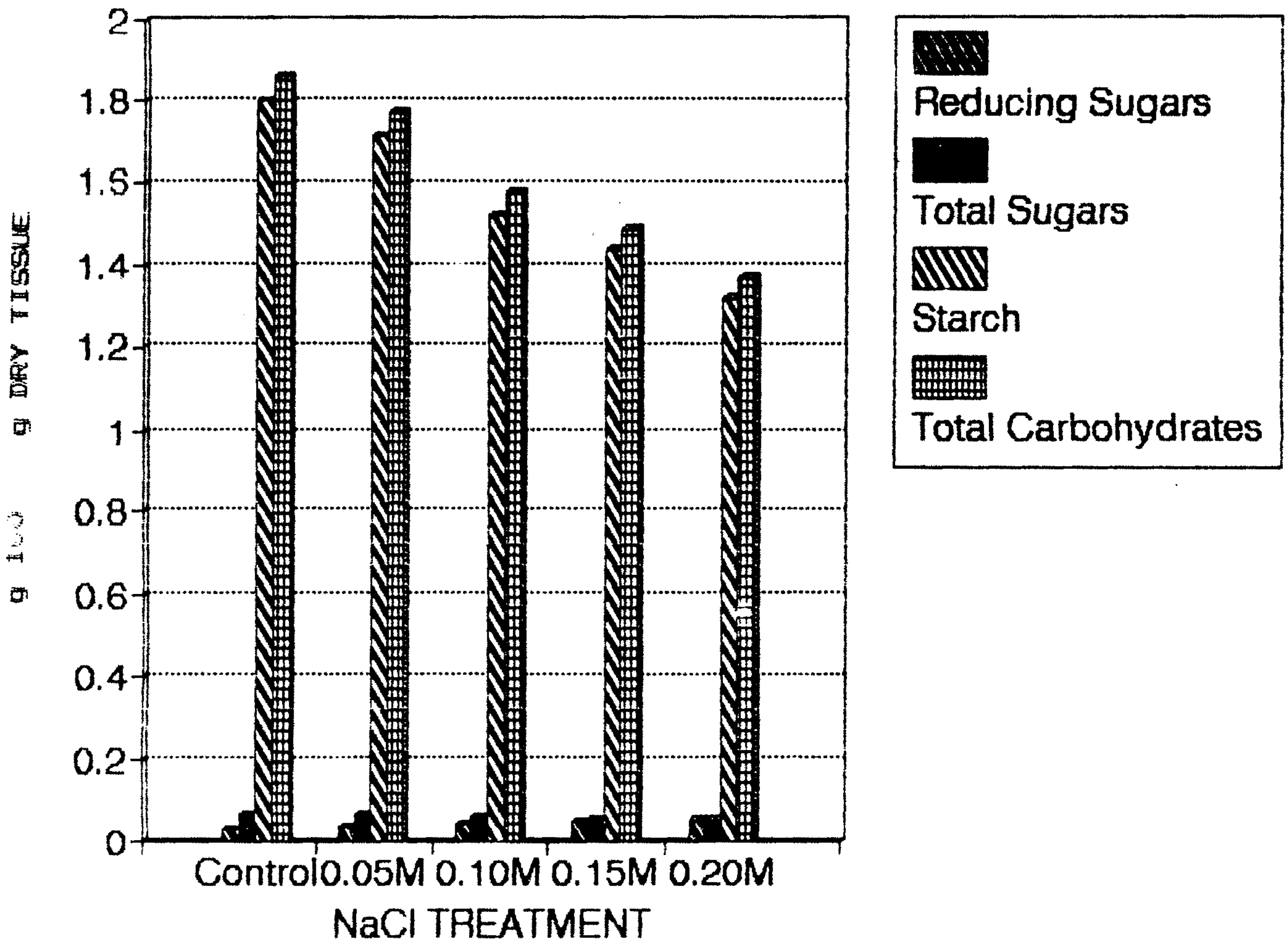

Fig.NO.13 Effect of various concentrations of NaCl salinity on carbohydrate content of Curcuma longa -variety Sugamdhum root.

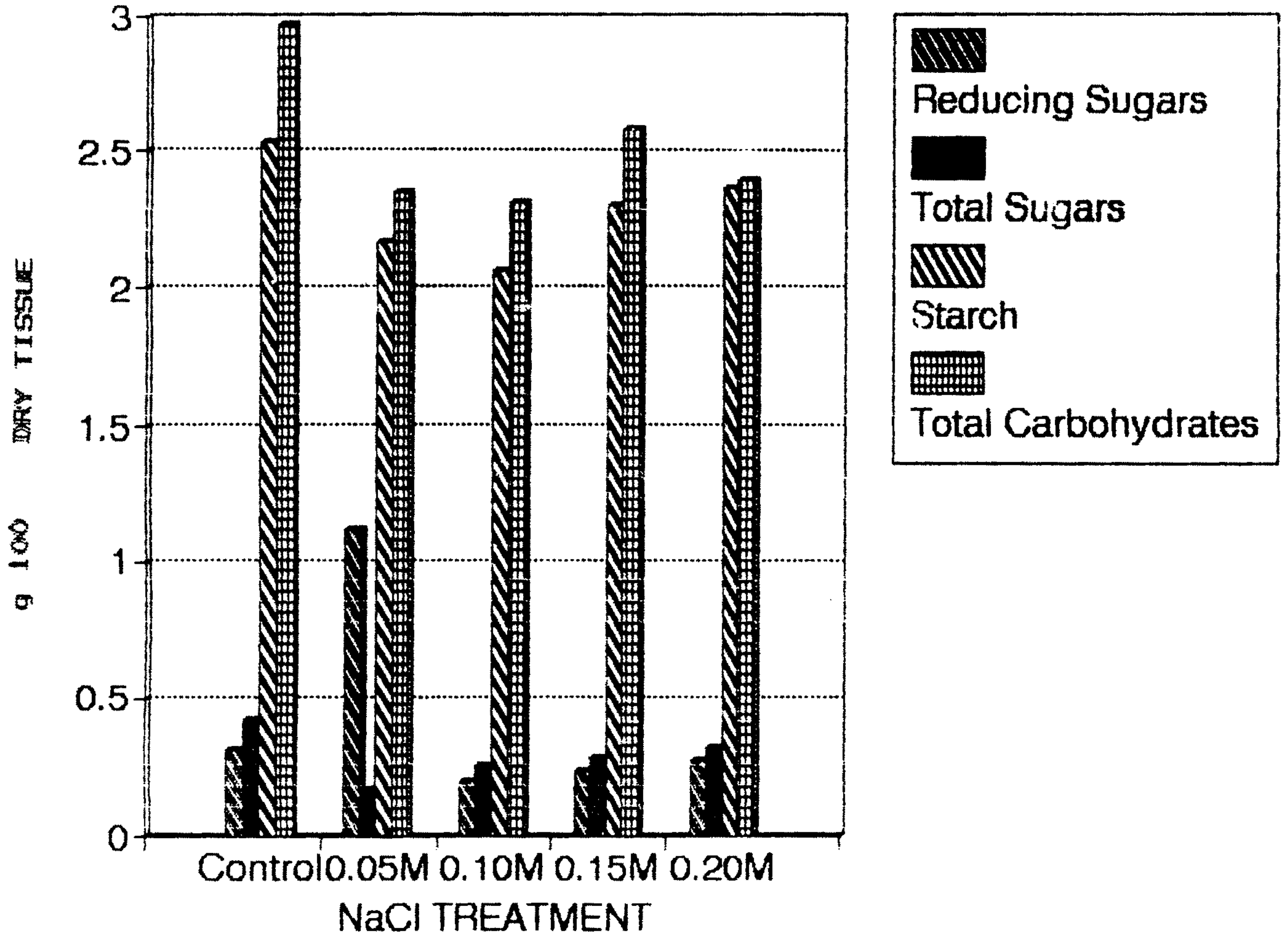

Fig.NO.14 Effect of various concentrations of NaCl salinity on carbohydrate content of Curcuma longa -variety Erode leaves.

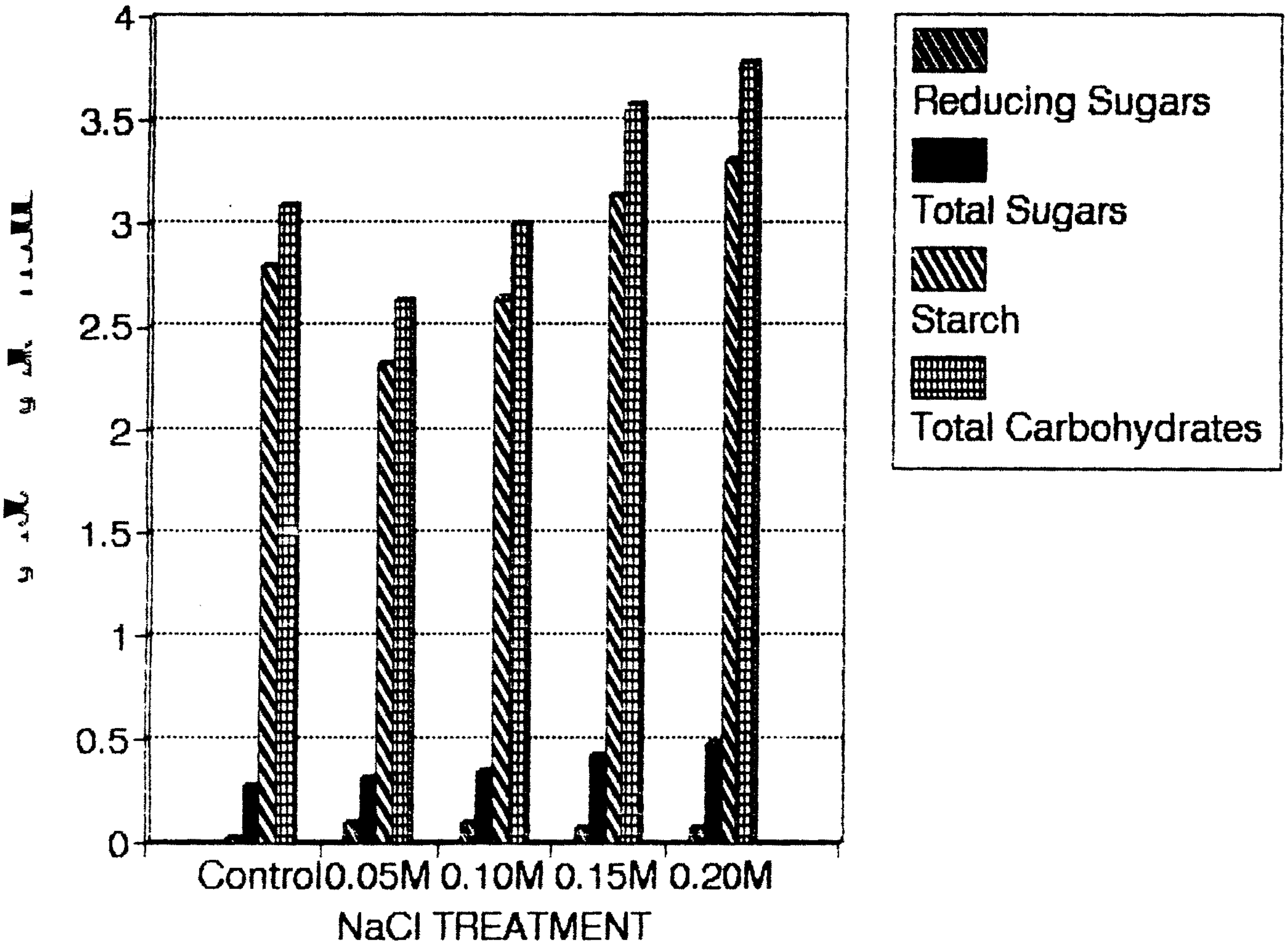

Fig.NO.15 Effect of various concentrations of NaCl salinity on carbohydrate content of Curcuma longa -variety Erode rhizome.

total sugars are increased at all the levels of NaCl salinity. Starch and total carbohydrates are decreased at lower levels and increased at higher levels of NaCl salinity.

In the Erode roots, reducing sugars and total sugars are increased as the level of NaCl salinity increases. Starch content is decreased at lower levels and increased at higher levels of NaCl salinity. Total carbohydrates are increased as the levels of salinity increases except at 0.1 M level it is slightly decreased

There are some reports regarding the enhancement of carbohydrate metabolism in various crop plants due to salinity is credited to Hayward and Long (1941), Gauch and Eaton (1942), Mass (1945) and Bernstein and Hayward (1958). Strogonov (1964) has also observed an increase in glucose and fructose concentration in maize sap due to salinity. Meiri et al. (1971) reported an increase in sugar percentage in bean plants under Chloride salinity.

Ahmed and Abdulla (1982) reported an increase in the level of reducing sugars in potato due to NaCl 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). Malik et al. (1983) reported that the content of total and reducing sugars was increased in radish and turnip due to salinity.

There are some reports regarding the negative action of salt on the carbohydrate metabolism of various plants. Thus, El-Saidi and Nawash (1971) reported that there is a decline in carbohydrates content in the leaves and stems of Hibiscus Sps. due to saline water. Briens (1982) noted a reduction in synthesis in sucrose and starch in Suaeda macrocarpa. Shimose (1973) reported that in Medicago sativa, the carbohydrate content declines due to chloride salinity. However, very little decrease in starch content was observed in lettuce and spinach plants by Matar et al. (1975). Deshpande (1981) has reported a decrease in the level of total sugar and starch except reducing sugars in pigeon pea under saline conditions. Malik et al., (1983) reported that the total and reducing sugar content is decreased in carrot due to salinity.

Our results indicates that the carbohydrate metabolism is disturbed in the different parts of Curcuma longa. Reducing sugars, total sugars, starch, starch and total carbohydrates were differently affected in different parts of Curcuma longa varieties under NaCl salinity. It is also observed that as compared to Sugamdhum variety, Erode variety, Erode variety accumulated more reducing sugars, total sugars, starch and total carbohydrate under saline conditions. Mostly these contents are decreased in the leaves, rhizome and roots of both the varieties under NaCl salinity. Sometimes these contents are increased at higher level of salinity in both the varieties.

8) **MINERAL NUTRITION**

A] Introduction

Plants need light, water, Co_2, and O_2 for the development and growth. However only these things are not sufficient. Besides, plants also need various mineral elements for normal growth and development. All such elements are called as essential elements. Thus mineral nutrients are essential for almost every aspect of plant growth and metabolism.

The plant nutrients may be divided into, "Macronutrients" and "Micronutrients". Macronutrients are found and needed in plants in relatively higher amounts than micronutrients. Based on the elements content of plant material C,H,O,N,P,S,K,Ca,Mg, (Na, Si) may be defined as macronutrients. The micronutrients are Fe^{3+} Mn^{2+}, Cu^{2+}, Zn^{2+}, Mo, B and Co.

The material of living plants consists of organic matter, water and minerals. For green plant material water is always present in the higher proportion (70%) and the mineral in the lowest (3%). The remaining (27%) make up only comparitively small proportion of dry matter. The mineral content of plants and plant organs is of physiological and practical significance.

Mineral contents differ considerably in different plant organs. Generally the vegetative parts of plant such as leaves, stem and roots vary to a higher extent in their mineral composition than fruits, seeds, tubers and seeds. The plant supplies its fruits or seeds with minerals and organic material at the expense of plant organs.

The main factor controlling the mineral content of the plant material is the specific genetically fixed nutrient uptake potential for the different mineral nutrients. This accounts for the fact that the N and K contents of green plant material are about 10 times higher than those of P and Mg which in turn are about 100 to 1000 times higher than the content of the micronutrients. This general pattern occures in all species of higher plants. Within the plant species, however, considerable differences in the mineral contents do occure, which are also genetically determined (Collander, 1941). It has frequently been observed that in dicotyledonous plants there is generally a large ratio of divalent to monovalent cations than in monocotyledonous plants.

The second factor controlling the mineral content of the plant material is the availability of plant nutrients in the nutrient medium. The higher or lower concentration of a particular mineral or nutrient in the medium adversely afects growth and development of a plant. Soil deficient in one or the other mineral nutrients or soil with excess salts are harmful for normal functioning of plants.

The mineral content of plants is also very much dependent on age of a plant or organ. Young plant and young plant parts usually have high concentrations of N,P and K. Older plants or more mature plant parts are usually rich in elements like Ca^{2+}, Mn^{2+}, Fe^{3+} and B (Smith, 1962). Usually more essential inorganic nutri ents are withdrawn from the older parts of a plant and translocated to the young growing plant parts.

B] **SALINITY AND MINERAL NUTRITION**

Influence of NaCl salinity on mineral constituents in different parts of Curcuma longa varieties Sugamdhum and Erode is recorded in Table ...8...... and fig ..16.TO.37.. . It is evident that salinity exerts a remarkable influence on the uptake and distribution of mineral nutrients in different parts of this plant.

[i] Na^{+} and Cl^{-}

It is clear from the results, Na^{+} and Cl^{-} are more in the leaves rhizome and roots of the plant with increasing concentration of NaCl salinity in the medium. There is accumulation of both the elements in all parts of the plant (Table No..8......). It is evident that as compared to control plants Na^{+} content increases varieties. In Erode leaves Na^{+} content slightly decreases at 0.1M NaCl concentration.

In the rhizome, Na^{+} content is increased by increasing salinity level both the varieties. Only in Sugamdhum rhizome at 0.15 M level it decreases slightly. It is apparent that due to salinity Na^{+} is accumulated more in the leaves than the rhizome and roots of the plant. This is suggestive of stimulation of translocation of this nutrient to the active part of the plant i.e. leaf. This can be considered as one of the adaptive features of Curcuma longa.

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; Ackerson and Youngner, 1975, in bean; Lessani and Marshner, 1978, in various

Table 8 :-

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl SALINITY ON MINERAL COMPOSITION OF <u>Curcuma longa</u> SUGAMDHUM VARIETY.

Mineral Element	NaCl treatment (M)				
	Leaf				
	C	0.05 M	0.10 M	0.15M	0.20 M
Na^{+}	0.0080	0.0100	0.008	0.012	0.014
Cl^{-}	2.1400	1.6000	2.140	2.680	3.210
K^{+}	0.0960	0.1760	0.114	0.146	0.174
Ca^{2+}	0.8016	0.8016	1.206	1.603	1.603
Mg^{2+}	0.6091	1.2180	1.218	1.705	1.949
P^{5+}	0.4750	0.2500	0.250	0.375	0.350
Fe^{3+}	0.1000	0.0400	0.080	0.120	0.140
Mn^{2+}	0.0102	0.0274	0.027	0.028	0.028
Cu^{2+}	0.0434	0.0022	0.004	0.004	0.004
Zn^{2+}	0.0162	0.0024	0.0028	0.002	0.003

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

Table 8 :-

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl SALINITY ON MINERAL COMPOSITION OF <u>Curcuma longa</u> SUGAMDHUM VARIETY.

Mineral Element	NaCl treatment (M)				
	Rhizome				
	C	0.05 M	0.10 M	0.15M	0.20 M
Na^{+}	0.008	0.008	0.006	0.004	0.007
Cl^{-}	0.320	0.420	0.530	0.640	0.750
K^{+}	0.066	0.064	0.058	0.048	0.054
Ca^{2+}	0.400	0.601	1.002	1.202	1.402
Mg^{2+}	1.461	0.609	1.218	1.340	2.192
P^{5+}	0.350	0.300	1.275	0.275	0.250
Fe^{3+}	0.060	0.060	0.080	0.084	0.092
Mn^{2+}	0.027	0.025	0.030	0.028	0.037
Cu^{2+}	0.015	0.004	0.001	0.021	0.054
Zn^{2+}	0.027	0.025	0.024	0.036	0.045

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

Table 8 :-

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl SALINITY ON MINERAL COMPOSITION OF <u>Curcuma longa</u> SUGAMDHUM VARIETY.

Mineral Element	NaCl treatment (M)				
	Root				
	C	0.05 M	0.10 M	0.15M	0.20 M
Na^+	0.005	0.005	0.005	0.006	0.006
Cl^-	0.250	0.280	0.320	0.380	0.450
K^+	0.052	0.049	0.045	0.041	0.038
Ca^{2+}	0.300	0.320	0.410	0.520	0.600
Mg^{2+}	0.900	0.930	0.980	1.200	1.500
P^{5+}	0.250	0.230	0.200	0.150	0.100
Fe^{3+}	0.030	0.035	0.041	0.045	0.055
Mn^{2+}	0.016	0.017	0.018	0.019	0.024
Cu^{2+}	0.001	0.001	0.001	0.001	0.0017
Zn^{2+}	0.018	0.019	0.02	0.025	0.0264

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

Table 8 :-

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl SALINITY ON MINERAL COMPOSITION OF <u>Curcuma longa</u> ERODE VARIETY.

Mineral Element	NaCl treatment (M)				
	Leaf				
	C	0.05 M	0.10 M	0.15M	0.20 M
Na^{+}	0.008	0.012	0.010	0.012	0.014
Cl^{-}	1.600	2.140	2 680	3.110	3.430
K^{+}	0.136	0.126	0.158	0.142	0.178
Ca^{2+}	1.202	1.603	0.801	1.202	2.004
Mg^{2+}	0.974	5.360	3.411	2.192	1.690
P^{5+}	0.250	0.250	0.200	0.275	0.300
Fe^{3+}	0.120	0.160	0.220	0.230	0.320
Mn^{2+}	0.040	0.039	0.034	0.037	0.0402
Cu^{2+}	0.004	0.004	0.004	0.0044	0.005
Zn^{2+}	0.004	0.004	0.004	0.0084	0.0112

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

Table 8 :-

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl SALINITY ON MINERAL COMPOSITION OF <u>Curcuma longa</u> ERODE VARIETY.

Mineral Element	NaCl treatment (M)				
	Rhizome				
	C	0.05 M	0.10 M	0.15M	0.20 M
Na^{+}	0.006	0.004	0.006	0.008	0.012
Cl^{-}	0.420	0.420	0.530	0.750	0.850
K^{+}	0.024	0.022	0.026	0.024	0.028
Ca^{2+}	0.400	0.601	0.801	1.002	0.801
Mg^{2+}	1.460	0.852	0.609	1.218	1.949
P^{5+}	0.125	0.125	0.200	0.150	0.175
Fe^{3+}	0.060	0.080	0.084	0.088	0.100
Mn^{2+}	0.0198	0.0182	0.0148	0.0226	0.0212
Cu^{2+}	0.0048	0.006	0.0034	0.0038	0.0034
Zn^{2+}	0.0022	0.0024	0.0028	0.003	0.0032

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

Table 8 :-

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl SALINITY ON MINERAL COMPOSITION OF *Curcuma longa* ERODE VARIETY.

Mineral Element	NaCl treatment (M)				
	Root				
	C	0.05 M	0.10 M	0.15M	0.20 M
Na^{+}	0.004	0.004	0.005	0.005	0.006
Cl^{-}	0.300	0.320	0.410	0.480	0.570
K^{+}	0.015	0.016	0.019	0.022	0.025
Ca^{2+}	0.250	0.270	0.350	0.410	0.500
Mg^{2+}	0.700	0.750	0.810	0.880	0.950
P^{5+}	0.090	0.100	0.120	0.150	0.190
Fe^{3+}	0.040	0.043	0.052	0.064	0.070
Mn^{2+}	0.012	0.013	0.0148	0.017	0.0196
Cu^{2+}	0.010	0.00104	0.00126	0.0126	0.0015
Zn^{2+}	0.001	0.0014	0.0016	0.0174	0.0192

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

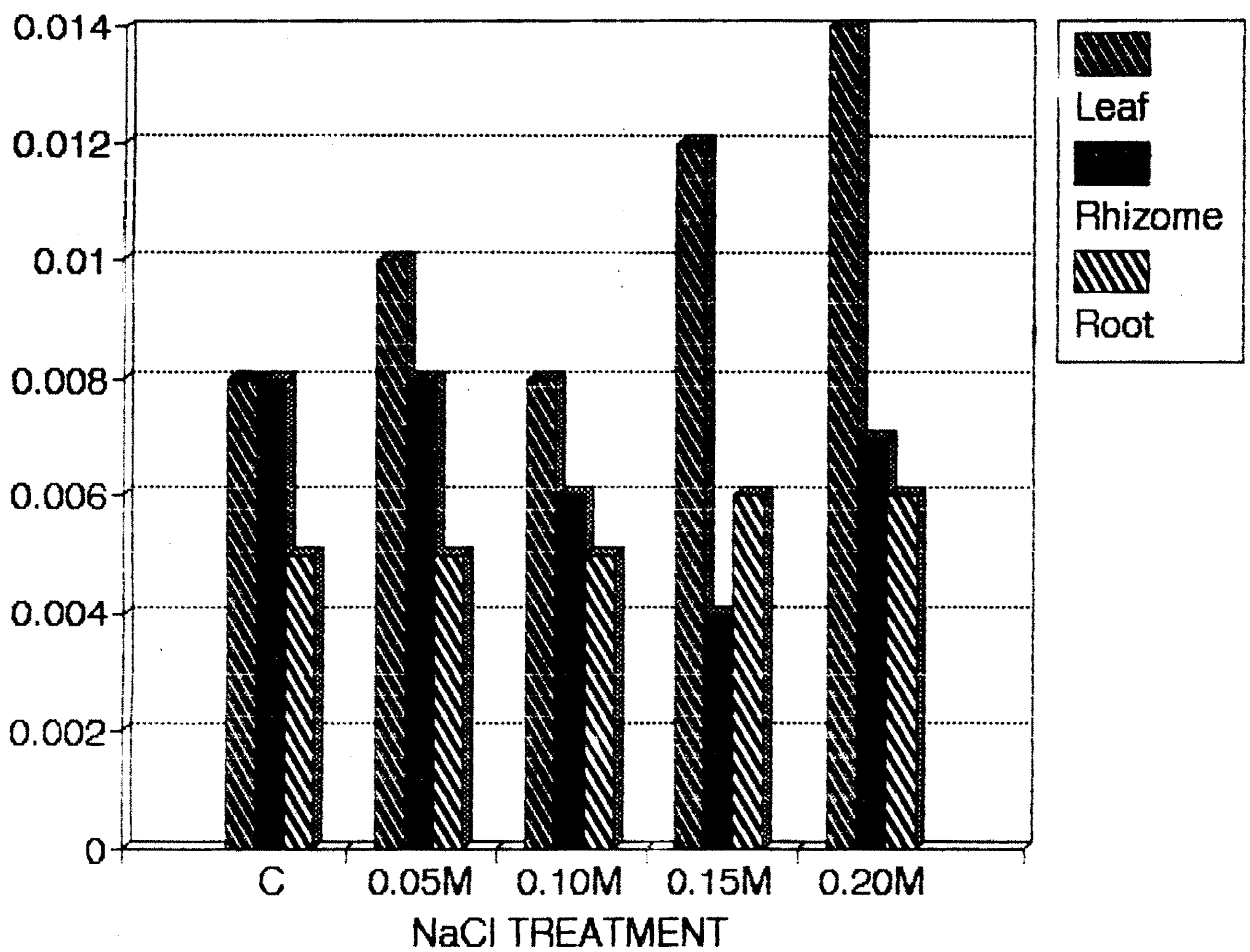

Fig.NO.16 Effect of various concentrations of NaCl salinity on sodium content of Curcuma longa - Sugamdnum variety.

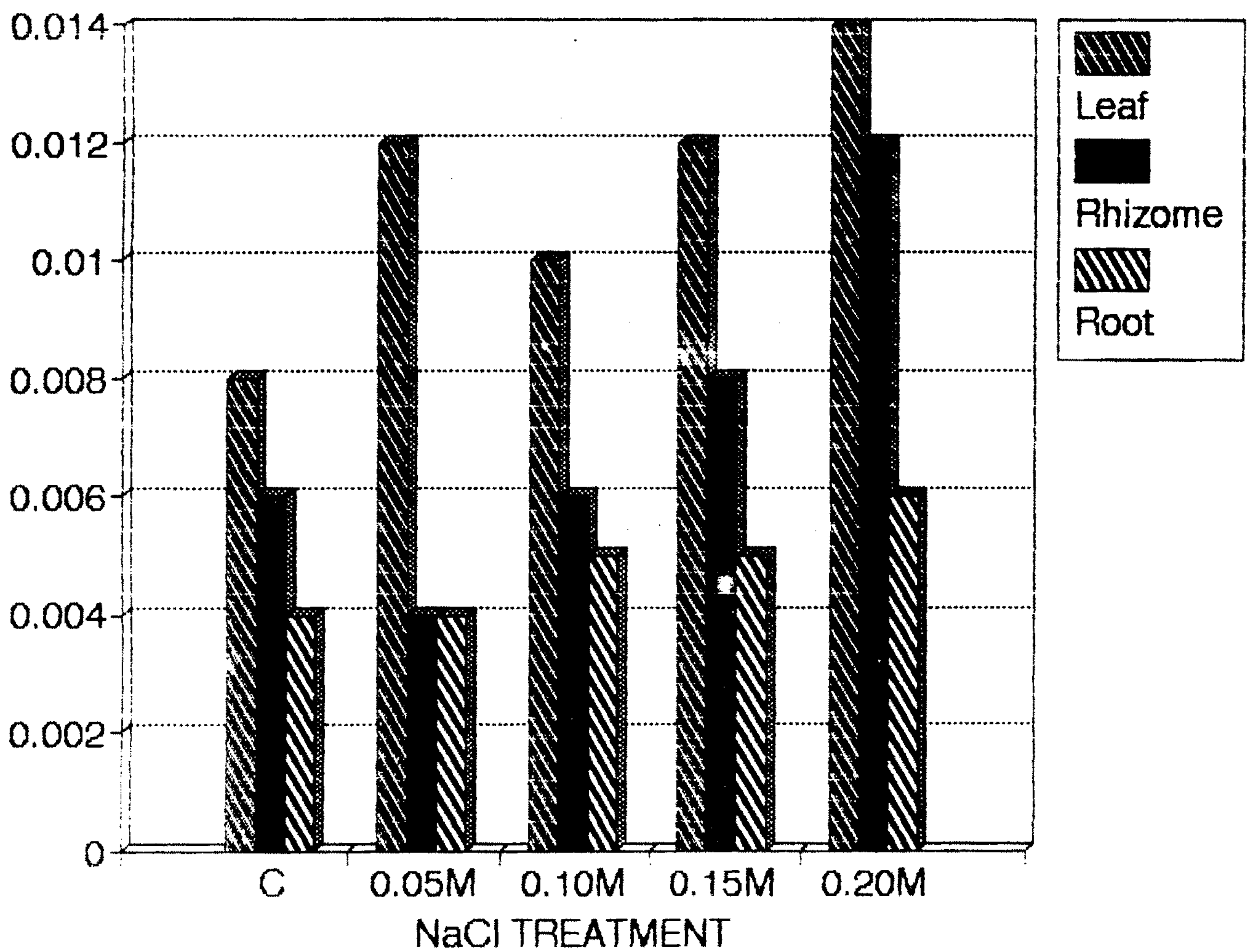

Fig.NO.17 Effect of various concentrations of NaCl salinity on sodium content of <u>Curcuma longa</u> - Erode variety.

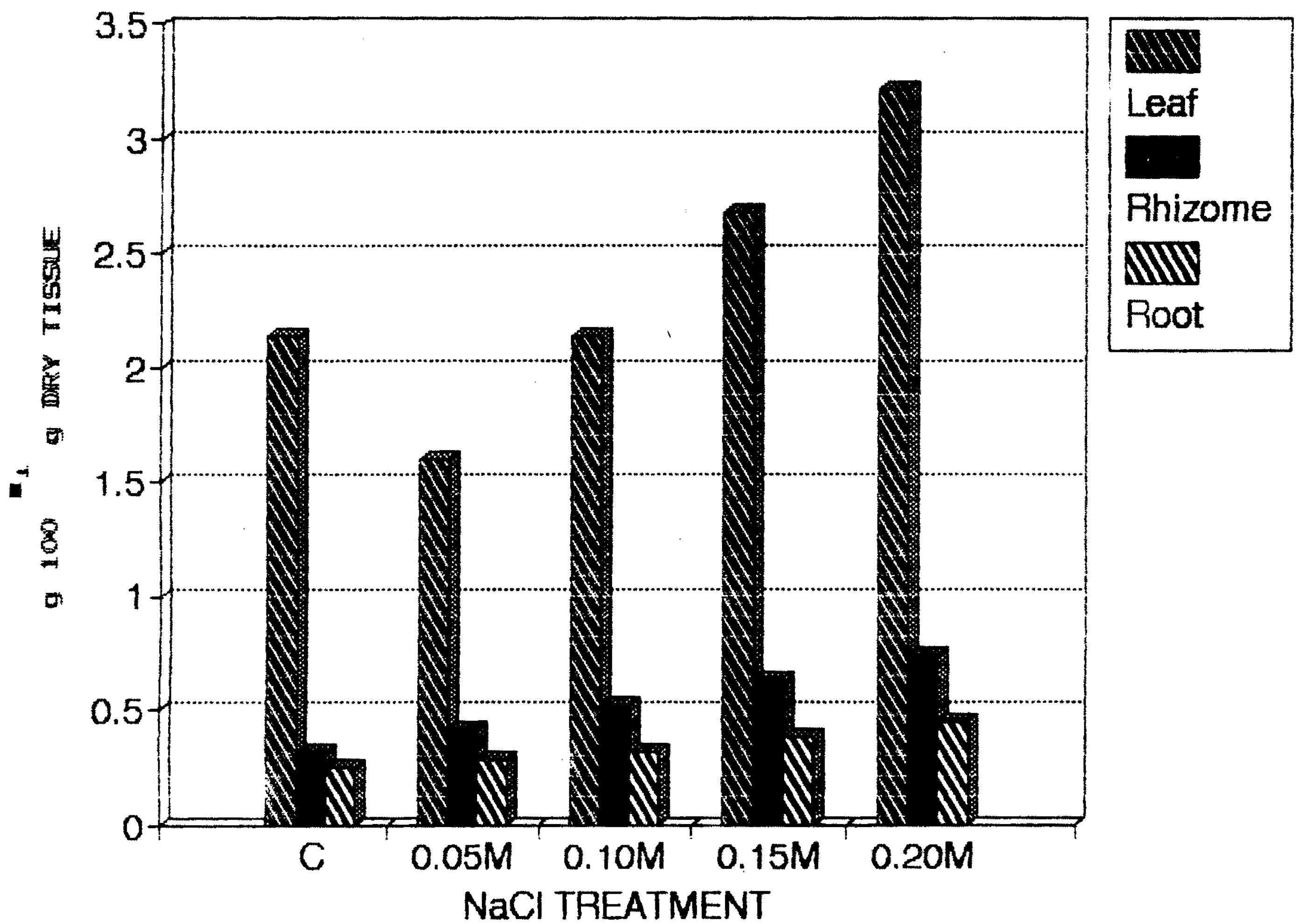

Fig.NO.18 Effect of various concentrations of NaCl salinity on chloride content of <u>Curcuma longa</u> - Sugandhum variety.

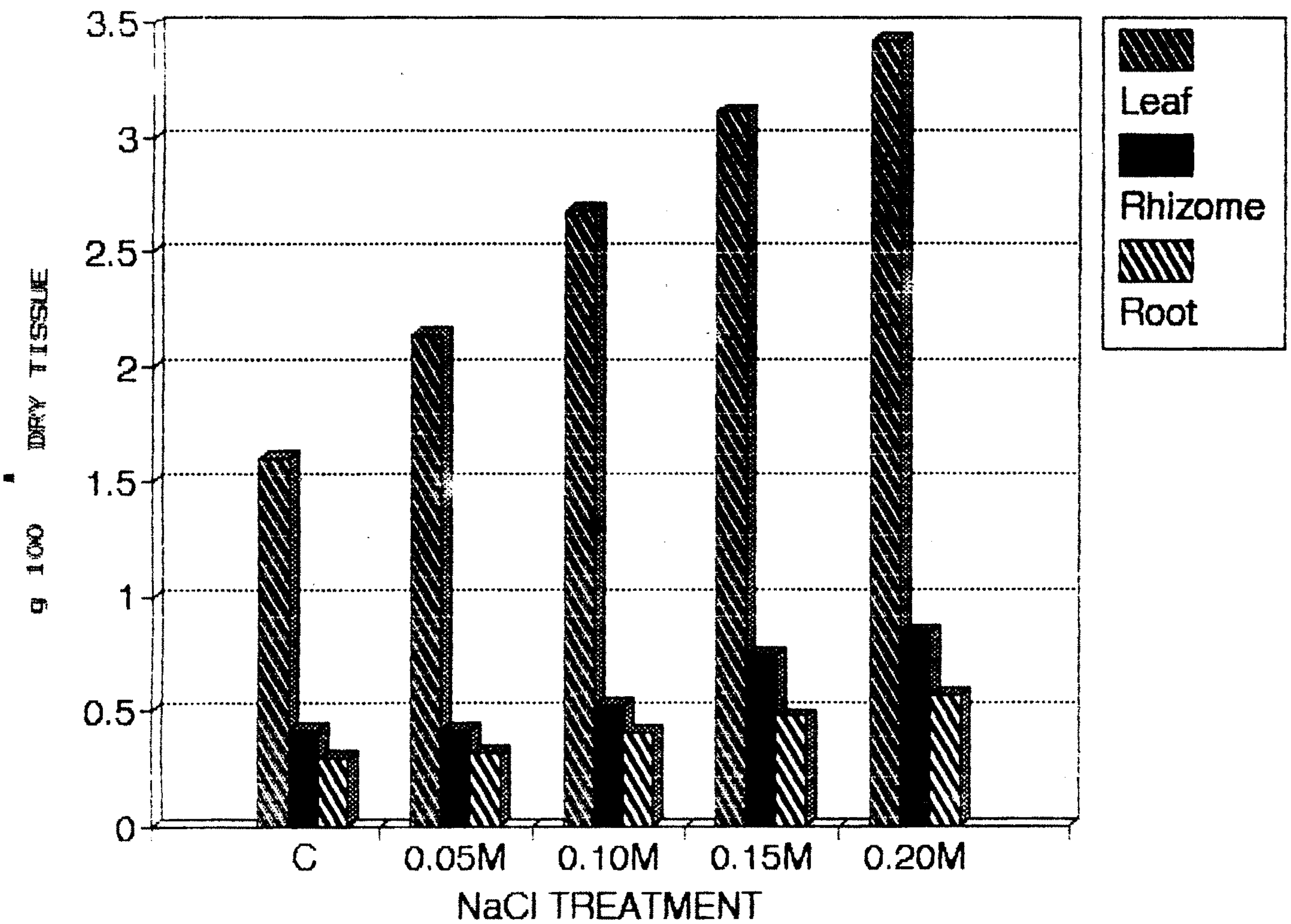

Fig.NO.19 Effect of various concentrations of NaCl salinity on chloride content of *Curcuma longa* - Erode variety.

crops. West and Tayler, 1980, in Phaseolus vulgaris, Rathert et al., 1983, in bush bean and sugarcane; Abdul Rehman, 1987, in Cowpea Bhandari (1988), also observed an increase in Na^+ content in two Capsicum annuum, cultivars.

Ayoub (1976) has shown that Ca^{2+} interfers the sodium absorption and translocation. There are some reports regarding the increase in Na^+ content is 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 decreasd the plant height, no. of pods and yield per plant etc. in the field experiment in case of gram.

Recently Roth, Hannelore (1989) reported increased Na^+ contents in the seedlings of Triticum aestivum L, Hordeum vulgare L, and Oryza sativa L due to NaCl salinity.

There is a report about decrease in Na^+ content Abdel - Rehman et al (1974) noted that NaCl induced gradual decrease in Na^+ content in 2 cultivars of castor bean resulting in a decrease in K^+ content.

In case of Cl^- however, the effect of salinity is remarkably different. It can be seen that Cl^- is accumulated more in the leaves than the rhizome and root Lauchli and Weineke (1979) have reported similar results in salt sensitive variety (Jackson) of soybean. They found that in this variety as the external salt concentration is increased Cl^- was accumulated extensively in all parts of the shoot, particularly in the leaves inducing necrosis. On the contrary they have reported that moderately salt tolerant species "Lee" excluded Cl^- very efficiently from the shoot but accumulated it in the root.

The concentration of this anion in all parts of the plant and in all conditions is considerably higher than Na^+. This clearly indicates the differential uptake and distribution of these two elements. Lessani and Marschner, (1978) have suggested that Na^+ and Cl^- are absorbed at different rates and through mechanism independent of each other. Na^+ has been shown to be relatively more harmful component of salinity (Gates et al., 1970) and possibly by checking its translocation to the leaves a plant can adapt to saline conditions. Further more salt sensitivity of Cl^- in the leaves. Similar situation is apparent in Glycine tomentella (Wilson et al., 1970)

According to Meiri and Poljakopf-Mayber (1967) 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.

Gauch and Wadleigh (1943, 1945) observed higher accumulation of chloride in leaves than stem and roots of salinized plants. Greenway et al., (1966) observed accumulation of chlorides in bean plants in ascending order from root (minimum) stem and leaves (maximum) due to salinity.

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

From the present observations it is clear that Na^{+} and Cl^{-} contents are increased in the leaves and rhizome of Erode variety while in Sugamdhum variety Na^{+} content is increased only in the leaves while in rhizome it decreases at increasing levels salinity.

There is tremendous accumulation of Na^{+} and Cl^{-} in the leaves and rhizome of both the varieties. The accumulation of Cl^{-} in all the parts of the plant is considerably higher than Na^{+}. This clearly indicates the differential uptake and distribution of these two elements. Increased Na^{+} and Cl^{-} under saline conditions may be the causative factor for the failure of the plant growth and development in the two varieties - Sugamdhum and Erode which clearly indicates the salt sensitive nature of turmeric plant.

ii) **POTASSIUM :**

Effect of NaCl salinity on K^{+} content of Curcuma longa - varieties Sugamdhum and Erode are presented in the Table No...8... and Fig No.20.,21. . It is evident from the observations that as compare to control plants, K^{+} content is increased in the leaves of both the varieties. In the Erode rhizome and roots K^{+} content is also increased while in Sugamdhum rhizome and root it decrease

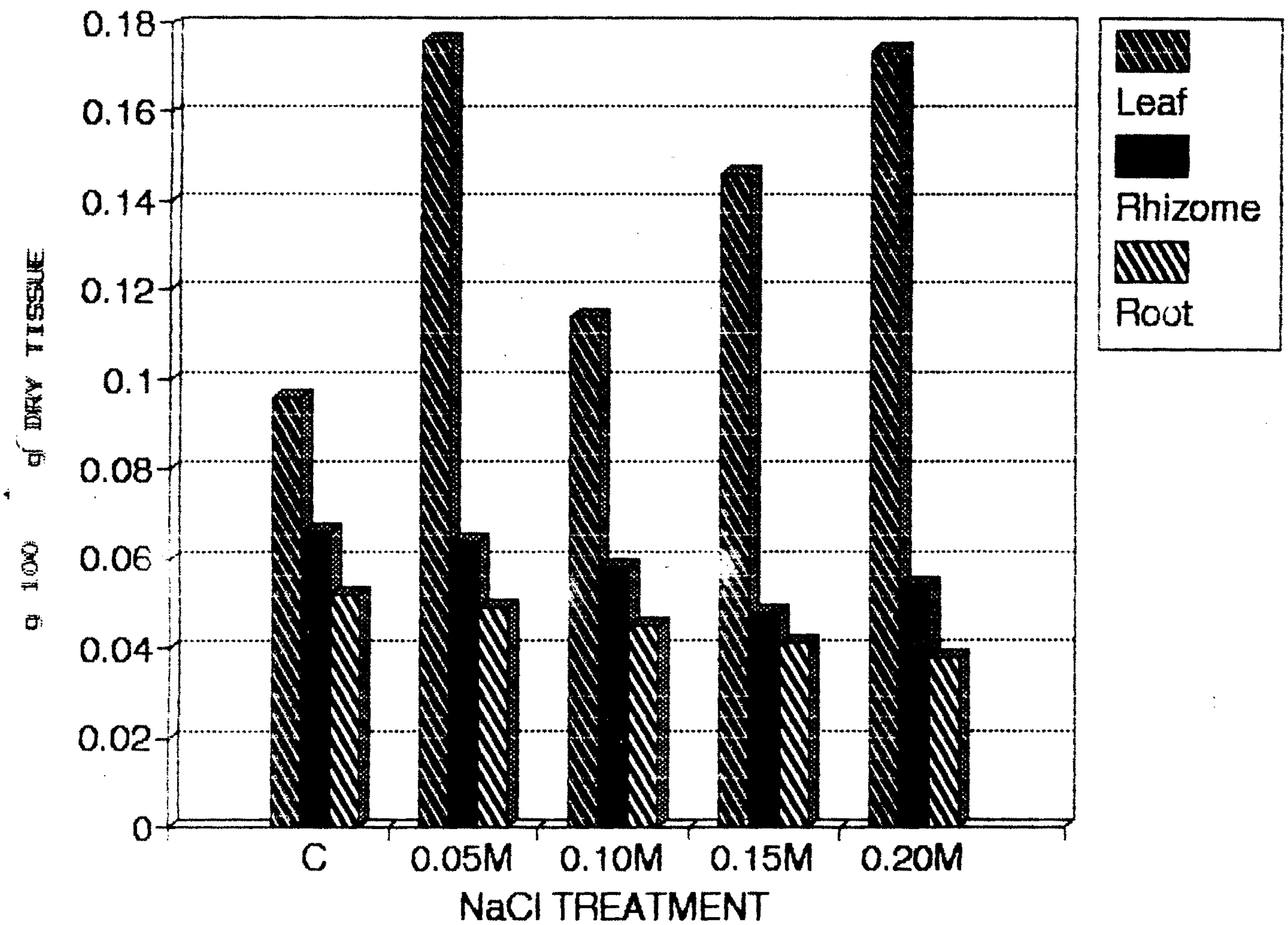

Fig.NO.20 Effect of various concentrations of NaCl salinity on potassium content of Curcuma longa - Sugandhum variety.

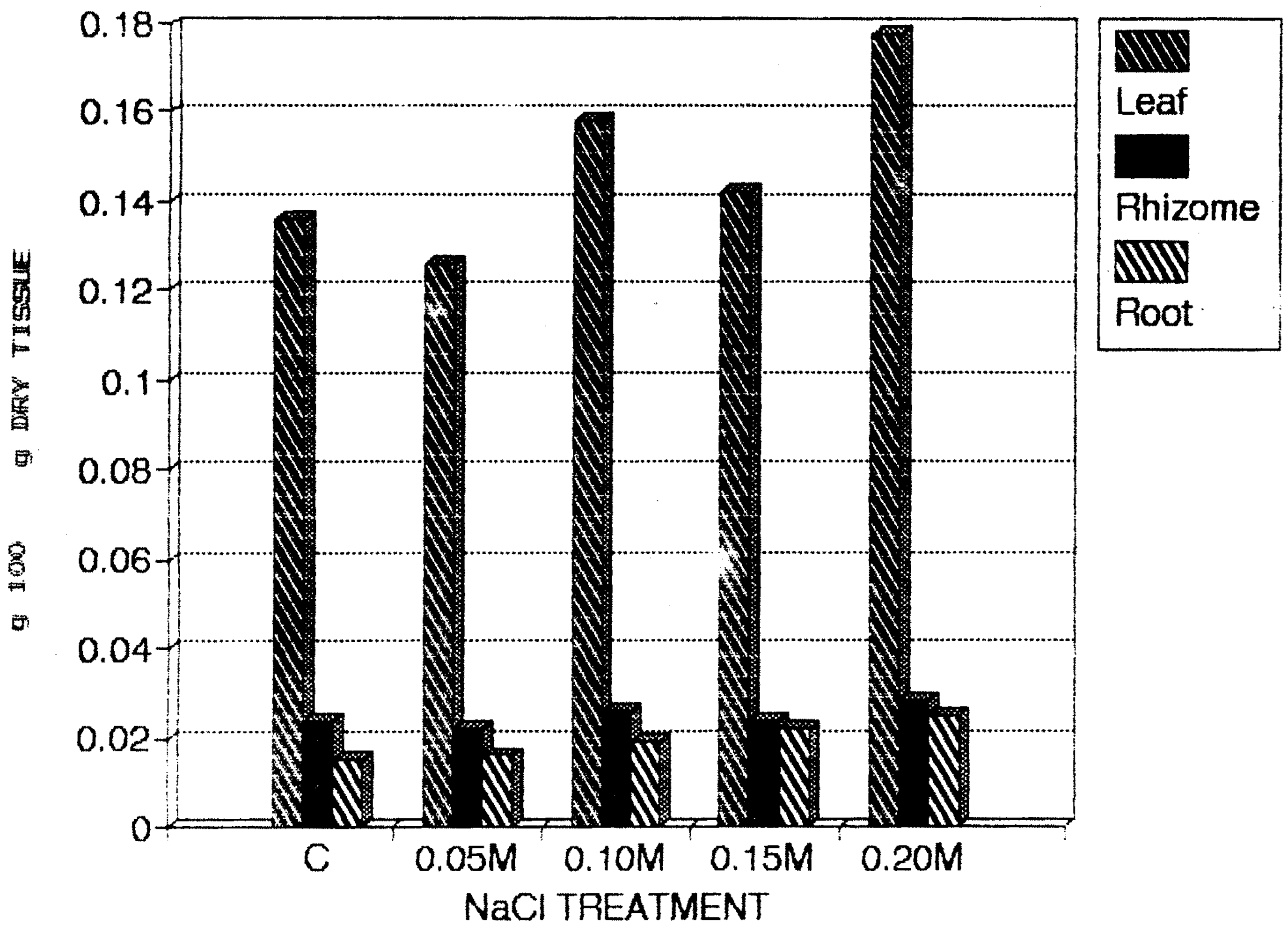

Fig.NO.21 Effect of various concentrations of NaCl salinity on potassium content of <u>Curcuma longa</u> -Erode variety.

at all the levels of the salinity.

K^+ content is more in leaves of both the varieties than the rhizome and roots.

The work of Sutcliff (1962) has clearly indicated that marine plants have developed efficient mechanism of K^+ uptake. Rains and Epstein (1967) have also shown the preferential obsorption of K^+ in mangroves. Similar type of phenomenon has been described by Joshi (1976) in many mangroves. Form these reports it is clear that K^+ plays an important role in halophytes towards salt tolerance. However, this preferential K^+ uptake mechanism in presence of salt is lacking in most of the glycophytes - (Guillen et al., 1978; Laszlo and Kuiper 1979; Karadge, 1981).

There are many reports about decrease in K^+ content due to salinity. Gauch and Wadleigh (1944) in bean, Mata (1975) in spinach and lettuce, Sarin (1962) in Cicer arientum; Nieman and Poulsen (1967) in bean Lessani and Marshner (1978), El-Hamid (1963), Kawate (1986) in Safflower, and Mishra and Shitole (1988) in oat. Bhandari (1988) in Capsicum annuum cultivars observed decrease in K^+ content at all the levels of NaCl salinity.

There are many reports about adverse effect of NaCl salinity on K content. (Hasson - Porath et al 1972; Azizbekova and Bharadwaj 1984 in Zea mays; Paliwal and Maliwal, 1972 and 1975, in Abelmoschus esculentus, Luffa cylindrica and Brassica oleraceae; Iyengar et al., 1974 in sugarcane var.co.740; Chavan and Karadge, 1980 in Arachis hypogea.

Recently there is a report about the effect of NaCl salinity on thr growth and dry matter production of Triticum aestivum L, Hordeum vulgare L, and Oryza sativa by Roth, Hannelore (1989). He observed that there is a decrease in K^+ content due to NaCl salinity. Aly et al (1989) observed a decrease in K^+ content in Lycopersicon esculentum. Similar observation is made by Liuk-B and S-XLi (1991) in Lycopersicon esculentum.

From our results it is clear that in the leaves, rhizome and root of Erode variety K^+ content is significantly increased with increasing salinity levels. In Sugamdhum variety K^+ content is increased in the leaves while it is decreased in the rhizome and roots at all the levels of salinity.

The effect of chloride salinity on K^+ uptake seems more probable. Thus it is clear that the two varieties sugamdhum and Erode showed efficient K^+ uptake mechanism under saline conditions. This may be considered as important factor for the survival of the plant growth under saline conditions.

iii) **CALCIUM**

The effect of various concentrations of NaCl on Ca^{2+} contents of various parts of Curcuma longa varieties Sugamdhum and Erode has been presented in Table No....8.... . The results have been graphically presented in fig No 22,23... . The table as well as figure indicates that Ca^{2+} contents in leaves, rhizome and roots of both the varieties increases with increasing NaCl salinity levels. In the leaves of both the varieties Ca^{2+} contents are

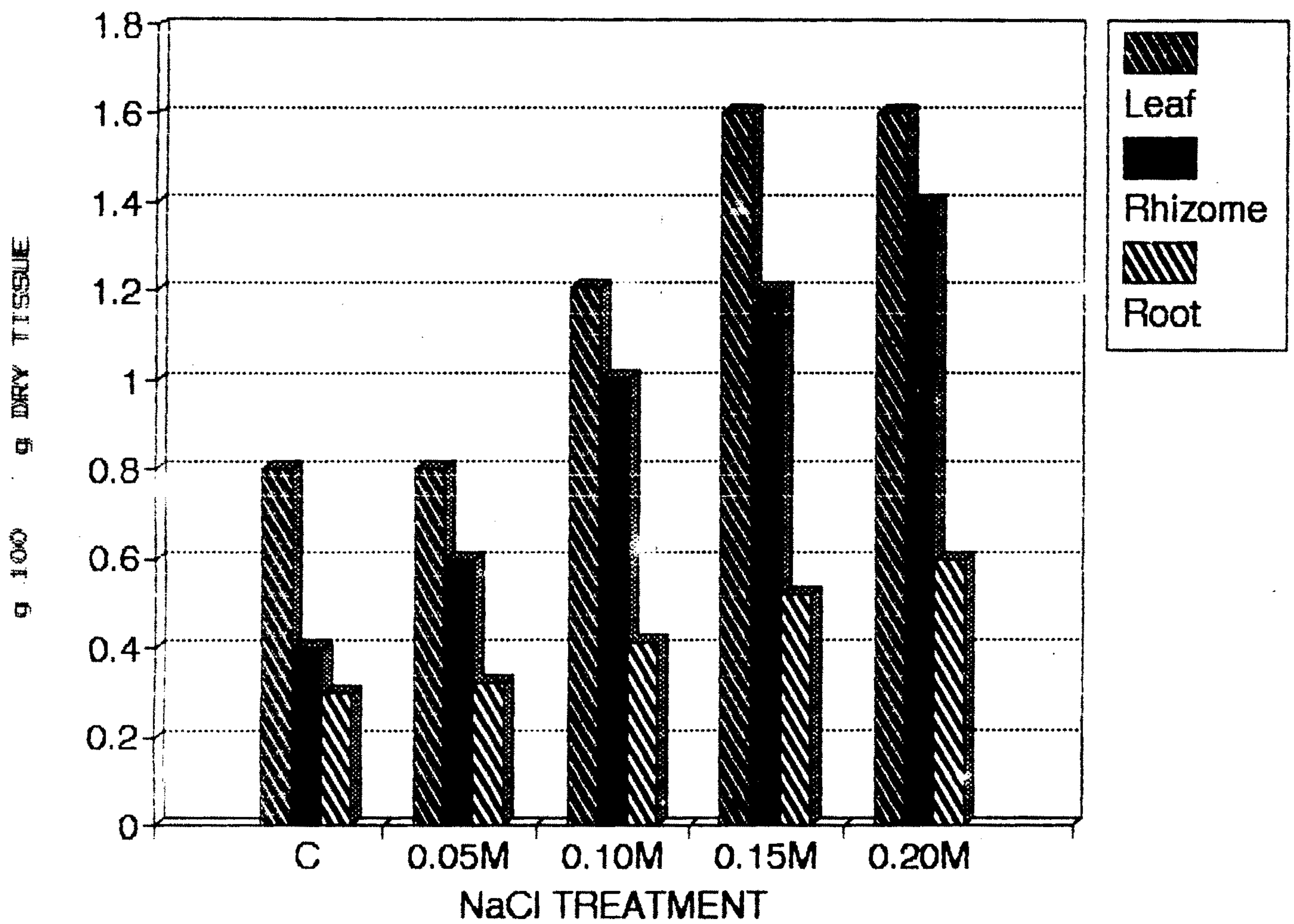

Fig.NO.22 Effect of various concentrations of NaCl salinity on calcium content of <u>Curcuma longa</u> - Sugandhum variety

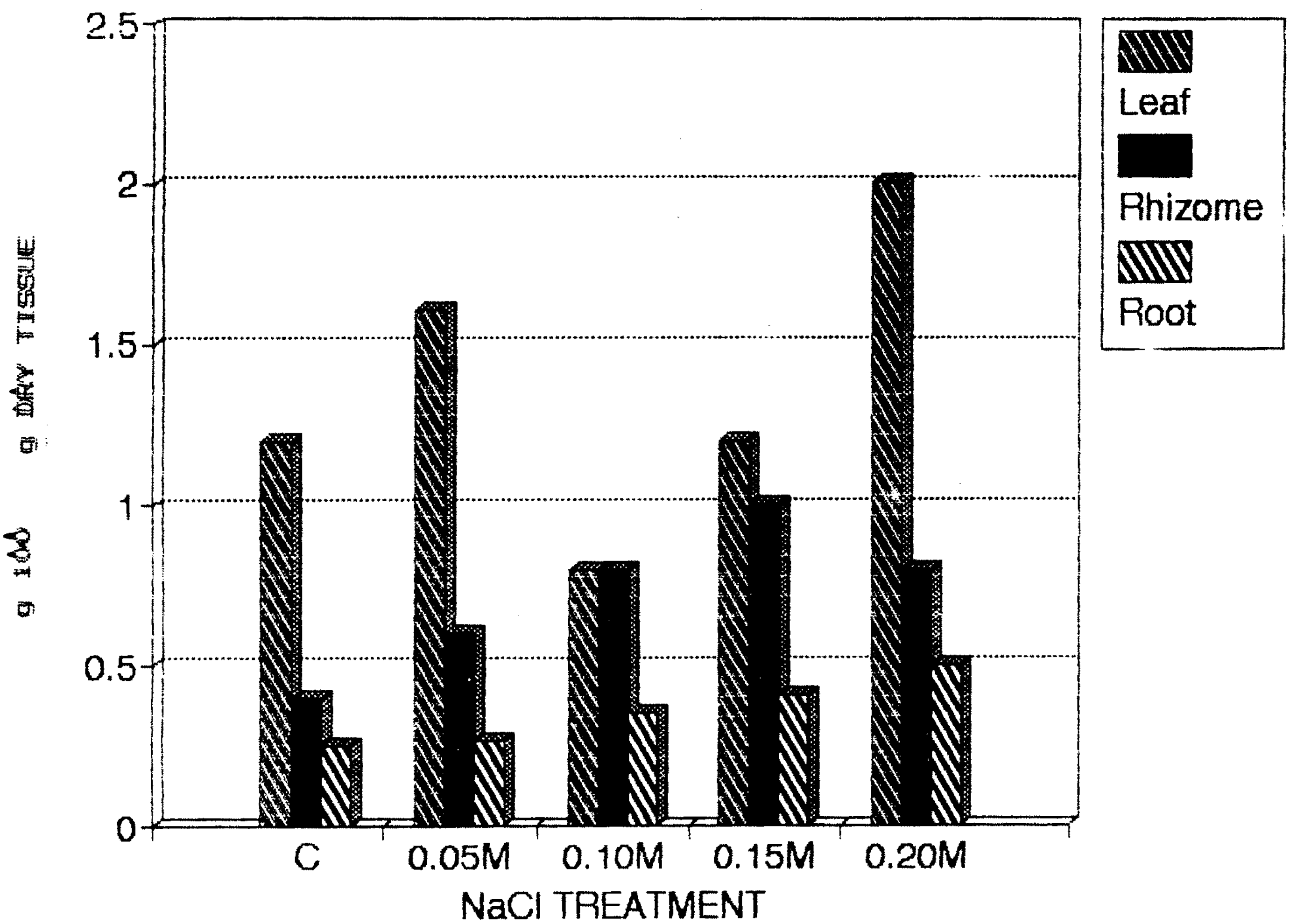

Fig.NO.23 Effect of various concentrations of NaCl salinity on calcium content of <u>Curcuma longa</u> - Erode variety.

more than that of rhizome and roots.

A great importance has been attributed to Ca^{2+} in salt tolerance (Elzam and Epstein, 1969) Ca^{2+} plays a definite role in induction of salt tolerance even though at the low salinity levels.

There are reports about increase in Ca^{2+} content. Similar results are observed by Bhandari (1988) observed an increase in Ca^{2+} content in *Capsicum annuum* cultivars Pant C1 and NP46A. This increase in Ca^{2+} content is also observed by Walvekar (personal communication, 1992) in *Capsicum annuum hybrid varieties*.

There are reports that salinity suppresses Ca^{2+} uptake (Strogonov, 1964; Osmond, 1967; Laszlo and Kuiper, 1979; Paliwal and Maliwal, 1980; Divate and Pandey, 1981; Kawasaki *et al.*, 1983; Imamul Huq and Larher, 1984).

Increase in Ca^{2+} content in some plant species under saline conditions is also observed by Ayoub, 1977 and Karadge and Chavan, 1983.

There are some reports about the decrease in Ca^{2+} contents. A reduction in Ca^{2+} uptake under saline conditions in salt sensitive plants is observed by several workers (Matar *et al.*, 1975; Guggenheim and Waisel, 1977; Laszlo and Kuiper, 1979; Starck and Kozinska, 1980; Divate and Pandey, 1981).

There is a report on decreased Ca^{2+} content in the tolerant variety of Lycopersicon esculentum by Aly et al., (1989). He observed that Ca^{2+} content is significantly decreased due to NaCl salinity.

Recently Adams and Holder (1992) have studied the effect of humidity, calcium and salinity on the accumulation of dry mater and calcium by the leaves and fruits of tomato (Lycopersicon esculentum) and observed that accumulation of Ca^{2+} by the fruits was marked reduced by high salinity.

From the present observations it is clear that there is accumulation of calcium in leaves, rhizome and roots of both the varieties of Curcuma longa - Sugamdhum and Erode. Ca^{2+} content of total plant (leaves, rhizome and roots together) was more than control at all the levels of salinity. These results indicates that there is even distribution of Calcium in the leaves, rhizome and roots of both the varieties.

PHOSPHORUS :

Effect of NaCl salinity on uptake an distribution of P^{5+} in Curcuma longa has been presented in Table No...8... and fig No. 24,25 . It is clear that this inorganic nutrient is only slightly influenced by salinity. It can be seen that as compared to control plants, there is a linearly decrease in P^{5+} content in the leaves, rhizome and roots of Sugamdhum variety. In treated content is less and at higher concentration it is more. But the values are less than control plants. While in the Erode variety

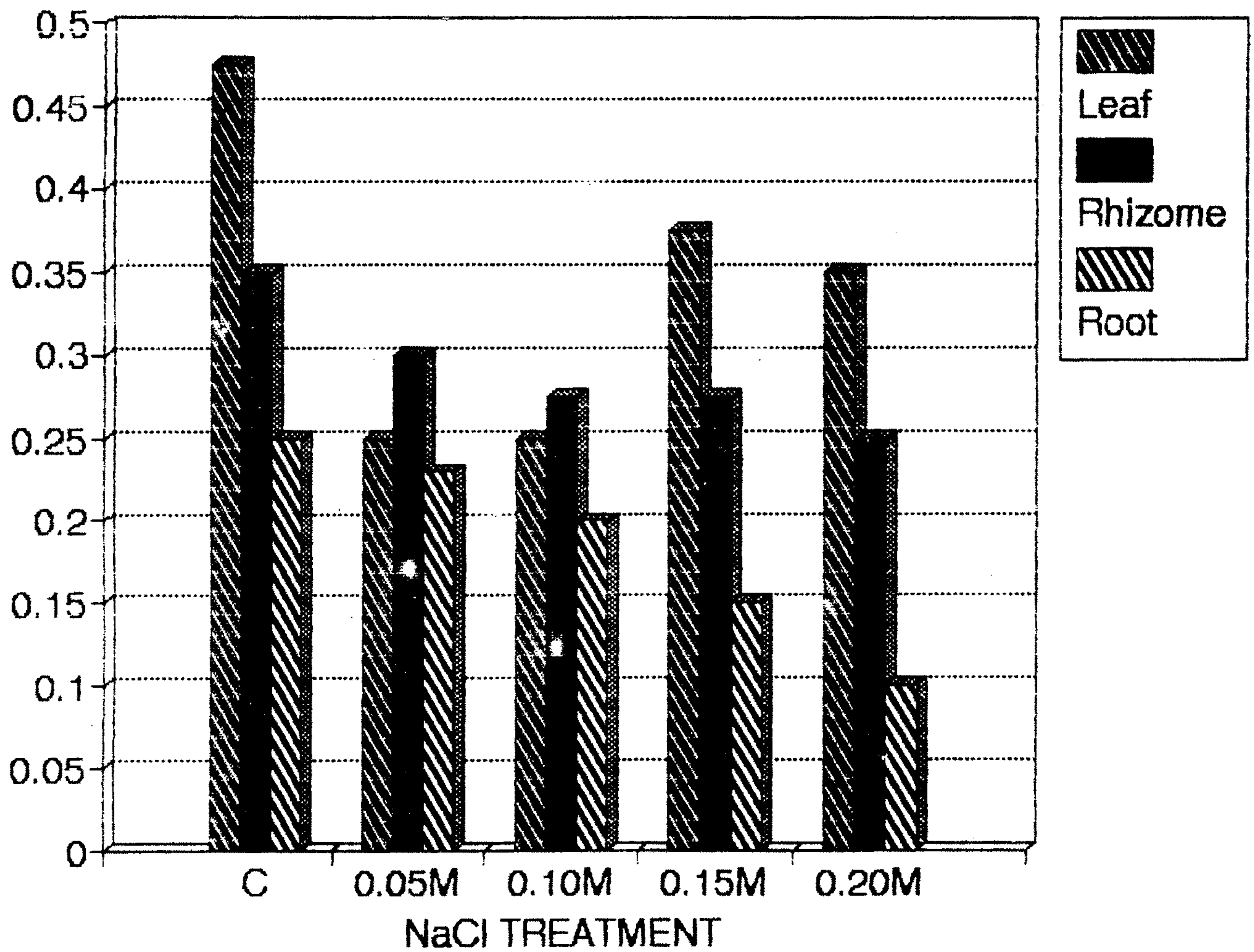

Fig.NO.24 Effect of various concentrations of NaCl salinity on phosphorus content of Curcuma longa - Sugandhum variety.

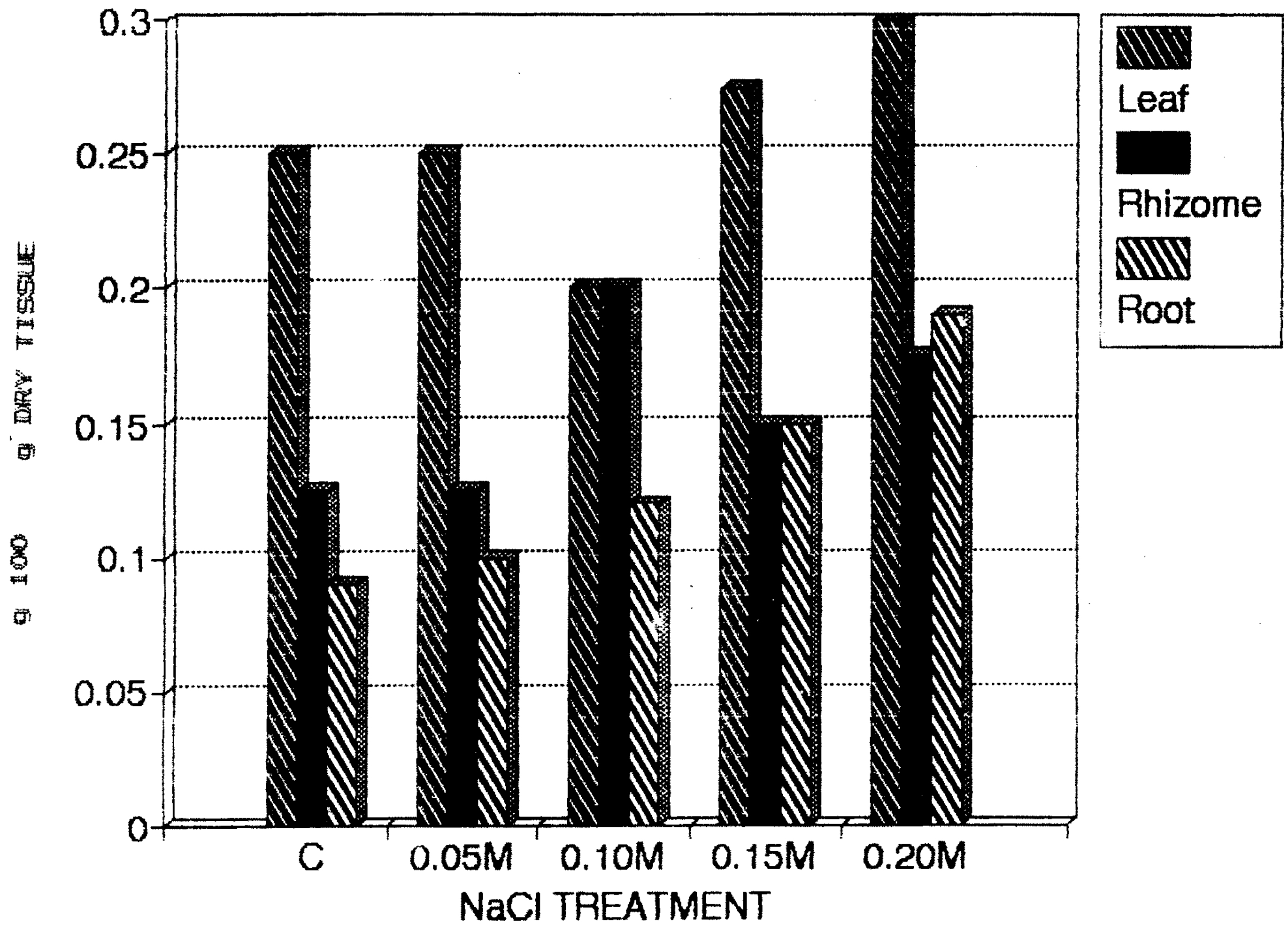

Fig.NO.25 Effect of various concentrations of NaCl salinity on phosphorus content of Curcuma longa - Erode variety.

leaves the P^{5+} content is increased at higher concentrations and decreased at the lower concentration. In the rhizome and roots there is increase in P^{5+} content at all the levels of NaCl salinity.

Importance of P^{5+} accmulation in the resistance to secondary salt induced stress has been reported by Wilson et al., (1970), Accumulation of this ion in different parts of salt tolerant as well as sensitive plants grown under saline conditions has been reported by many workers (Narayanan, 1975; Chavan and Karadge, 1980). Increase in P^{5+} content under saline conditions is recorded by several workers like Ansari and Bowling (1972); Lal and Bharadwaj (1980) and Nukaya et al., (1982).

There are many reports regarding the reduced P^{5+} uptake due to salt stress has been observed by (Udovenko et al., 1971; Paliwal and Maliwal, 1972; Zhukhovskaya, 1973; Singh et al., 1974; Kleinkoff et al., 1975; Dahiya and Singh 1976; Tindal et al., 1979; Starck and Kozinska, 1980; Karadge et al, 1983).

From the present results it is observed that P^{5+} content is slightly affected in Sugamdhum leaves, rhizome and roots due to NaCl salinity. While in Erode variety P^{5+} content is decreased at lower levels of salinity and increased at higher levels of salinity in the leaves under saline conditions and in rhizome and roots P^{5+} content is increased. These results indicates that Erode variety is better in accumulation of P^{5+} than Sugamdhum under saline conditions. There is more accumulation of P^{5+} in the leaves than in the rhizome and roots in both the varieties under saline conditions.

v) **MAGNESSIUM**

The effect of NaCl salinity on the Mg^{2+} content of Curcuma longa varieties - Sugamdhum and Erode has been presented in the table no..8... and fig no..26,-27. . It is evident that as compared to control plants, the Mg^{2+} content is increased in the leaves of salt treated plants of both the varieties. Only in Erode variety leaves, these values increased at higher levels of salinity. In the rhizome and roots of both the varieties Mg^{2+} content is increased at all the levels of salinity.

Atkinson et al (1967) have stated that Mg^{2+} maintains the salt balance in the leaves of Aegialitis, a mangrove species.

There are many reports of increase in Mg^{2+} contents under saline conditions. Hassan et al, (1981) in barley and corn; Syed and Swaify (1973) in sugarcane; Aslam (1975) in safflower and Iyengar et al., (1978) in cotton reported an increase in Mg^{2+} content under saline conditions.

Increase in Mg^{2+} content due to NaCl salinity has been reported by many workers (Azizbekova and Babaeva, 1979; Meiri et al, 1971; Lashin and Atansia, 1972; Guillen et al., 1978; Karadge and Chavan, 1983).

In the same time there are few reports where decreased Mg^{2+} uptake due to chloride salinity has been recorded (Matar et al.,

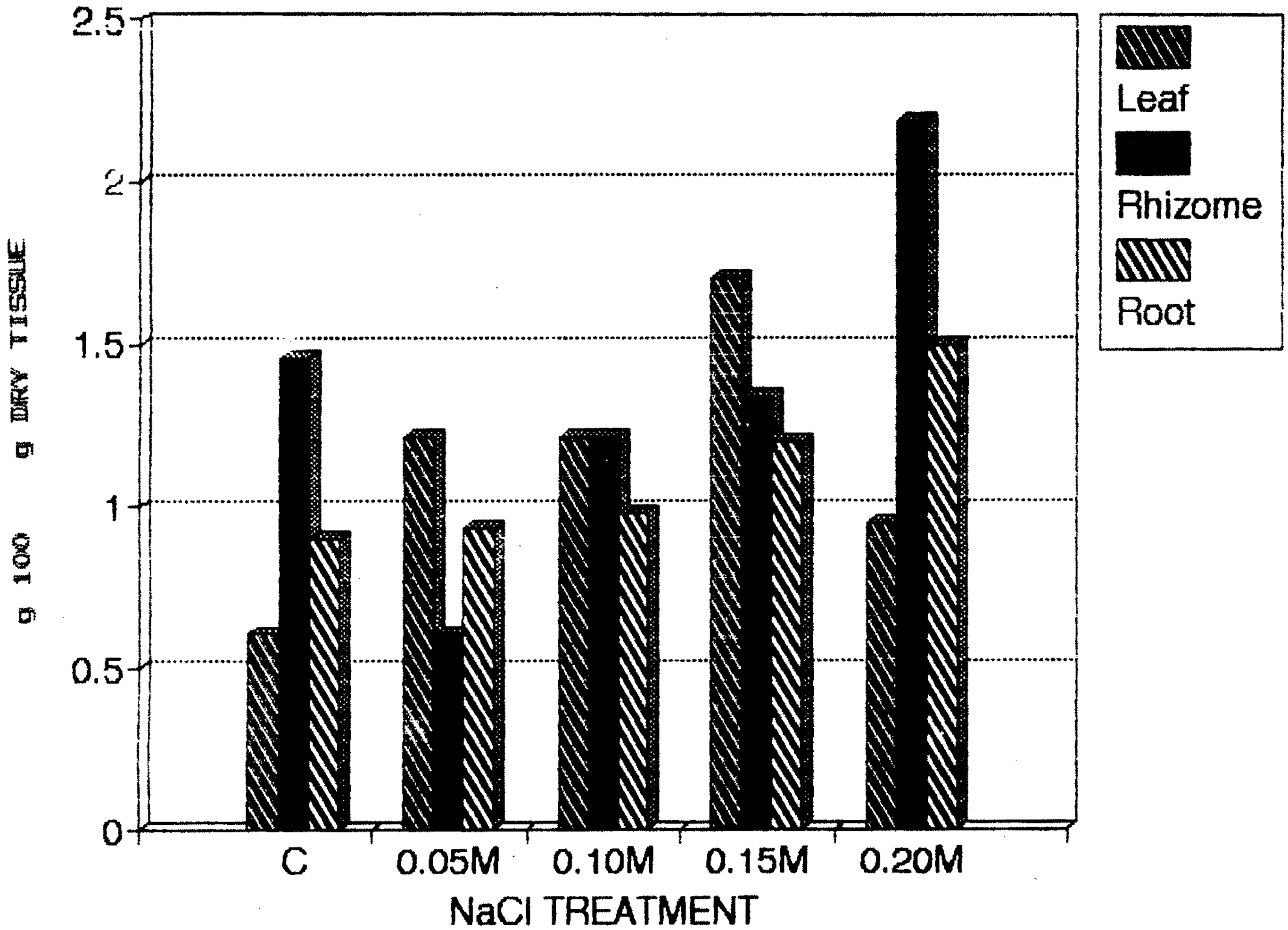

Fig.NO.26 Effect of various concentrations of NaCl salinity on magnesium content of <u>Curcuma longa</u> - Sugandhum variety.

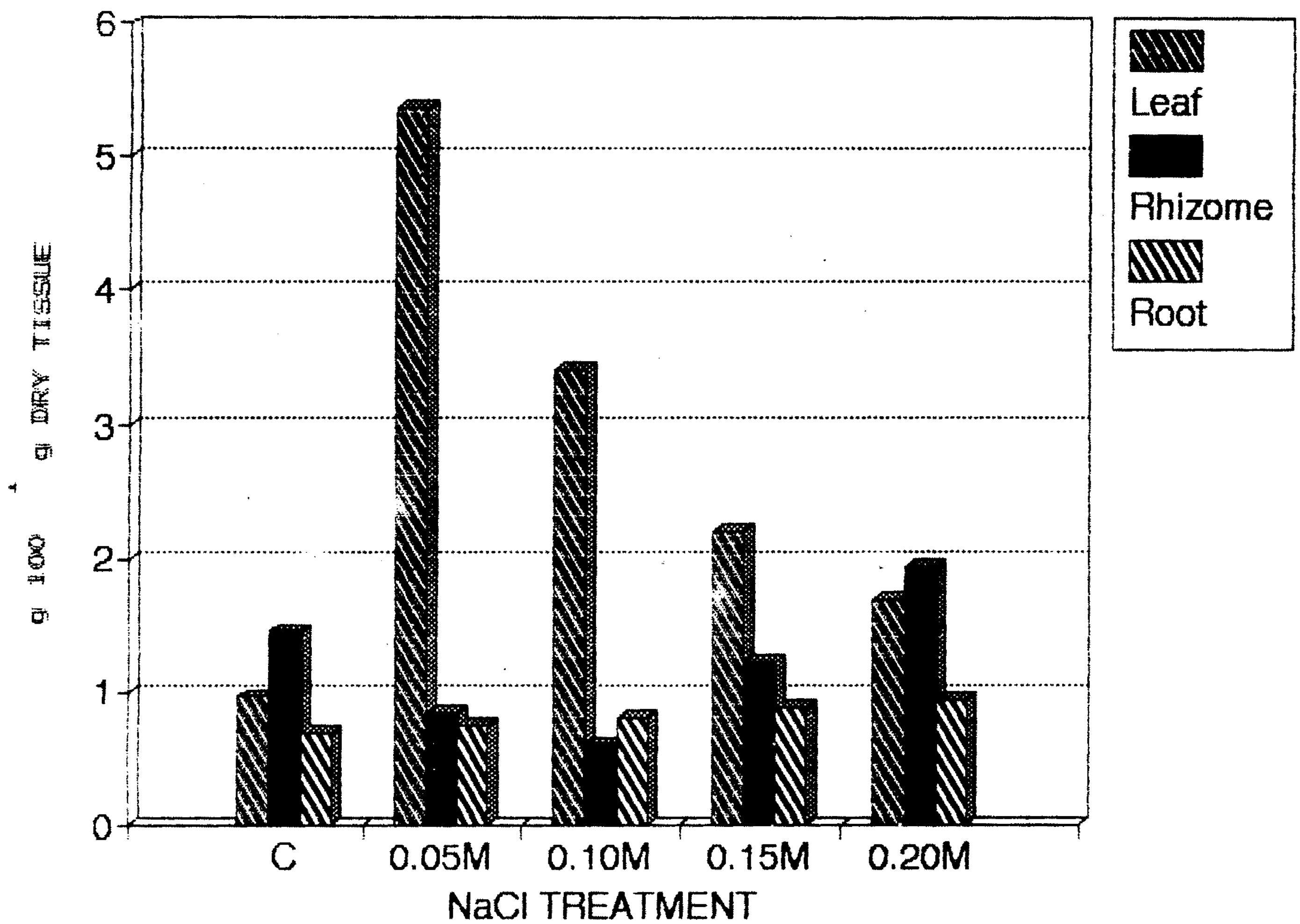

Fig.NO.27 Effect of various concentrations of NaCl salinity on magnesium content of Curcuma longa - Erode variety.

1975; Ackerson and Younger, 1975; Gugenheim and Waisel, 1977; Paliwal and Maliwal, 1980). Mishra (1967) reported a decrease in Mg^{2+} content in the leaves of _Clerodendron inerme_ under saline conditions.

There are several other workers who have reported decreased Mg^{2+} uptake due to salinity (Rahman _et al_., 1972; Copper and Dumbroff 1973; Kleinkoff _et al_., 1975; Laszlo and Kuiper, 1979) Nimbalkar and Joshi (1975) reported that lower concencentrations of NaCl reduced the Mg^{2+} content of sugarcane leaves while higher concentration caused an increase in it. Chavan, (1980) reported that Mg^{2+} uptake was considerably increased in NaCl treated Ragi plants.

From the present observations it is clear that there is an increase in Mg^{2+} content in the leaves, rhizome and roots of both the varieties of _Curcuma longa_, Sugamdhum and Erode. Except in Erode leaves where there is decrease in Mg^{2+} level at higher levels of NaCl salinity. In the roots of both the varieties also Mg^{2+} content is increased at all the levels of salinity.

These observations indicate that there was more accumulation of Mg^{2+} in Erode variety while in Sugamdhum variety Mg^{2+} uptake was affected in both the leaves and rhizome under saline conditions.

From these evidences it can be said that Mg^{2+} uptake is more in Erode variety as the level of salinity increases while in Sugamdhum variety it is less.

MICRONUTRIENTS

There are very few attempts which describe effect of NaCl salinity on micronutrient metabolism. Relatively Fe^{3+} and Mn^{2+2} are studied by some workers.

a) **Fe^{3+} (Iron)**

Effect of NaCl salinity on uptake and distribution of Fe^{3+} in Curcuma longa varieties - Sugamdhum and Erode has been recorded in Table No..8.... and Fig No28..29.. It is clear that with increasing concentrations of salts there is increase in the level of Fe^{3+} in the leaves, rhizome and roots of both the varieties. Fe^{3+} content is more in the leaves than in the rhizome and root. However, in the rhizome and root Fe^{3+} content is affected a little bit. Thus in Curcuma longa it appears that the translocation of Fe^{3+} and its accumulation in the leaves is notably higher only in plants grown under various salinity levels.

There are some reports regarding the increase in Fe^{3+} content. Mass et al., (1972) observed concentration of Fe^{3+} was found to be increased in the roots and tops of tomato, squash and soybean with increasing NaCl (upto 100 meq) concentration in the medium. Dahiya and Singh (1976) also observed increased Fe^{3+} uptake in peas grown in salinized medium. Shimose (1972) observed that species differ in Fe^{3+} uptake in salt rich environment. According to Mass et al., (1972) increase in Fe^{3+} content may be due to the restricted growth of tops or due to abrupt changes of membrance permeability. Karadge and Chavan (1983) have observed

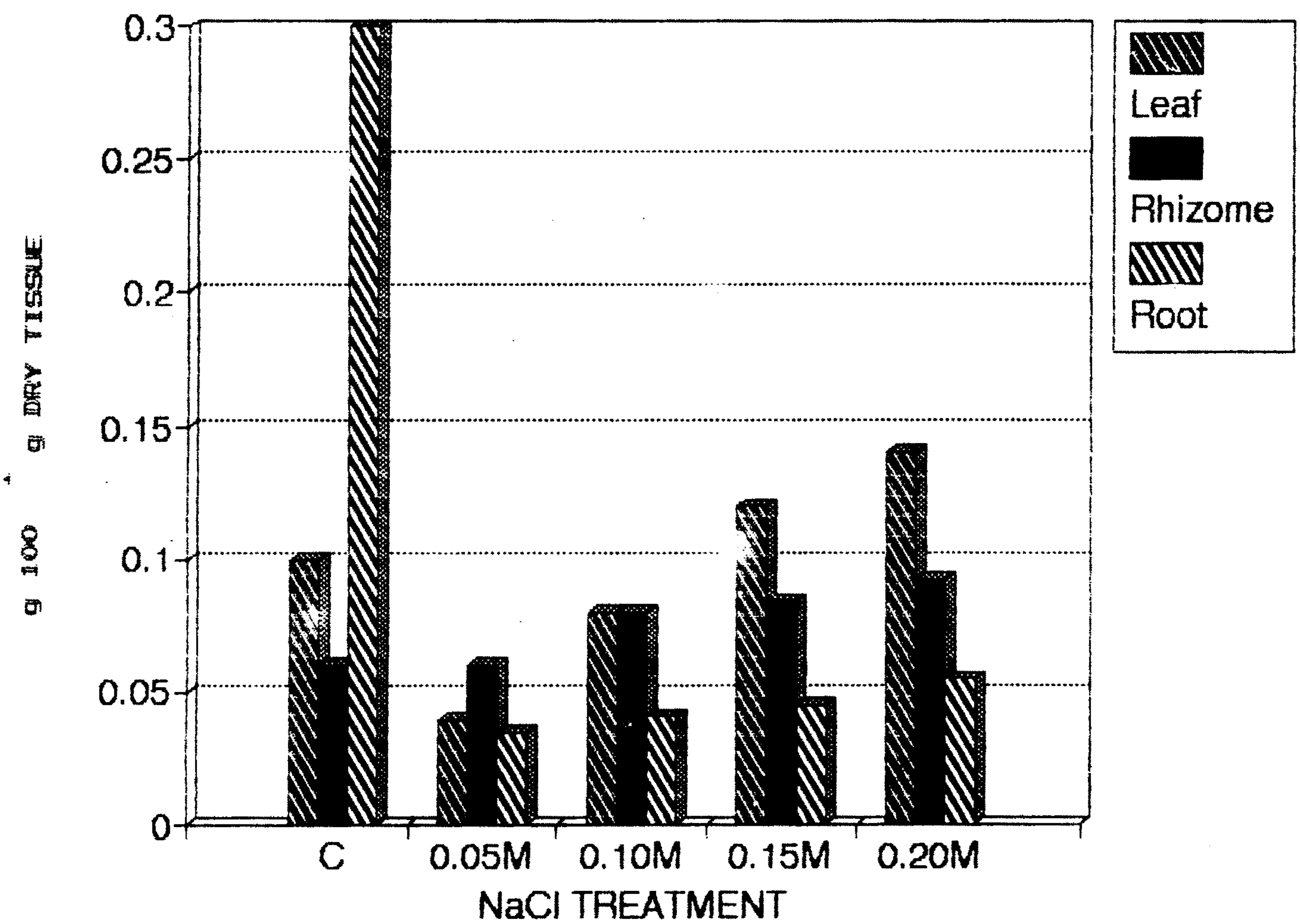

Fig.NO.28 Effect of various concentrations of NaCl salinity on iron content of <u>Curcuma longa</u> - Sugandhum variety.

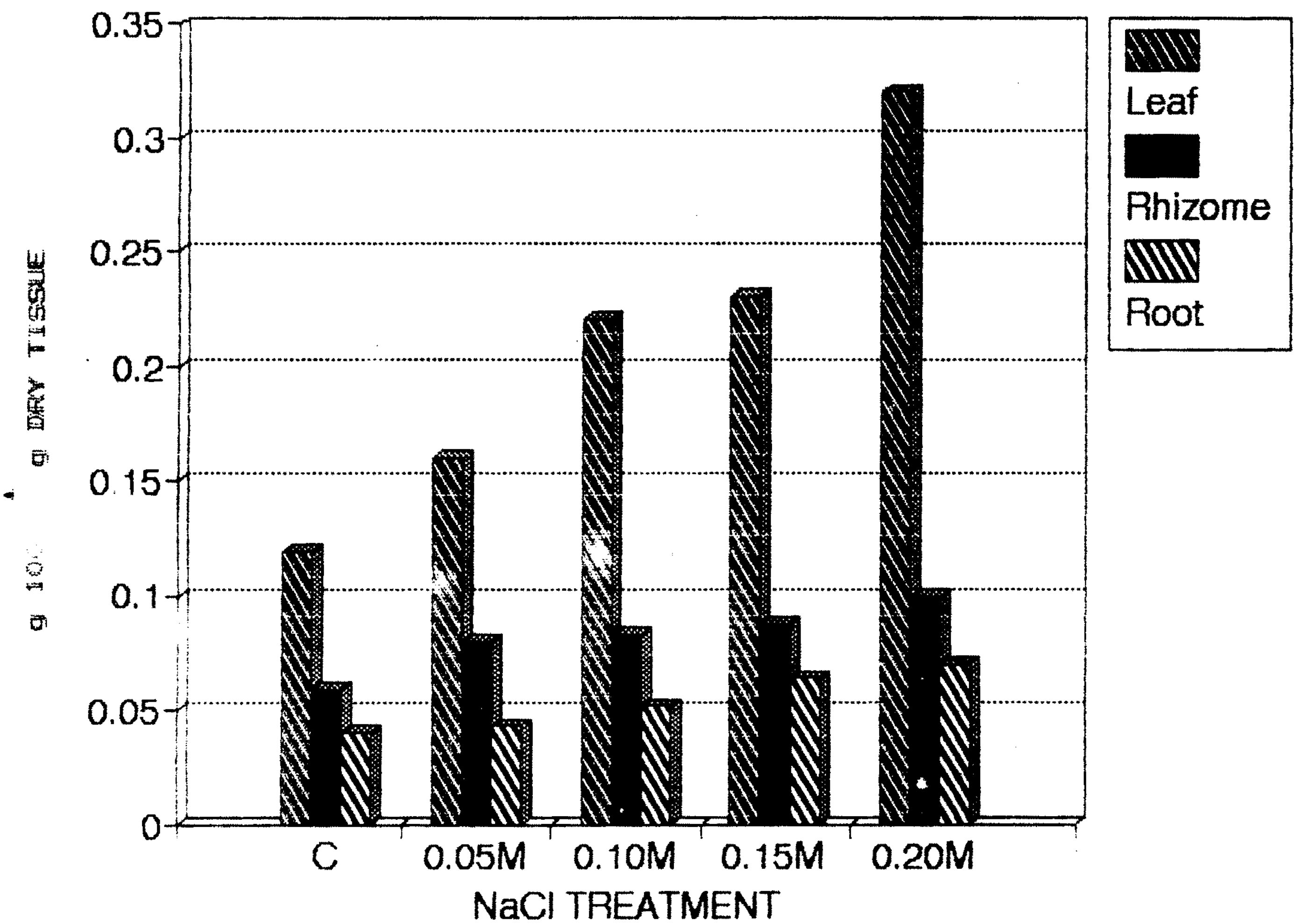

Fig.NO.29 Effect of various concentrations of NaCl salinity on iron content of <u>Curcuma longa</u> - Erode variety.

stimulation of Fe^{3+} absorption due to salinity in <u>Sesbania</u> species. They found that Fe^{3+} remains accumulated in roots and thus the leaflets, the active parts of the plant, are kept away from the toxic effects of the hgih accumulation of this ion. They have classified this plant as salt tolerant species.

There are some reports regarding the decrease in Fe^{3+} content due to NaCl salinity. Strogonov (1964) found that chloride salinity causes decrease in Fe^{3+} content in gram and cotton. Rehman <u>et al</u>., (1972) have also reported a decrease in Fe^{3+} content due to NaCl salinity in <u>Panicum turgidum</u>, <u>P</u>. <u>antidotale</u>, <u>P</u>. <u>coloratum</u>, <u>P</u>. <u>marimum</u>, <u>Oryzopsis miliacea</u>, <u>Crotalaria aegyptiaca</u>, <u>Medicago sativa</u> and <u>Chloris gayana</u>, Gullein <u>et al</u>. (1978) however observed no effect on Fe^{3+} content of <u>Citrus</u> seedling irrigated with saline water.

From our present observations it is clear that there is increase in Fe^{3+} content in the leaves, rhizome and roots of both the varieties of <u>Curcuma longa</u> - Sugamdhum and Erode as the levels of NaCl salinity increased.

Fe^{3+} is accumulated more in the leaves than the in rhizome and root of both the varieties. It is likely that this accumulation of Fe^{3+} particularly at the higher salinity levels may be troxic, causing disturbance in the metabolic process which may cause the retardation of growth in both the varieties under saline conditions.

b) **Mn^{2+} (Manganese)**

Uptake and distribution of Mn^{2+} in different parts of <u>Curcuma longa</u> varieties - Sugamdhum and Erode grown under saline conditions have been recorded in Table ...8..... and fig no ..30.,.31.. . It is evident that as compared to control plants, Mn^{2+} content decreased in Erode leaves while in Sugamdhum leaves, it is increased at all the levels of NaCl salinity. In the rhizome of Erode variety Mn^{2+} content decreases at lower levels of NaCl salinity and increases at higher levels of NaCl salinity. While in Sugamdhum rhizome Mg content is increased at all the levels of NaCl salinity except at 0.05 M salinity level where it is slightly decreased. In the roots there is increase in Mn^{2+} content in both the varieties Sugamdhum and Erode.

Mn^{2+} is another important micronutrient which plays an important role in many enzymatic reactions as a co-factor. Hasson <u>et al</u>. (1970) have shown a positive correlation between soil salinity and Mn^{2+} content of the plant. They observed an increase in acid extractable Mn^{2+} content by salt stress in barley. Mass <u>et al</u>. (1972) also found an increase in Mn^{2+} content in tomato and Soybean tops under saline conditions. However, it was found to be decreased in squash. Shimose (1972,1973) studied the effect of salinity on Mn^{2+} content in barley, wheat, Italian ryegrass, Cucumber, Lucerne, Asparagus and spinach. He found that absorption of Mn^{2+} and its accumulation in the leaves of barley and wheat decreased with increasing salt concentration. It was observed that decrease of absorption of the element in them was

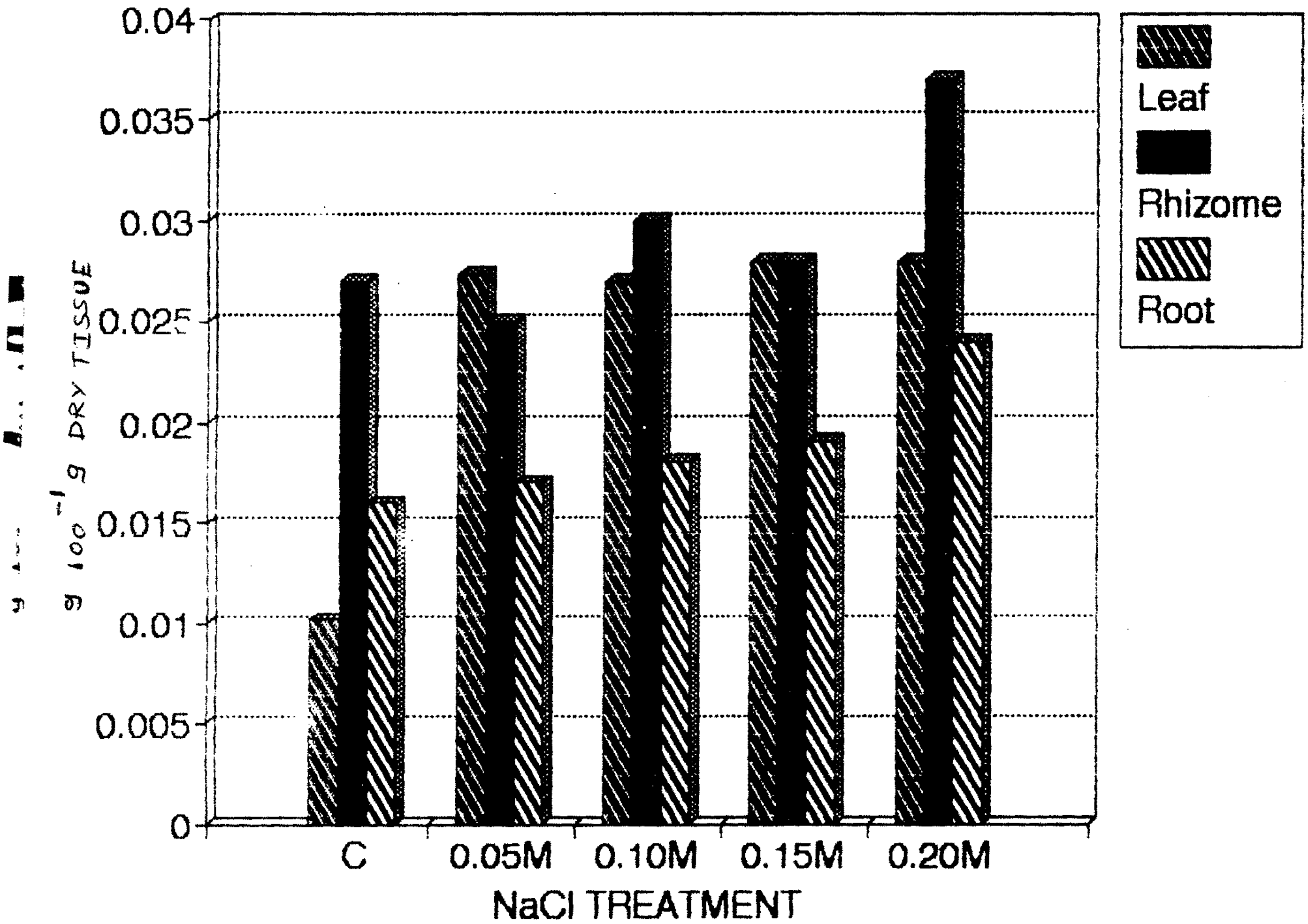

Fig.NO.30 Effect of various concentrations of NaCl salinity on manganese content of <u>Curcuma longa</u> - Sugamdhum variety.

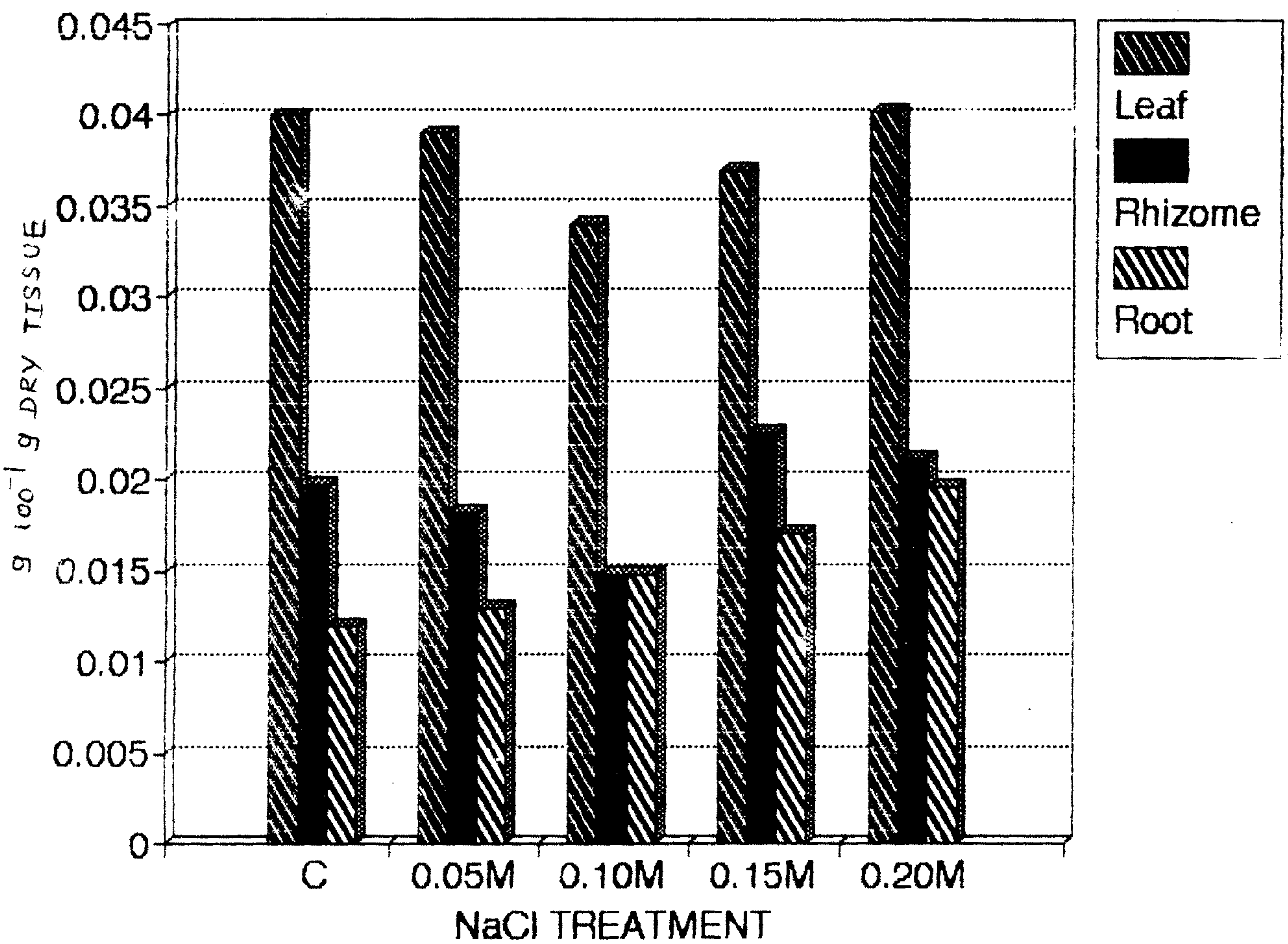

Fig.NO.31 Effect of various concentrations of NaCl salinity on manganese content of <u>Curcuma longa</u> - Erode variety.

higher in Na_2So_4 salinity than NaCl.

Decrease in Mn^{2+} content has been reported by many workers like Pandey and Khanna (1979) in beans, Chavan and Karadge (1980) in peanut have reported stimulatory effect of salinity on Mn^{2+} content. While Shimose (1973) in barley and Deshpande (1981) in pigeon pea, observed adverse effect of salinity on Mn^{2+} content.

From the present observations it is clear that there is increase in Mn^{2+} content in both the varieties at all the levels of salinity. Only in Erode rhizome it decreases at lower concentration of NaCl salinity and increases at higher levels of salinity. In roots of both the varieties Mn^{2+} content is increased due to salinity.

From the above results it is suggested that there is accumulation of Mn^{2+} in all the plant parts of both the varieties under saline conditions. The leaves accumulate more Mn^{2+} than the rhizome and root.

c) **Cu^{2+} (Copper)**

The effect of NaCl salinity on Cu^{2+} content in both the varieties of <u>Curcuma longa</u> - Sugamdhum and Erode has been recorded in Table no...8.... and fig no..32.,.33... . The table reveals that in the leaves of Erode variety Cu^{2+} content is increased while in Sugamdhum rhizome decreases due to NaCl salinity. In the Sugamdhum rhizome Cu^{2+} content is decreased at lower levels and increased at higher levels of NaCl salinity while in Erode rhizome it is

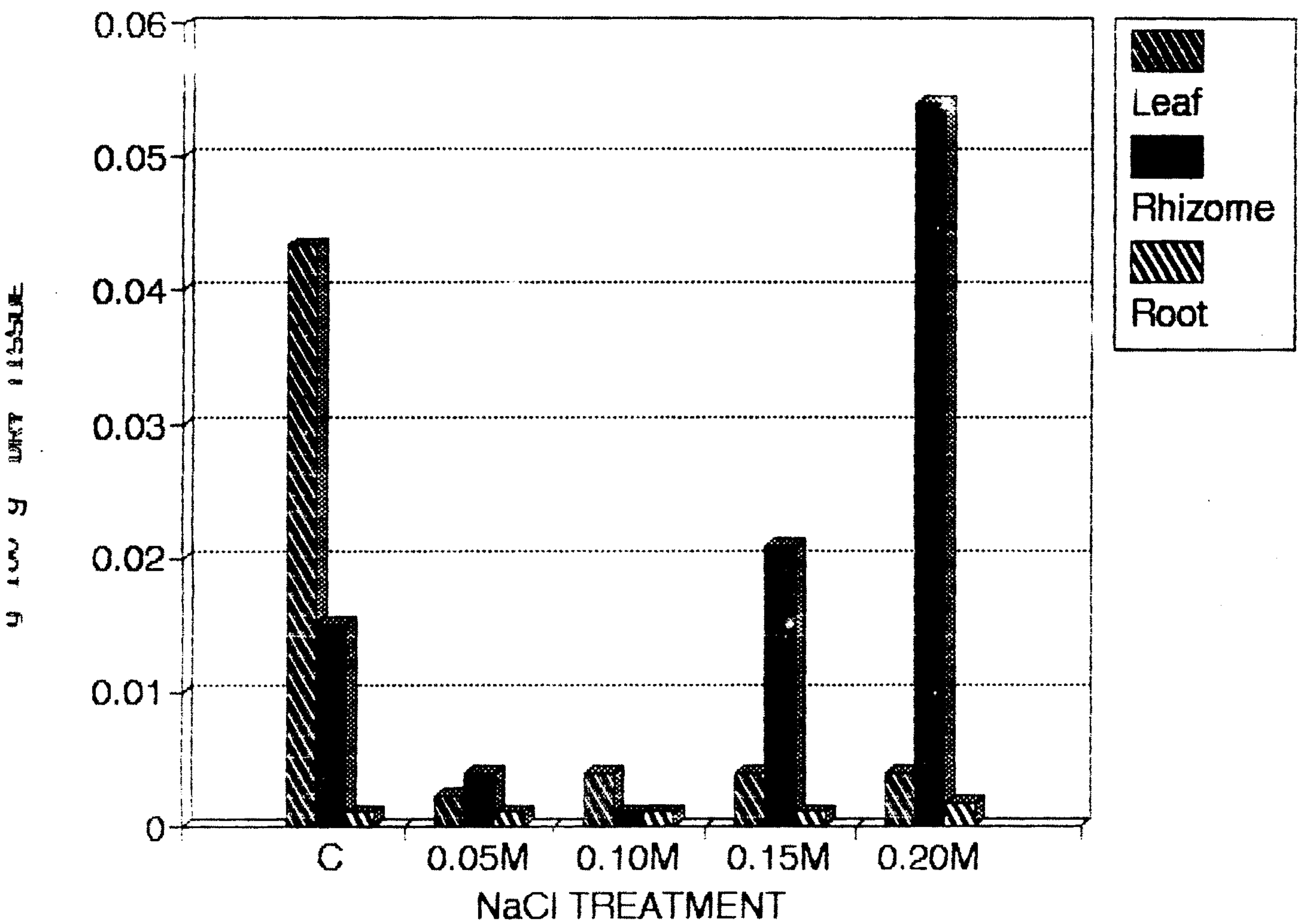

Fig.NO.32 Effect of various concentrations of NaCl salinity on copper content of <u>Curcuma longa</u> - Sugamdhum variety.

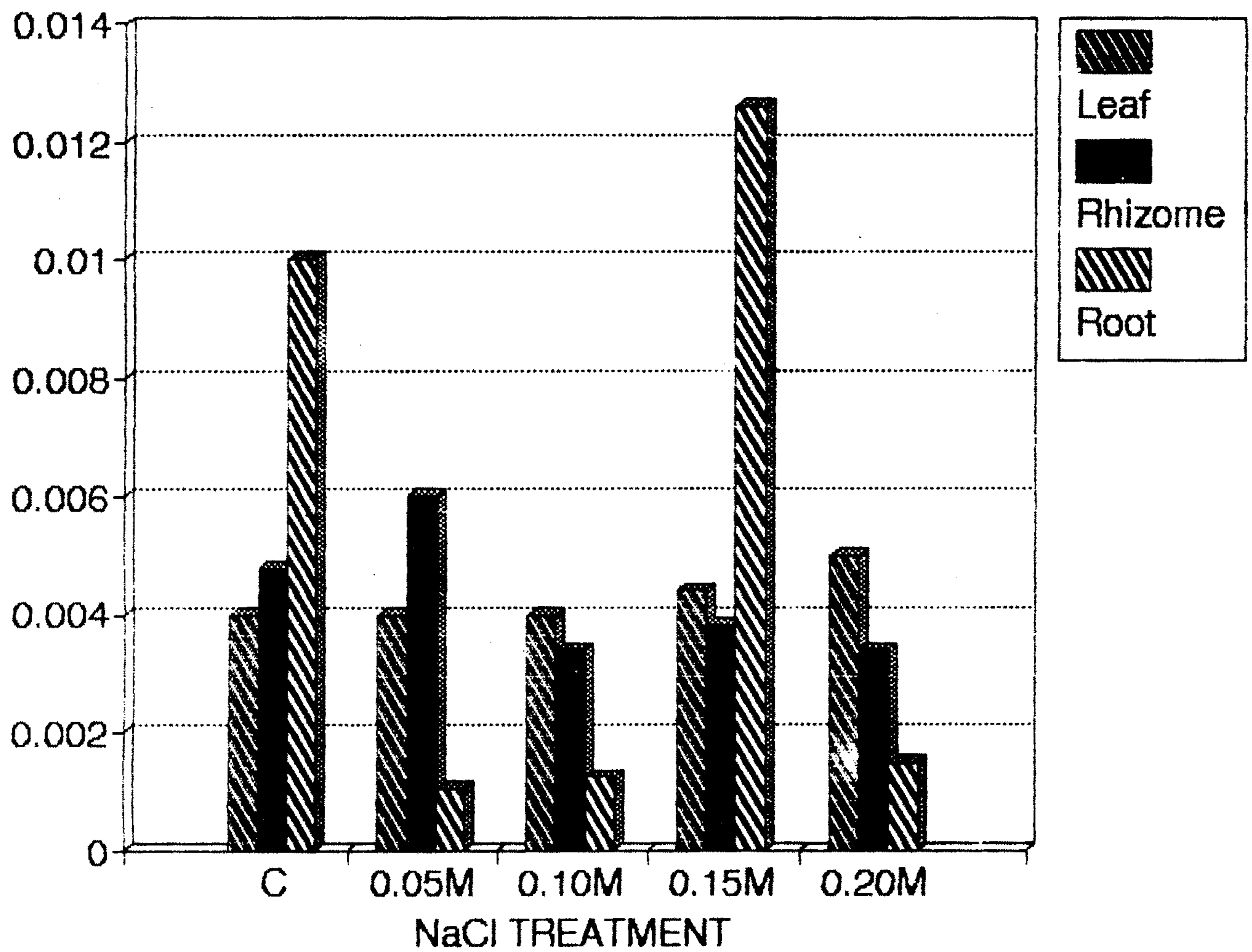

Fig.NO.33 Effect of various concentrations of NaCl salinity on copper content of <u>Curcuma longa</u> - Eoode variety.

decreased at all the levels of salinity except at 0.05 M salinity level it is increased. In the roots Cu^{2+} content is increased with increasing NaCl salinity level.

There are many reports about increase in Cu^{2+} content under saline conditions. Smith et al., (1981) have noticed increased Cu^{2+} uptake under saline conditions in Alfa alfa. Increase in Cu^{2+} content is also reported by Khot (1978) in root, stem, leaves of *Phaseolus aureus* and Rajmane (1984) in *Psophocarpus tetragonolobus*.

There are some reports about decrease in Cu^{2+} content due to salinity. Hassan et al. (1970) and Bhatti and Sarwar (1977) reported a reduced Cu^{2+} content in barley and corn due to NaCl salinity. The Cu^{2+} content is reduced mainly in leaves of fresh bean cultivars Vaghya under the influence of both the salt.

Cu^{2+} increases with increase in salt conc.^{n} in the root medium of salt sensitive plants while it decreases or remains stable in salt tolerant plants (Townseno, 1980).

From the present observations it is clear that there is increase in copper content in Erode leaves as the levels of NaCl salinity increases while in Sugamdhum leaves there is a decrease at all the levels of NaCl salinity.

In the rhizome of Erode variety there is decrease in Cu^{2+} content at all the levels of salinity except at 0.05 M salinity level where it increases while in Sugamdhum variety there is decrease in copper content at lower levels and increases at higher levels of salinity. In the roots Cu^{2+} content increases due to NaCl salinity.

From the above observations it is clear that there is efficient uptake of Cu^{2+} in Erode variety than Sugamdhum variety at various concentrations of NaCl salinity.

d) **Zn^{2+} (Zinc)**

The effect of NaCl salinity on Zn^{2+} content in the two varieties of Curcuma longa – Sugamdhum and Erode has been recorded in the table no..8.... and fig no. 34, 35. the table reveals that in the leaves of Sugamdhum variety Zn^{2+} content decreases at all the levels of NaCl salinity while in Erode leaves it is decreased at lower levels and increased at higher levels of NaCl salinity. In the rhizome of Erode variety Zn^{2+} content is increased while in Sugamdhum rhizome it is decreased at lower levels and increased at higher levels of NaCl salinity. In the roots of both the varieties Zn^{2+} content is increased with increasing salinity levels.

There are some reports about increase in Zn^{2+} content under saline conditions. Increase in Zn^{2+} content under saline conditions is also observed by Bhandari (1988) in Capsicum annuum cultivars Pant C1 and NP46A.

Wallace et al., (1980) and D' Arrigo et al. (1983) in bush bean plants. Rajmane (1984) in Psophocarpus tetragonolobus also observed an increase in Zn^{2+} content under saline conditions.

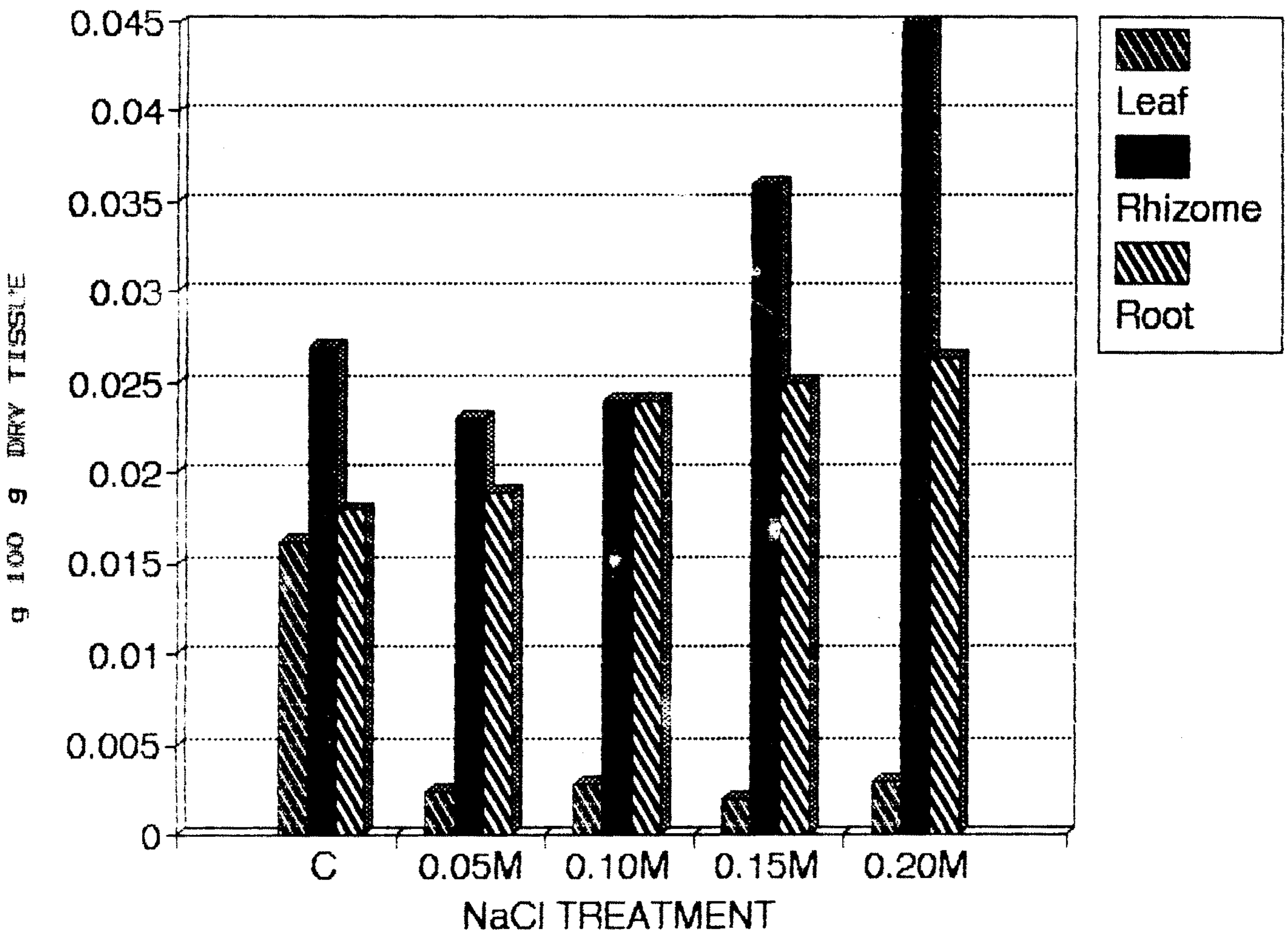

Fig.NO.34 Effect of various concentrations of NaCl salinity on zinc content of *Curcuma longa* - Sugandhum variety.

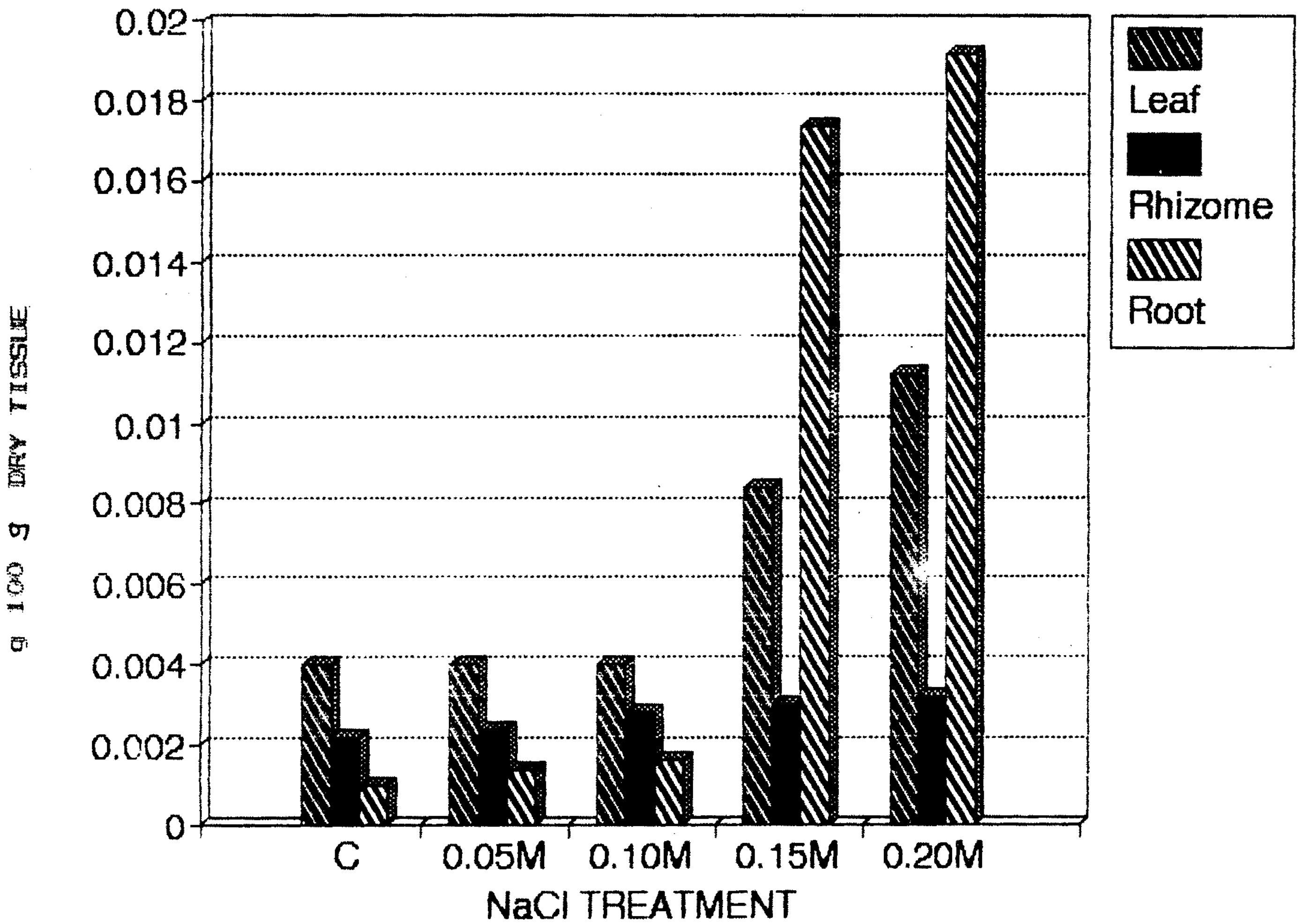

Fig.NO.35 Effect of various concentrations of NaCl salinity on zinc content of *Curcuma longa* - Erode variety.

El-Sharbierry et al., (1986) reported that Zn^{2+} content increased with increase in levels of Chloride salinity in shoots of 4 wheat cultivars. At the same time there are reports about decrease in Zn^{2+} content due to salt stress Patil and Patil (1983) have reported about decline in Zn^{2+} content due to salt stress in Jamum tree.

From the present observations it is clear that there is maximum increase in Zn^{2+} content in the rhizome of both the varieties of Curcuma longa at all the levels of salinity while the leaves accumulated less Zn^{2+} in both the varieties. There was decrease in Zn^{2+} content in the leaves of Sugandhum variety and in Erode variety it is decreased at lower concentrations and increased at higher concentrations of salinity.

From these observations it is clear that there is slow transloca-tion of Zn^{2+} through roots to the leaves. The rhizome stores more in Zn^{2+} content.

e) **CURCUMIN**

Curcumin is a yellow coloured pigment present in the plants of Curcuma longa L. The well established plants of curcuma longa varieties - Sugamdhum and Erode were grown in different concentrations of NaCl. The rhizomes of the treated plants were analysed for the curucmin content. The results have been compared with control plants grown in absence of salinity and discussed below.

The effect of various concentrations of NaCl on curcumin content of rhizome of both the varieties are shown in the table no....9.... and fig no ..36.,37. . The table reveals that as compared to control plants curcumin content is linearly increased in both the varieties of Curcuma longa at all the levels of NaCl salinity. The highest curcumin content is recorded at 0.1 M NaCl salinity level of Sugamdhum variety.

The results suggest that Curcuma longa, Sugamdhum variety contains more curcumin than the Erode variety. As the level of salinity increases curcumin content increases in both the varieties. As compared to control plants, the curcumin is accumulated more in salt stressed plants. But the productivity is affected under saline condition.

Table No. 9

EFFECT OF VARIOUS CONCENTRATIONS OF NaCl ON CURCUMIN CONTENT OF 2 VARIETIES OF *Curcuma longa* - SUGAMDHUM AND ERODE.

Variety	Concentrations of NaCl	Curcumin content in Rhizome (%)
Sugamdhum	Control	6.71
	0.05M	6.76
	0.10M	11.76
	0.15M	10.52
	0.20M	9.6
Erode	Control	2.25
	0.05M	5.38
	0.10M	7.856
	0.15M	6.713
	0.20M	10.64

values are expressed in as % 100^{-1} g fresh tissue.

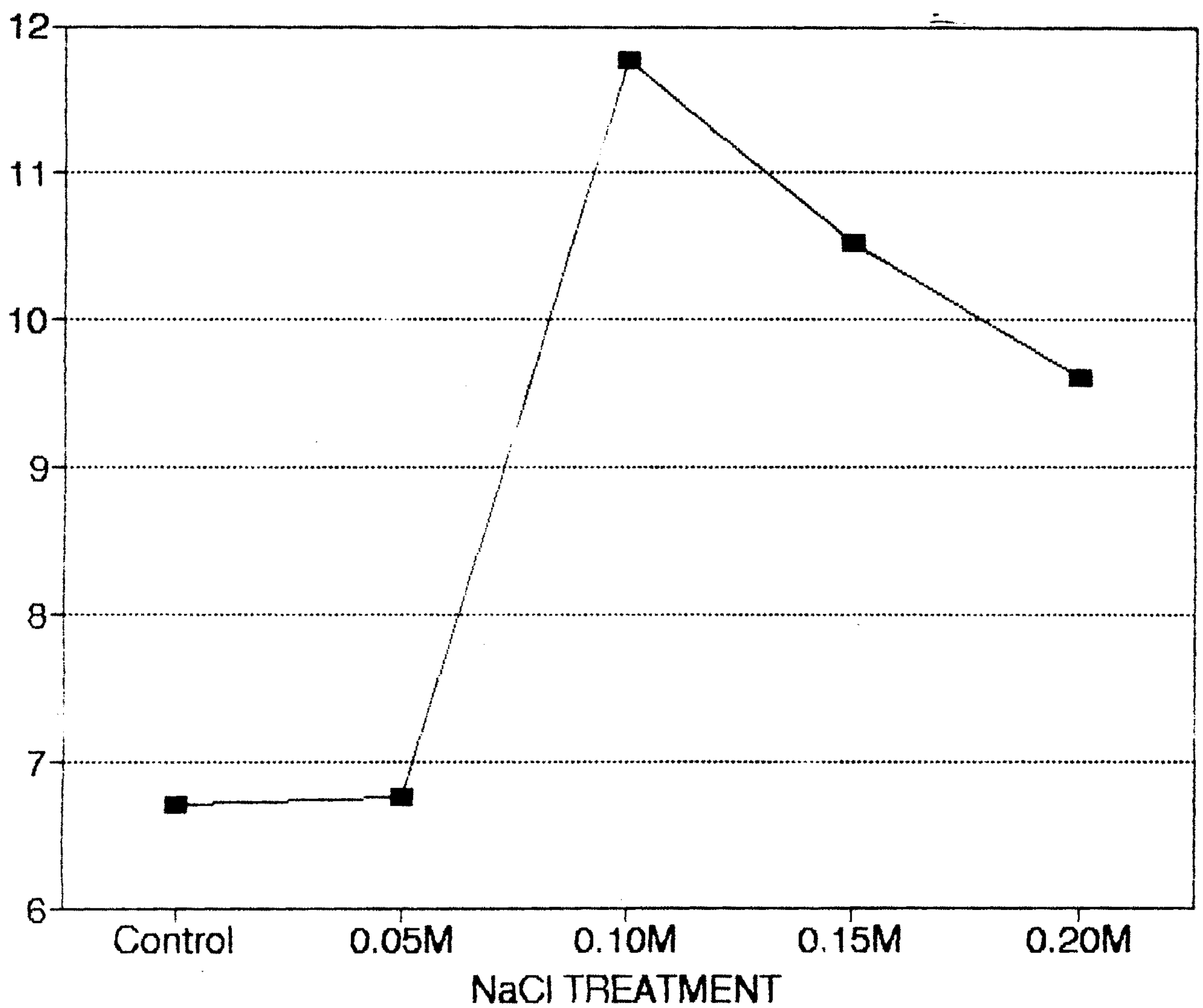

Fig.NO.36 Effect of various concentrations of NaCl salinity on curcumin content of Curcuma longa - Sugamdhum variety.

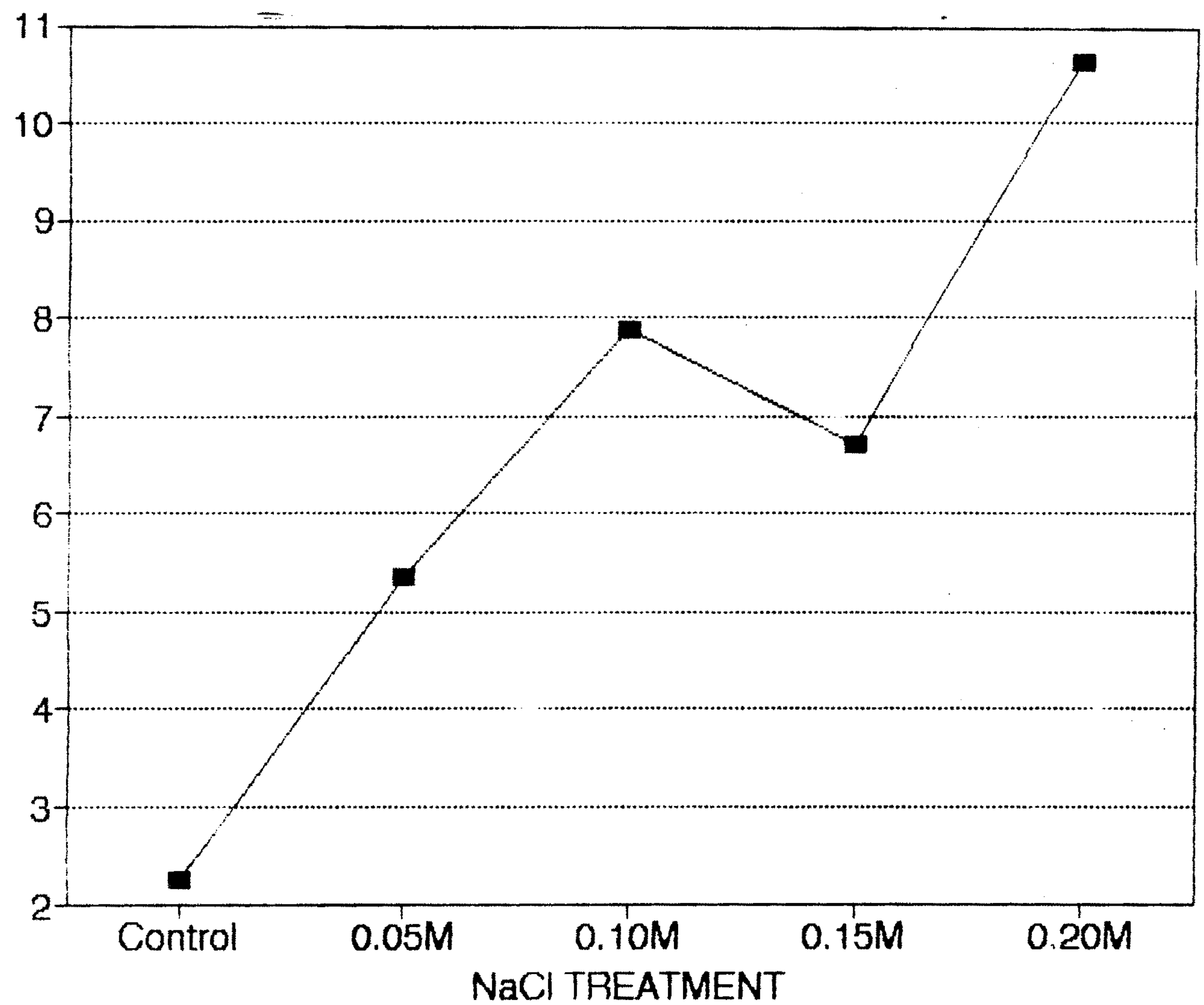

Fig.NO.37 Effect of various concentrations of NaCl salinity on curcumin content of *Curcuma longa* - Eoode variety.