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The influence of *Chromolena odorata* leaf extract and leachate on the food intake of coastal species.

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Abstract

Allelopathy, a natural phenomenon happens when biosynthetic compounds or metabolites created by one living being affect the development, maturation, and reproduction of different species. Such organisms that develop toxins are called invading species. One of the invasive species from the Asteraceae family, *Chromolena odorata* (L.) R. M. King & H. Rob, was chosen for study because of its allelopathic effect on the nutritional uptake potential (N, P, K, Ca, Mg, S, Zn, Fe, Mn and...) of some costal species. It is evident from this study that the invasive weed's leaf leachate and leaf extract have a significant impact on the micro and macronutrient contents of the studied plant species, and that this species either directly or indirectly inhibits the growth and development of other plants. Hence it is required to eliminate the *Chromolaena odorata* an invasive plant from coastal line vegetation. This will help to rebuild the mangrove vegetation over the coastal line and also aid to protect them in their natural habitat. *Chromolena odorata* is a plant that may therefore be used to make weedicide or herbicide.

Keywords: Allelopathy, *Chromolena odorata*, mineral uptake, invasive species, mangrove associate

Introduction

Chromolaena odorata, or Siam weed, is a fast-growing Asteraceae perennial shrub. It is native to Central and Southern America but has become an invasive weed in tropical Asia, Africa,

and the Pacific. Shrubs spread and scramble. In open areas, the plant can grow 3–7 meters. Devil weed, French weed, communist weed, hagonoy, and co-hoy are other names. (Ngozi et al., 2009; Chandrasekaran and Swamy,

2010; Vaisakh and Pandey, 2012). In Sawantwadi taluka, District Sindhudurg, Maharashtra, it is known by common name Ranmodi. Due to its invasive and allelopathic nature, this weed has been categorized as one of the most hazardous weeds worldwide. It was introduced to numerous locations either on purpose or by error as an ornamental plant (Vaisakh and Pandey, 2012; Otariho and Morenikeji, 2013). The younger leaves of *C. odorata* are toxic due to high levels of nitrate (Orapa et al., 2002).

In a preliminary survey, it was marked that a vast area of land, especially in the roadside of coastal area of Sawantwadi, Maharashtra are infested with the weed. But now days, it grows along estuarine region and sea shores. The research on the effects of Siam weed or its extracts on the growth of other coastal plants is limited. Keeping the above background in mind, the current study aimed to assess the allelopathic effects of Siam weed aqueous leaf extract and leaf litter leachate on mineral nutrient metabolism in selected coastal plant species.

Material and method:

Acid digestion method of Toth et al., (1948) has been followed for the analysis of inorganic constituents. Leaves were collected and washed with water blotted to dry and then kept in oven at 60°C till a constant weight was obtained. The oven dried plant material was randomly combined and pulverized. The sulphur content was determined according to the method of Blanchard et al., (1965). Sodium and potassium were estimated flame photometrically using standard procedure on flame photometer. The remaining inorganic elements viz. calcium, potassium, magnesium, iron, manganese, zinc and copper were

estimated using atomic absorption spectrophotometer (P-E, 3030 A).

Result discussion:

Every organism on earth requires a continual nutrition supply to live and to complete its life cycle. These nutrient substances they obtain from external sources rely on habitat of that organism. In plants nutrients necessary must be in their inorganic type.

According to Mengel and Kirkby (1982) mineral absorption capability of plants is always specific, genetically programmed for the different mineral nutrients. There are distinct 16 most important mineral elements required by plant in more or less amount for their typical optimal growth. As per requirement or essentiality of these element, they are classed as macronutrients (N, P, K, Ca, Mg, S, and Na) which are found and needed by plants in comparatively higher levels and micronutrients (Fe, Mn, Cu, Zn, Mo, B and Cl) that are found and needed by plants in relatively fewer amounts. Both these mineral elements are crucial for physiological and biochemical activities.

According to Marschner (1986) these micro and macronutrients requirement directly or indirectly related with various metabolic processes in their life of organism. Therefore, both are essential to govern entire productivity of that organism (plant). The mineral absorption potential values are largely depending on plant type, plant age and concentration of other mineral components. This figure may alter based on several things including pH, composition and constituents of soil, climate, significant rain fall. Which may lead to develop shortage of mineral elements in plants (Gauch, 1972). The poor environmental

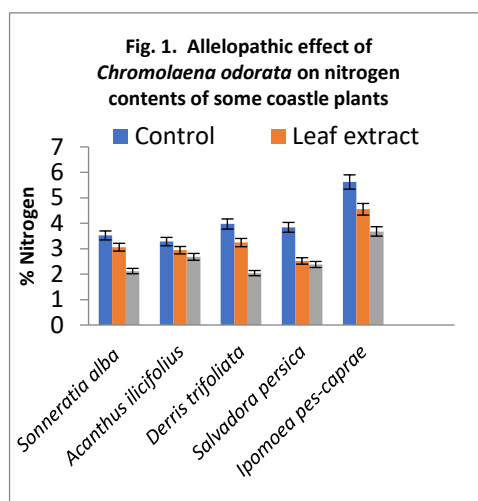
conditions also impede the uptake, transport and distribution of plant nutrients throughout the plant body. Epstein (1972) and Rain (1976) revealed nutritional deficiencies and accompanying effects on plant metabolism. Mineral deficient plant presents different indications like chlorosis, malformation, dwarfism (restricted growth), dieback and eventually death of plant. In present investigation, it was thought that the status of these mineral nutrients may give an idea about adaptability and luxuriant growth of the costal plant species also. Following account is regarding the status of mineral elements under different treatments of *Chromolaena odorata*.

Nitrogen

The influence of leaf extracts and leaf leachate of *Chromolaena odorata* on nitrogen contents of few coastal species have depicted in Fig. 1. It is evident from results that under controlled condition 5.62% nitrogen content is highest level observed in *Ipomoea pes-caprae* and that 3.28% lowest found in *Acanthus ilicifolius*, among all studied plant species. In other studied plants nitrogen accumulation found as 3.52% in *Sonneratia alba*, 3.97% in *Derris trifoliata*, and that 3.84% in *Salvadora persica* under same control condition.

One quite observant macronutrient found in plants is nitrogen. In an organism, it serves as the building block of nitrate, nitrite, amino acids, amide, urea, ammonia, hexacosamines, quaternary ammonium compounds, proteins and many other metabolites. Most of the metabolic activities occur in cells similar to photosynthesis, protein metabolism, chlorophyll synthesis, in transport and

signaling activity, enzyme component (RUBISCO), respiration, in cell division, synthesis of alkaloids, glucosides, contribute to the structure of nucleotide bases, nucleic acids (RNA and DNA), phytohormones IAA, Cytokinins, Polyamines Co-enzyme NAD and NADP (Murata, 1969; Penning de vries, 1975; Chapin, 1980; Delgado et al., 1994; Gastal and Lemaire, 2001; Leigh, 2003).



As per mentioned by Marschner (1986), the nitrogen content range between 2 to 5 % is essential for optimal growth of plant and it depends on the plant species, developmental stage and organ of the plant. According to Parsa and Bagheri (2008) the minimum amount 1to 2% requirement of nitrogen in plants and 4 to 6% is highest amount ranges of it.

In current study, Leaf leachate and leaf extract treatment of *Chromolaena odorata* both found adversely affecting nitrogen contents of all studied coastal plants. In leaf extract treatment highest loss (34.38%) in nitrogen content observed in *Salvadra persica* (From 3.84 to 2.52% nitrogen) and that lowest 10.37% of total nitrogen found in

Acanthus ilicifolius (It fall down from 3.28 to 2.94% nitrogen). Under this treatment other studied plants found same kind of decrease in nitrogen content viz. In *Sonneratia alba* 13.07% loss of total nitrogen, in *Derris trifoliata* 18.39% loss and that 19.04% decline of total nitrogen observed in *Ipomoea pes-caprae* as compare to same.

In case of leaf leachate treatment of *Chromolaena odorata* higher decrease /decline in total nitrogen content observed than that of leaf extract treatment of same and control condition. Under this leaf leachate treatment highest decline in nitrogen content observed in *Derris trifoliata* (48.61% loss) and lowest loss under same treatment observed in *Acanthus ilicifolius* (18.29% of total nitrogen) as compare to control of same. In *Sonneratia alba* 39.77% loss in total nitrogen, in *Salvadora persica* 38.02% loss and that 34.52% decrease in total nitrogen content observed in *Ipomoea pes-caprae* as compare to nitrogen level observed at control condition in same.

Nitrogen act as fundamental element in various structures of cell, tissue, organ and even entire organism therefore alteration in this element highly impact on total growth of organism. Hence from result it can be concluded that *Chromolaena odorata* compete other plants by attacking directly or indirectly on their nitrogen metabolism. From overall observation of current study, it is apparent that nitrogen uptake and distribution is markedly disturbed due to influence of allelochemicals of *Chromolaena odorata* in all studied plants. This may lead to further alterations in the overall metabolism in influenced plants. As per earlier

mentioned by Gallacher and Sprent (1978) total nitrogen reflects the total plant growth. Thus, the studies of nitrogen uptake and its partitioning give a very good idea about essential measure to improve the overall crop productivity. Hence it can also conclude that allelochemicals of *Chromolaena odorata* hampers the net productivity of other plants. In general, it appears that the nitrogen metabolism seems to be rather sensitive to allelochemicals of *Chromolaena odorata* in all studied plant species.

Phosphorus

One of the macroelement necessary for plant development via several metabolic processes is phosphorus. Usually, a decrease in its contents causes a decrease in the rate of several metabolic activities. Inside all living cells, it is found as inorganic phosphorous, phosphate ester, and as energy-rich phosphate bonds.

Fig. 2 shows in present work allelopathic influence of leaf extract and leaf leachate of *Chromolaena odorata* on phosphorous content of coastal plant species. Results clearly show that phosphorous contents drop under both these *Chromolaena odorata* treatments as compared to control. In control condition among investigated coastal plant greatest phosphorous absorption potential observed in *Ipomoea pes-caprae* and that lowest 0.19% observed in *Sonneratia alba* as well as in *Salvadora persica*. In *Acanthus ilicifolius* this potential is observed as 0.237%; in *Derris trifoliata* as 0.24. These levels fall within the range of ideal need for it from 0.1 to 0.5 % of the dry weight as stated for other plants or agricultural crops by Marschner (1986).

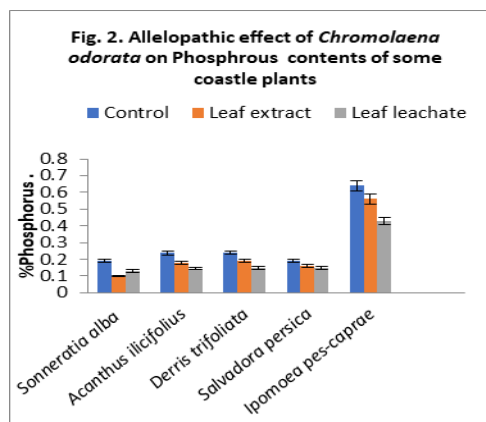
Phosphorus exists in phosphor lipids as well as in the nucleic acid (DNA and RNA both). As ATP, in all living entities it serves as building block of biological energy. < Phosphorus hence is essential for many different kinds of biological activities.

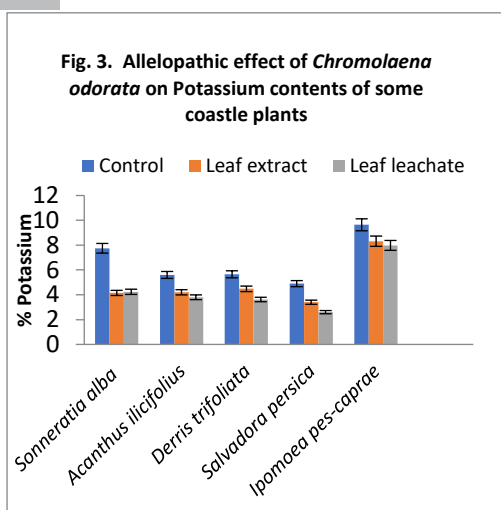
According to Grattan and Grieve (1992) phosphorus accumulation in plant tissues depends on experimental conditions and a type of plant cultivar. In present study, under leaf extract treatment *Chomolaena odorata* phosphorus contents found decline in all studied plants. Highest decline 47.37% of total phosphorus observed in *Sonneratia alba* and that lowest decline 12.50% of total phosphorus observed in *Ipomoea pes-caprae* under this treatment of *Chromolaena odorata*. In this leaf extract treatment 24.89% decline observed in *Acanthus ilicifolius*, that 20.83% decrease in *Derris trifoliata* and 15.79% total phosphorus content decline in *Salvadora persica* as compare to control one of same.

While in leaf leachate treatment of same *Chromolaena odorata* plant highest decrease in total phosphorus uptake potential recorded than that of leaf extract treatment and control. Under this leaf leachate treatment lowest fall down 21.05% loss reported in *Salvadora persica* as compared with control among all investigated plants. In *sonneratia alba* 31.58% decline of total phosphorus level observed which is less that under leaf extract treatment 47.37% of same plant. Except *Sonneratia alba*, in all other studied plant higher decline in total phosphorus level under this leaf leachate treatment observed. Viz. 39.2% loss observed in *Salvadora persica* as compared with control among all studied

plants. In *sonneratia alba* 31.58% decline of total phosphorus level observed which is less that under leaf extract treatment 47.37% of same plant. Except *Sonneratia alba*, in all other studied plant higher decline in total phosphorus level under this leaf leachate treatment observed. Viz.39.2% decline in *Acanthus ilicifolius*, that 37.50% in *Derris trifoliata* and that 32.81% decrease in total phosphorus content observed in *Ipomoea pes-caprae*.

It may be concluded from finding that allelochemical treatment of *Chromolaena odorata* adversely affect phosphorus absorption capability of other plants. Which ultimately results into impairment of all metabolic activities of other plants due to scarcity development in phosphorus contents. Therefore, it can also mention allelochemical created by *Chromolaena odorata* are useful for itself to reduce plant natural rivalry for nutrition acquirement. Phosphorus regulates the photosynthesis and glucose metabolism and via which it limits reproductive growth and finally decides the yield. Hence it can say that allelochemicals emit from *Chromolaena odorata* responsible to fall production of other plants.





Potassium

Effect of leaf extract and leaf leachate treatment of *Chromolaena odorata* on potassium uptake potential of certain coastal plant (*Sonneratia alba*, *Acanthus ilicifolius*, *Derris trifoliata*, *Salvadora persica* and *Ipomoea pes-caprae*) have been depicted in Fig.3. It is obvious from finding that with both treatment potassium contents detected decreased in all tested coastal plants.

Potassium is a primary micronutrient that contributes to plant growth and development in a variety of ways, including photosynthesis, protein and carbohydrate translocation, ribosome stability, protein synthesis, nitrogen metabolism, carbohydrate metabolism, glycolysis, phosphorylation, and adenine biosynthesis, as enzyme catalysts, stomatal behavior, and plant osmoregulation, among others. (Suelter, 1970; Humble and Raschke, 1971; Ben-Zioni et al., 1971; Peoples and Koch, 1979; Marschner, 1997).

Epstein (1972) reported 1% potassium plants require for their optimal growth. In extant investigation at control condition highest potassium contents

9.64% observed in *Ipomoea pes-caprae* and that lowest 4.9% potassium observed in *Salvadora persica* among all studied plants. Potassium content in other studied plants under same condition observed as *Sonneratia alba* 7.75%, in *Acanthus ilicifolius* 5.6% and in *Derris trifoliata* 5.65%. These values observed are much higher than that of optimal requirement for normal growth as described by Epstein (1972). But these results can be supported by Leigh et al. (1984) noted that potassium which is the most abundant inorganic constituent in higher plants attaining the concentration as high as 10 % of plant dry weight. That elevation in potassium may be due to impact of coastal ecological condition (halophytic condition) and adjustment of plants with that. According to Golldack et al., (2002) plant adaptations to salt stress (halophytic condition) involves marked reprogramming of potassium channel gene expression in the leaves. Similar kind of results i.e. accumulation of potassium higher than optimal requirement have been noted by Karmarkar (1965) in *Bryophyllum pinnatum* 1.85 % potassium, that 1.89% (dry wt.) in *Portulaca oleracea* (Karadge, 1981), 2.04 % in *Cassia* species on dry wt. basis (Patil, 2009). and by Naik (2009) upto 2.4 to 2.6 % potassium in grape.

According to Mengel and Krikby (1982), potassium deprivation in plants causes a decrease in nitrate reductase activity, disruption of protein metabolism, and the buildup of amino acids and soluble organic nitrogenous substances.

Under leaf extract treatment of *Chromolaena odorata* decrease in total potassium content observed in all studied

coastal plants. In this treatment, highest 46.45% decrease in total potassium content of same observed in *Sonneratia alba* and that lowest 13.69% in *Ipomoea pes-caprae*. In *Sonneratia alba* this decrease in potassium content is highest than that of leaf leachate treatment 45.29%. In leaf extract treatment 25% loss in total potassium content observed in *Acanthus ilicifolius*, that 20.71% loss in total potassium in *Derris trifoliata*, 30.61% decrease in *Salvadora persica* and that 13.69% loss in total potassium content observed in *Ipomoea pes-caprae* as compare with control of same.

In case of leaf leachate treatment maximum decline in potassium content observed than that of leaf extract treatment of *Chromolaena odorata* (except in *Sonneratia alba*) in all studied plants. Under this treatment highest decrease of total potassium 46.94% observed in *salvadora persica* and that lowest decline 17.22% in *Ipomoea pes-caprae*. In other studied plants decrease in total potassium content observed as 45.29% loss in *Sonneratia alba*, 32.14% in *Acanthus ilicifolius* and 35.93% in *Derris trifoliata*.

As a result of the findings, it is feasible to conclude that *Chromolaena odorata* allelochemicals have a deleterious influence via changing potassium-related metabolism such as osmoregulation and reducing important enzyme systems such as reduction nitrate reductase activity. *Chromolaena odorata* produces toxic allelochemicals that inhibit the growth and development of other plants by interfering with their potassium uptake potential, resulting in failures in a variety of mechanisms such as photosynthesis, protein and carbohydrate translocation,

ribosome stability, protein synthesis, nitrogen turnover, and so on.

Sodium:

Effect of leaf extract and leaf leachate of *Chromolaena odorata* on sodium concentrations of certain coastal plant species (viz. *Sonneratia alba*, *Acanthus ilicifolius*, *Derris trifoliata*, *Salvadora persica* and *Ipomoea pes-caprae*) have been presented in Fig. 4. It is obvious from data that under both these allelochemical treatments of *Chromolaena odorata* discovered accountable for reduction in salt levels in all tested plants.

The range of sodium for healthy growth of normal plants as glycophytes as stated by Chirputkar (1969) and Gauch (1972) is 0.1 to 1.4% dry wt. Na concentration reported greater in the vacuoles than in cytoplasm halophytes (Greenway and Munns, 1980). From present study it is observed that in controlled state highest sodium accumulation 9.5% found in *Crotalaria retusa* and that lowest 2.69% sodium found in *Acanthus ilicifolius* among all studied plant. Sodium level pattern in studied plants found as *Ipomoea pes-caprae* > *Salvadora persica* > *Sonneratia alba* > *Derris trifoliata* > *Acanthus ilicifolius* at control condition. In *Sonneratia alba* 4.35% sodium, in *Derris trifoliata* 3.79% sodium, in *Salvadora persica* 6.9%, in *Crotalaria verrucosa* 7.65% and that 8.4% sodium contents observed in *Ipomoea pes-caprae* under control. The range of sodium here found much higher than adequate level given by Chirputkar (1969) and Gauch (1972). Which may play key part of luxuriant growth of these coastal plants. But results support theory of Flowers et al., (1977) which have revealed that halophytes require

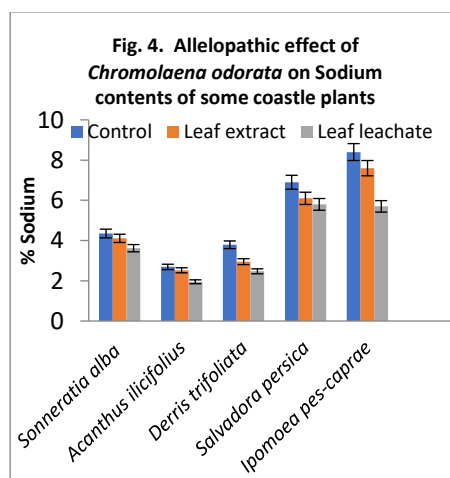
sodium for growth, notably in C4 and CAM plants and some halophytes require very high concentration of Na for their maximal growth.

Sodium is macronutrient which is most necessary because of its role in plant growth, development and metabolism. Which have been reported by several researches as it accountable for stimulation of growth with non-modifying C4 photosynthetic activity, during nitrate uptake NO₃⁻ reduction and its subsequent incorporation into proteins resulting in growth improvement, in some monocots plants Na increased the NR activity, Na caused to stimulate the growth through cytokinin mediated functions and high levels of alanine, in few succulent halophyte Na contributes to the internal osmotic potential, it contributes in osmotic prospective of cell, sodium maintain the functional integrity of mesophyll cell chloroplasts (Rains, 1972; Mengel and Kirkby, 1982; Nable and Brownell, 1984; Matoh et al., 1986; Ohta, et al, 1987, 1988; Brownell and Bieling, 1996 and Pujol et al. 2001). Enzymatic role of sodium has been reported by several contributors as activator for some enzymes like ATPase, Nitrate reductase, pyruvate phosphate kinase, PEP-case (Evans and Sorger, 1966; Kylin, 1973, Shomer-Ilan and Waisel, 1973).

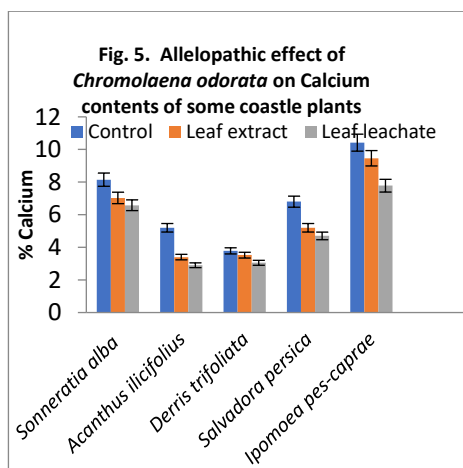
From current study it can be revealed that all studied coastal plants shown same kind of response to leaf extract treatment of *Chromolaena odorata* i.e decline in sodium contents. Under this treatment maximum prominent 22.16% % decline and minimum 5.52% decrease in total sodium observed in *Derris trifoliata* and *Sonneratia alba*

respectively. In same treatment sodium contents found 6.332% decrease of total in *Acanthus ilicifolius*, that 11.59% in *Salvadora persica*, and that 9.52% decrease in sodium content of *Ipomoea pes-caprae* as compare with control one of them.

As compare with leaf extract treatment and leaf leachate treatment of *Chromolaena odorata* found responsible for more decline in sodium level of all plant studied. Highest decline 34.83% and lowest decline 15.94% in sodium content observed under this leaf leachate treatment in *Derris trifoliata* and *Salvadora persica* respectively. Due to this treatment pattern of sodium level (accumulation) found changed as *Salvadora persica* > *Ipomoea pes-caprae* > *Sonneratia alba* > *Derris trifoliata* > *Acanthus ilicifolius*. In this treatment of leaf leachate of *Chromolaena odorata* change in sodium content found as 16.78% loss of total sodium in *Sonneratia alba*, 27.51% decrease in *Acanthus ilicifolius*, and that 32.14% decrease in sodium content of *Ipomoea pes-caprae* as compare with control one of them.



From the outcome it may be stated that allelochemicals of *Chromolaena odorata* influences sodium contents / uptake potential of other plants. It reveals their harmful impact on growth, development and metabolism of predicted plants. That may cause imbalance in osmotic potential, reduction in enzymatic activity and directly or indirectly slowing growth and development in treated plants.



Calcium

The effect of leaf extract and leaf leachate (allelochemicals) of *Cromolaena odorata* on calcium contents of few coastal plant species have been depicted in Fig. 5. It is evident from results that highest calcium content 10.42% observed in *Ipomoea pes-caprae* and lowest 3.78% in *Derris trifoliata* under control condition. Under leaf extract and leaf leachate both treatments found responsible to decline total calcium contents of all studied coastal plants.

Calcium is one of the most critical plant macronutrients. Calcium is a non-hazardous mineral element, at high concentration also and is particularly efficient in detoxifying larger concentrations of other elements in

plants (Clarkson and Hanson, 1980). The principal job carried out by calcium in plants is to bond with proteins, nucleic acids and lipids to impact cell adhesion, membrane chromatin arrangement and enzyme conformation (WynJones and Lunt, 1967; Burstrom, 1968; Mengel and Kirkby, 1982; Renzel, 1992 andso on).

There are multiple findings relating various enzymes were catalysed by calcium such as ATPase, Protein kinase, Pyruvate kinase, nuclease, α - amylase, esterase, pectin esterase, lipoxygenase, polygalacturonase, transaminase and glucose 6-phosphate dehydrogenase. Many researchers have found that calcium regulates activity of enzymes such as phospholypase, ATPase, nitrogenase, nitrate reductase, esterases, pectin esterases, lipoxygenases, nucleases, protein kinase, pyruvate kinase, polygalacturonictransminase and glucose -6- phosphate dehydrogenase (Davidson and Long, 1958; Dodds and Ellis, 1966; Wyn Jones and Lunt, 1967; Clarkson and Hanson, 1980; Clark, 1984; Poovaiah and Reddy, 1987 and Jones et al., 1993).

Salisbury and Ross (1995) revealed that the 0.2 % dry weight is critical concentration of Ca for dicots and that less than 1% for monocots. It is evident from current result that calcium contents under controlled condition found as 8.15% found in *Sonneratia alba*, 5.2% in *Acanthus ilicifolius*, 3.78% in *Derris trifoliata* and 6.8% in *Salvadora persica*. This level of calcium found much higher than optimal requirement of normal plants. Similarly high level of calcium reported in *Portulaca oleracea* leaves 4.4 % (dry wt.) calcium was recorded by Karadge (1981) and 2.57 to 3.37 % (dry

wt.) calcium in the leaves of *Cassia* species was recorded by Patil (2009).

In case of leaf extract treatment of *Chromolaena odorata* decrease in calcium content observed in all studied plants. Highest decline 34.62% of total calcium content observed in *Acanthus ilicifolius* (i.e. calcium content falls down from 5.2% to 3.4% calcium) and that lowest 6.88% of total calcium content observed in *Derris trifoliata* (i.e. from 3.78 to 3.52% calcium) as compare with control one of same among all studied plants. In other studied plants under this treatment calcium content found as 7.03% in *Sonneratia alba* (13.74% decrease) 5.2% in *Salvadora persica* (23.53% decline) and 9.46% calcium in *Ipomoea pes-caprae* (9.21%) loss.

In leaf leachate treatment more decrease in calcium content were observed than leaf extract treatment of *Chromolaena odorata* in all studied plants. Under this leaf leachate treatment highest decline 44.23% observed in *Acanthus ilicifolius* (i.e. calcium content decreased from 5.2% to 2.9% calcium) and that lowest decrease 19.31% observed in *Derris trifoliata* (i.e. calcium 3.78% to 3.05%) as compare to control of same. In *Sonneratia alba* 19.26% loss in total calcium contents, in *Salvadora persica* 30.88% and that in *Ipomoea pes-caprae* 25.34% decline in total calcium contents observed under this leaf leachate treatment of *Chromolaena odorata*. According to Miller and Claude (1983) calcium deficiency responsible to decline the activities of enzymes nitrogenase and nitrate reductase.

Hence from overall observation it can be conclude that *Chromolaena odorata* impacts calcium uptake potential

adversely which may lead to drop in activation of numerous enzymes. Which directly or indirectly affects metabolic processes in those plants. And it may also be concluded that drop in calcium under examined treatment demonstrates decline in productivity of those plants via decline in catalyzing rate of nitrate reductase, nitrogenase and other key enzymes. All tested plant displays greater calcium content which may useful to them to nullify toxicity of other minerals.

Magnesium

Change in Magnesium content under allelopathic treatment of *Chromolaena odorata* in some coastal plants have been depicted in Fig. 6. It is clear from result that like other macronutrient magnesium also found decline under all these studied treatment in all plant studied as compare to control of them. Among all studied coastal plant magnesium content found highest 0.98% in *Ipomoea pes-caprae* and that lowest 0.12% in *Sonneratia alba* under control condition. Although, the magnesium concentration in the leaves of most studied plants is lower than that of critical value, no any plant species show any deficiency syndrome observed in them.

Magnesium is a tiny, mobile, and strongly electropositive divalent cation found in plants. According to Kirkby and Mengel (1967), magnesium is an important macronutrient that plays an important role in various metabolic processes in plants. It interacts with organic ions such as citrate, oxalate, malate, and pectate, as well as inorganic anions, and it also contributes to the electrical neutrality of organic compounds such as sugar phosphates, sugar nucleotides, organic acids, and

amino acids. Magnesium, according to several researchers, functions as a catalyst for numerous enzyme systems involved, activating enzymes carboxylases, RuBP carboxylase, oxygenase, ATPase, RNA polymerase, nitrate reductase, catalase, glutamate dehydrogenase, peroxidase, and RNAase. (Clark, 1984; Marschner and Cakmak, 1989; Khurana et al., 2005). Magnesium plays vital role of joining the ribosomal subunits (Cammarano et al., 1972).

Medicinal importance of magnesium reported by different workers as it is essential in muscle relaxation after contraction, Mg deficiency may causes neuromuscular symptoms such as tetany, an extreme and prolonged contraction of the muscles, along with various medicinal drugs it helps to control hypertension and heart diseases, diabetes, osteoporosis, migraine headaches and asthma (Liao and Seinfeld, 1998; Paolisso et al., 1992; Sojka and Weaver, 1995; Whitney and Rolfes, 1997; Mauskop and Altura, 1998 and Cydulka, 1996). As per Food and Nutrition Board of the Institute of Medicine (2004) mentioned daily requirement of Mg is 420 mg/ day fulfill diet.

According to Epstein (1972) up to 2% Mg cations as critical value in the plants on a dry weight basis. In current investigation under control condition this level found much less than its critical level in all studied plants as 0.64% Mg cations observed in *Acanthus ilicifolius*, that 0.46% in *Derris trifoliata* and that 0.92% in *Salvadora persica*. These values are supported by similarities with earlier reports of various researchers as in *Portulaca* leaves, 0.3 % (dry wt.) Mg

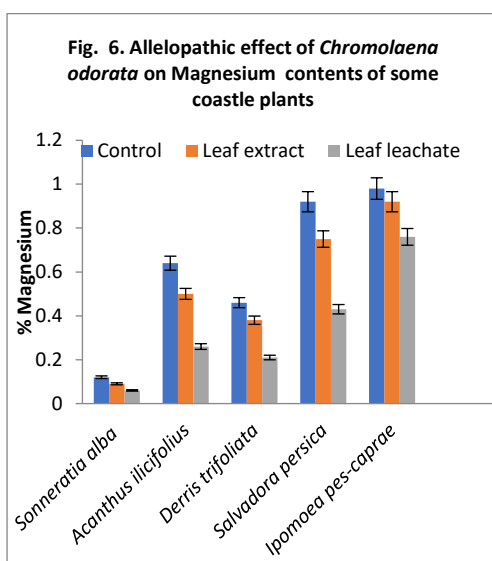
(Karadge, 1981), in mulberry varieties ranges 0.2%– 0.8% (dry wt.) Mg (Duke, 1983 and Khade, 2007), in *Cassia* species, 0.28 % to 0.37 % (dry wt.) Mg (Patil, 2009), in *Morinda* species range from 0.3 to 0.5 % (dry wt.) Mg (Desai, 2011).

Under allelopathic treatment of leaf extract of *Chomolaena odorata* there is decreased magnesium level observed in all studied plants. Maximum prominent decline 25% observed in *Sonneratia alba* and lowest or less prominent decline observed in total magnesium content of *Ipomoea pes-caprae* as compare with control one of same and among all studied plants. There is 21.88 % loss in total magnesium content of *Acanthus ilicifolius*, 17.39% decline of *Derris trifoliata*, 18.48% of *Salvadora persica*, and 6.12% decrease in total magnesium content of *Ipomoea pes-caprae* observed under this leaf extract treatment as compare to control one of same.

In case of leaf leachate treatment higher loss in magnesium level observed than that of leaf extract treatment among all studied plants. Under this treatment highest decrease 59.38% observed in *Acanthus ilicifolius* as compared with control of same. Under this treatment of leaf leachate *Sonneratia alba* shown 50% decline in total Magnesium content (declines from 0.12% upto 0.06% Magnesium), that 54.35% decrease in *Derris trifoliata*, 53.26% decline in *Salvadora persica*, and that 22.45% fall down in total magnesium of *Ipomoea pes-caprae* (i.e. from 0.98 to 0.76% Magnesium) as compared with control one of them.

Consequently, the results of this study imply that the allelopathic impact of *Chromolaena odorata* therapy lowers

magnesium concentration, which in turn prevents the activation of numerous enzymes. Hence, it was determined that the metabolism of the plant under study was abnormal. It has the potential to reduce enzyme activity such as catalase, acid phosphatase, and ATPase as well as protein synthesis, chlorophyll a and b levels, and biomass. In the end, it was determined that other plants' photosynthetic efficiency was lowered by *Chromolaena odorata*.



Sulphur (S)

It is clear Fig.7 shows how *Chromolaena odorata* allelochemicals affect coastal species' sulphur levels. The results show that these treatments reduce sulphur in all plants except *Sonneratia alba*.

Sulphur is one of the key macro nutrients for healthy growth and development of plants. Marschner (1995) described various role of sulfur as a component of amino acids viz. cysteine, and methionine. That is, it plays key function in synthesizing proteins and nitrogen metabolism. It aids in stability of protein structures by generating disulfide bonds and sulphydryl (Saito, 2000). It plays

crucial role of control of numerous enzymes involve in redox reaction (Nazar et al., 2011). It operates as component of many secondary metabolites and useful for manufacture of gaseous hormone ethylene (Koprivova et al., 2008) in plants. i. e., it has important status in ripening or maturation of plants. It involves in electron transport chain as component of Iron-Sulfur protein and also important for formation of Ferredoxin and Photosystem-I in chloroplast (Yabe et al., 2008).

For optimum for plant growth 30 m mol kg⁻¹ sulphur is sufficient (Bahboudian et al., 2003) and as per suggested by Durenkamp and De Kok (2004) it is sulfur requirement 0.03 to 2 m mol Kg⁻¹ dry weight of plant. According to Munson (1998) optimum value of sulphur in plant species is in the range 0.08 to 1.56 %. In current study under control condition highest 0.74% sulphur contents found in *Acanthus ilicifolius* and that lowest 0.12% sulphur found in *Sonneratia alba* among all studied plants. The pattern of sulphur level found in all studied plants is as *Acanthus ilicifolius* > *Ipomoea pes-caprae* > *Salvadora persica* > *Derris trifoliata* > *Sonneratia alba*. In *Derris trifoliata* 0.19% sulphur, and *Salvadora persica* 0.28% sulphur, and that 0.64% sulphur contents found in *Ipomoea pes-caprae* under controlled condition.

The decrease or maximum use of sulfur mostly takes in the chloroplast in aerial region of plants. As per Crawford et al. (2000) leaf is the principal location of sulfur assimilation and it is transferred to other plant parts through phloem with the help of plasma membrane sulfate transporters.

In extract treatment of *Chromolaena odorata* sulphur contents found reduced in all studied plants except *Sonneratia alba* as compare to control one of same. After this treatment sulphur level pattern found changed as *Ipomoea pes-caprae* > *Acanthus ilicifolius* > *Derris trifoliata* > *Salvadora persica* = *Sonneratia alba*. Under this leaf extract treatment highest decrease 46.43% observed in *Salvadora persica* and that lowest 9.38% decrease in total sulphur level in *Ipomoea pes-caprae* as compare with control. Except in *Sonneratia alba* there is increase in sulphur contents found by 25% of total. While in other studied plants sulphur level found as 35.14% decline in *Acanthus ilicifolius* and that 15.79% decline in *Derris trifoliata* as compare with control of them.

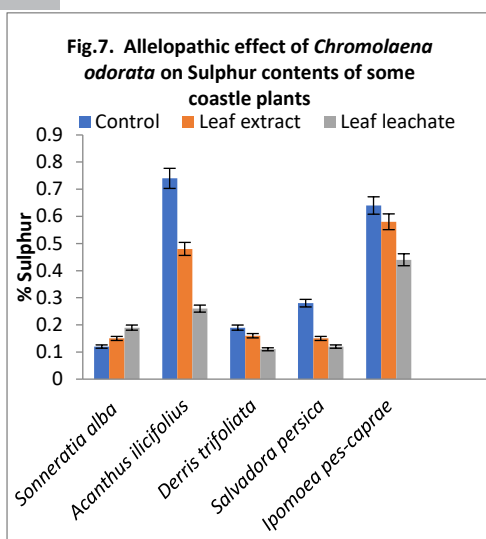
In other treatment i.e. leaf leachate treatment of *Chromolaena odorata* same kind of behaviour of decline sulphur level observed. In *Sonneratia alba* only 58.33% elevation in total sulphur observed under this treatment. While in all other studied plants decrease in sulphur content observed as compare with control one of them. Under this treatment pattern of sulphur accumulation in all studied plant again found changed as *Ipomoea pes-caprae* > *Acanthus ilicifolius* > *Sonneratia alba* > *Salvadora persica* > *Derris trifoliata*. Under this leaf leachate treatment of *Chromolaena odorata* highest 64.86% decline in sulphur level or accumulation observed in *Acanthus ilicifolius* and that lowest 31.25% decrease in total sulphur contents found in *Ipomoea pes-caprae*. In *Derris trifoliata* 42.11% loss of total sulphur, that 57.14% loss in *Salvadora persica* under this leaf leachate treatment of *Chromolaena odorata* as compare

with control one of them. Same kind of reduction in sulphur under salinity impact in leaves of soybean and of Sorghum have been reported by Nukaya et al. (1982) and Clark et al. (1999). Similarly in Hibiscus reduction of the sulfur content under saline impact noticed by Sonar (2013).

It may be concluded from result all researched plants were collected and experimented in coastal region consequently they may be under halophytic affect. Under impact of allelopathic compounds of *Chromolaena odorata*, all plants suffer from oxidative stress which may be managed by utilizing or reducing sulphur available to bear stress. Loss in sulphur also suggests its negative impact on net productivity of plant due to loss in the chlorophyll production process (Tandon, 1991). From impact of present treatment of *Chromolaena odorata* on sulphur contents, furthermore it can be concluded that it causes inhibition of protein synthesis and ultimately leads in reduction of biomass output in influenced plant.

Copper

Allelopathic effect of *Chromolaena odorata* on copper contents of some coastal plant species have been depicted in Fig. 8. It is evident from result that except *Sonneratia alba* copper content found decreases under both leaf extract and leaf leachate treatment among all studied plants. Copper content pattern among all studied plants found as *Ipomoea pes-caprae* > *Acanthus ilicifolius* > *Sonneratia alba* > *Derris trifoliata* under control condition.



Photosynthesis and respiration are two major processes in plants, which influences the plant production and copper plays vital part in both these processes. Copper is crucial micronutrients is involved in many metabolic redox reactions as a component of various metalloenzymes and it also appears to perform as an intermediate electron acceptor in the direct oxidation of substrate by molecular oxygen (Gupta, 1979). Copper is a constituent of number of enzymes such as, ascorbic acid oxidase, cytochrome oxidase, monoamino oxidase, phenolase, tyrosinase, urease and laccase. Copper has a crucial part in oxidative stress responses since as cofactor in Cu/Zn superoxide dismutase. Various workers reported role of copper in various metabolic processes as in signaling of transcription and protein trafficking machinery, oxidative phosphorylation and iron mobilization (Yruea, 2005), involve in cytochrome oxidase complex of mitochondrial electron transport chain (Kaim and Schwederski, 1995), also act

as constituent of plastocyanin which forms part of the electron transport chain (Taiz and Zeiger, 2006), Cu has vital role in complex-IV of respiratory system, in maintaining membrane structure of thylakoids (Henriques, 1989) and also act as a stabilizer of the lipid environment close to electron carriers of PSII complex (Baron et al., 1995 and Maksymiec, 1997). According to Sandman and Boger (1983) copper is present in three different forms in proteins such as blue protein, non-blue proteins and multicopper proteins. This element is able to exist in multiple oxidative states in vivo. Under the cellular conditions Cu can exist both as Cu^{2+} and Cu^{+} .

The deficiency symptoms of copper reported by several workers as production of dark green leaves containing necrotic patches (Taiz and Zeiger, 2006), plant appear twisted or malformed and they may abscise prematurely, deficiency may leads to decline soluble carbohydrates considerably (Mizuno et al., 1982), deficiency affect photosystem-I due to decreased level of plastocyanin (Bazzyński et al., 1978, Shikanai et al., 2003), this deficiency may induces the activity of ferric reductase enzyme, (Kochian, 2000).

Strain and Cashman (2003) reported the copper deficiency symptoms in human infants as prematurity, low birth weight and malnutrition especially when combined with feeding practices such as cowmilk or total parental nutrition.

High concentration of Cu also results in copper toxicity affecting overall growth and biomass (Marschner, 1995). Oxidative stress is also caused due to

Cu-toxicity and photosynthetic process is reduced (Luna et al., 1994).

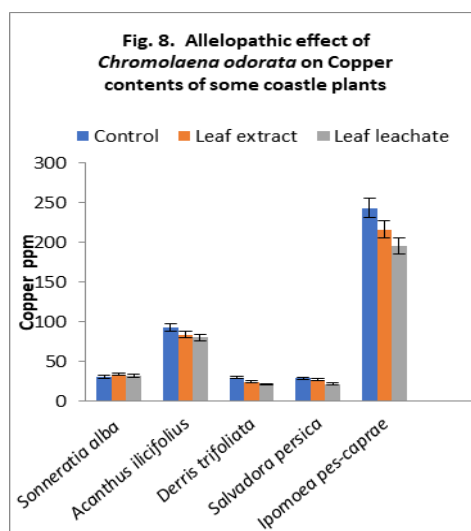
According to Baker and Senef (1995), the average Cu content in plant tissue is 10 µg/g dry wt., normal range of copper content in agricultural crops is reported to be 5 to 30 mg kg⁻¹ dry weight (Gupta, 1979), critical deficiency level of copper in vegetative parts is generally in the range of 3 to 5 µg g⁻¹ dry weight (Marschner, 1986). But according to Robson and Reuter (1981) this range can be larger depends on the plant species, plant organ, developmental stage and nitrogen supply available. In copper tolerant species range as high as 0.1% of the dry weight (Morrison et al., 1981) and as per stated by Munson (1998) that sufficient cu concentration of plant leaf is about 5 to 30 ppm.

In current investigation under control condition highest 243.12 ppm copper content found in *Ipomoea pes-caprae* and lowest 29.03 ppm observed in *Salvadora persica* among all studied plants. In *Sonneratia alba* 30.82 ppm copper contents, that 92.98 ppm in *Acanthus ilicifolius*, 29.92 ppm in *Derris trifoliata* and 29.03 ppm in *Salvadora persica*, 46.43 ppm.

In case of leaf extract treatment of *Chromolaena odorata* rather than *Sonneratia alba* all other studied plant shown decline in copper contents as compare with control one of same. In *Sonneratia alba* under this leaf extract treatment maximum elevation 11.29% in treatment of copper content observed which is higher than that of leaf leachate treatment 4.61% elevation. In other studied plant under same leaf extract treatment 6.92% lowest decline in copper content in *Salvadora persica* as compare with control of same. In

Acanthus ilicifolius 9.38% decline, in *Derris trifoliata* 18.58% decrease and that in *Ipomoea pes-caprae* 11.08% reduction in copper content observed under that leaf extract treatment as compare to control.

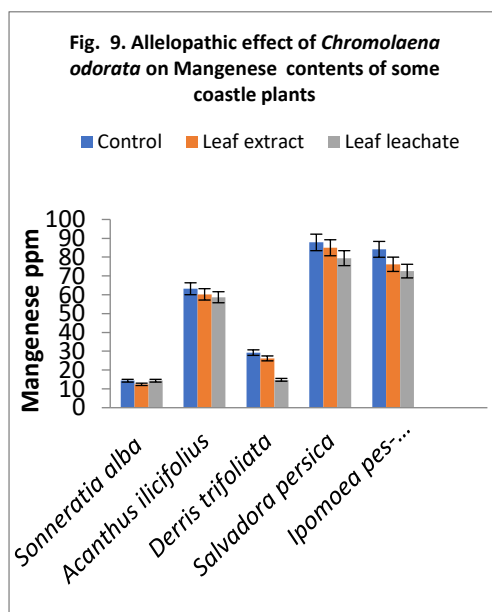
In leaf leachate treatment of *Chromolaena odorata* except *Sonneratia alba* all other plants studied found showing decline in copper content more than that of leaf extract treatment of some plant. Minimum 13.17% reduction in copper content observed in *Acanthus ilicifolius* under this leaf leachate treatment. The reduction % of copper uptake in studied plants found as 28.04% in *Derris trifoliata*, 24.70% in *Salvadora persica* and that 19.54% reduction in *Ipomoea pes-caprae* under this treatment as compare with control of same. Percentage reduction pattern observed in studied plants for copper contents found as *Derris trifoliata* > *Salvadora persica* > *Ipomoea pes-caprae* > *Acanthus ilicifolius* under this treatment. While in *Sonneratia alba* there is elevation of 1.42 ppm in copper content observed under same leaf leachate treatment of *Chromolaena odorata*.



Therefore, it may be concluded from result that *Chromolaena odorata* adversely influence on plant productivity, via altering/disturbing synthesis of numerous metalloenzymes and also affect adversely electron transport chain. It can also be determined that *Chromolaena odorata* responsible to create deficiency syndrome of copper in examined coastal plants i.e. it directly/indirectly effect on iron metabolism and decline therapeutic characteristics of plants.

Manganese (Mn⁺⁺)

Effect of leaf leachate and leaf extract treatment (allelochemicals) of *Chromolaena odorata* on manganese content of some coastal plant viz. *Sonneratia alba*, *Acanthus ilicifolius*, *Derris trifoliata*, *Salvadora persica* and *Ipomoea pes-caprae* have been illustrated in Fig. 9. It is evident from result both treatments found responsible to decline manganese content in studied plants (Except *Sonneratia alba* in leaf leachate treatment).



Manganese plays a critical part in linked with the Oxygen Evolving Complex in the process of photosynthesis. As described by Malkin and Niyogi (2000), manganese atoms are capable of water oxidation in the light reaction of photosynthesis. It acts as electron storage pool and transporting it to the chlorophyll reaction centre (Diedrick, 2010). It also has important role in catalyzing many metabolic processes (Mousavi et al., 2011) by activating more than 35 different enzymes as IAA oxidase, RNA polymerase (Mengel and Kirkby, 1982), Mn-SOD (Clemens et al., 2002), Mn-catalase, carboxylase, carboxykinase (Ducic and Polle, 2005), Nitrite reductase (Nicholas, 1961), glutamine synthase (Elliott, 1953), dehydrogenases and decarboxylase (Marschner, 1995) and so on. Manganese plays key part in biosynthesis of various substances such as ATP fatty acid, acyl lipids and proteins, chlorophyll, tyrosine, lignin, flavonoids and isoprenoids (Pfeffer et al., 1986; Ness and Woolhouse, 1980).

Manganese requirement of plant species differs from species to species. According to Manganese concentration required for optimal for plant growth is 2 - 30 mg 100 g⁻¹ dry tissue (Munson, 1998), the critical deficiency levels of manganese are between 10-20 mg g⁻¹ dry (Marschner, 1986), Stout (1961) reported 0.005% is an adequate concentration of manganese required by any plants, 50-300 mg Mn kg⁻¹ dry wt. is an adequate leaf Mn concentration (Clarkson, 1988). In present study, the manganese content found in studied plant showing pattern as *Salvadora persica* > *Ipomoea pes-caprae* > *Acanthus ilicifolius* > *Derris trifoliata* >

Sonneratia alba under control condition. The values of Mn in studied plants recorded in present investigations fall in the range quite higher (Fig.30). At this condition minimum 14.35 ppm manganese contents observed in *Sonneratia alba*. At the same condition 63.19 ppm manganese content observe in *Acanthus ilicifolius*, that 29.26 ppm in *Derris trifoliata*, 81.87 ppm in *Salvadora persica* and that 84.13 ppm in *Ipomoea pes-caprae*. Terenteva and Dorozhkina, (1967) reported, 110-118 mg kg⁻¹ the uptake of Mn by potato plants leaves and stems as the maximum content at the ripening stage.

In leaf extract treatment of *Chromolaena odorata* decline in manganese contents observed in all studied plants. Highest 13.45% decline and lowest in 3.25% decline in manganese content observed in *Sonneratia alba* and *salvadora persica* respectively under this treatment if leaf extract. Percentage reduction pattern in manganese content under this leaf extract treatment found as *Sonneratia alba* > *Derris trifoliata* > *Ipomoea pes-caprae* > *Acanthus ilicifolius* > *Salvadora persica*. It indicates that leaf extract of *Chromolaena odorata* alters manganese metabolism in all plants by reducing its content as 4.70% reduction of manganese in *Acanthus ilicifolius*, that 10.53% in *Derris trifoliata*, 12.26% in *Crotalaria verrucosa*, 4.48% in *Crotalaria retusa* and 9.44% loss of manganese content found in *Ipomoea pes-caprae*.

In case of leaf leachate treatment of same plant more decline in manganese level observed than leaf extract treatment except *Sonneratia alba* among all studied plants. Under this treatment

highest 49.35% decline and lowest 7.14% decline in manganese contents observed in *Derris trifoliata* and *Acanthus ilicifolius* respectively in all studied plants under this leachate treatment. In *Sonneratia alba* only there is no any kind of alteration observed in manganese uptake and accumulation found. In other studied plant percentage decrease pattern found as *Derris trifoliata* > *Ipomoea pes-caprae* > *Salvadora persica* > *Acanthus ilicifolius* under leaf leachate treatment. This treatment found responsible to decline manganese content as 9.53% decline in *Salvadora persica* 18.27% loss in manganese content of *Ipomoea pes-caprae* as compare to control one of them.

From the result it can be claimed that *Chromolaena odorata* adversely influences micronutrient uptake potential of other plant and generate shortage of nutrient among them to reduce competition. Manganese act as ingredient in chlorophyll component indicating its amount directly affect photosynthetic efficiency. Hence, it may be concluded that *Chromolaena odorata* adversely affect photosynthetic efficiency of other plants.

Iron (Fe⁺⁺)

The change in concentration of Fe +3 in few coastal plants under allelochemical treatment of *Chromolaena odorata* (Leaf extract and leaf leachate treatments) is recorded in Fig. 10. It is evident from result that both leaf extract and leaf leachate treatment of *Chromolaena odorata* have significantly inclined the ferrous contents of all studied plants. In control state highest 892.27 ppm and lowest 59.52 ppm iron contents found in *Acanthus ilicifolius* and *Derris trifoliata*

respectively among all studied plants. Same kind of iron concentration in different plants have been reported by Karadge (1981) in *Portulaca oleracea* leaves 0.08 % (dry wt.) iron, in *Cassia* species, 0.376 % (dry wt.) iron by Patil (2009), in *Cleome* sps in range of 0.04326 to 0.312 % (dry wt.) iron by Aparadh (2011) and many others. The pattern of Fe +3 concentration found in studied plants is *Acanthus ilicifolius* > *Ipomoea pes-caprae* > *Salvadora persica* > *Sonneratia alba* > *Derris trifoliata* under control condition. The concentration of Fe +3 this control condition is found as 267.79 ppm in *Sonneratia alba*, 592.45 ppm *Salvadora persica* and that 884.04 ppm Fe +3 concentration in *Ipomoea pes-caprae*. These iron values are much higher than adequate value of it for optimal growth of plants is 100 ppm (0.01%) as reported by Stout (1961) and Epstein (1972).

Iron deficiency responsible to cause degradation of chlorophyll structure and loss of chlorophyll. Iron deficiency studied in human being indicates reduction in haemoglobin, myoglobin and iron containing enzymes which may cause fatigue, restlessness and impaired work performance allied with anemia (Strain and Cashman, 2003). Iron is an immobile microelement. Iron is engrossed by plant roots in its ionic form Fe²⁺ or as Fe chelate, which are soluble and therefore available to roots. It involved in many metabolic reactions in plant as well as animal bodies as in oxidation, reduction reactions, ferredoxin formation and chlorophyll synthesis (Spillar and Teny, 1980 and Machold and Stephan, 1969), it acts as component of electron transmitters in chloroplasts and mitochondria, it takes

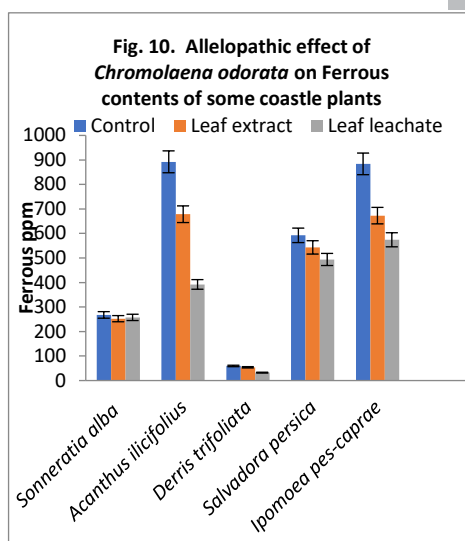
part in formation of cytochromes (Hochmuth, 2011). Iron is a constituent of enzymes like peroxidase, catalase, nitrate reductase, cytochrome oxidase and many other enzymes. Iron deficiency causes reduction of nitrate reductase activity and chlorosis (Bennett, 1945; Perur et al., 1961). Iron serves as cofactor for enzyme aconitase in TCA cycle (Curie and Briat, 2003). Iron plays imperative role in ribonucleotide dinitrogen reduction and energy yielding process of electron transfer chain (Guerinot and Ying, 1994).

In current study it is clear from results that leaf extract treatment of *Chromolaena odorata* decrease in Fe+3 concentrations observed in all studied coastal plants. Under this treatment maximum 23.96% decrease in iron content observed in *Acanthus ilicifolius* and *Sonneratia alba* respectively. Under this treatment decline in ferrous content was observed as 15.33 ppm in *Sonneratia alba* (5.72% decline), 213.79 ppm loss of ferrous in *Acanthus ilicifolius* (23.96%), 5.46 ppm decline in *Derris trifoliata* (9.17%), 49.17 ppm decrease in *Salvadora persica* (8.30%) and that 211.26 ppm reduction in Fe +3 contents observed in *Ipomoea pes-caprae* as compared to control one. In case of *Sonneratia alba* only leaf extract treatment found highly responsible to maximum decline in Fe +3 contents than leaf leachate treatment of *Chromolaena odorata*.

In case of leaf leachate treatment same kind of decline but maximum decline that of leaf extract treatment observed in all studied plants (except *Sonneratia alba*). Under this treatment maximum prominent iron decrease 56.05% and that minimum 3.78% observed in *Acanthus*

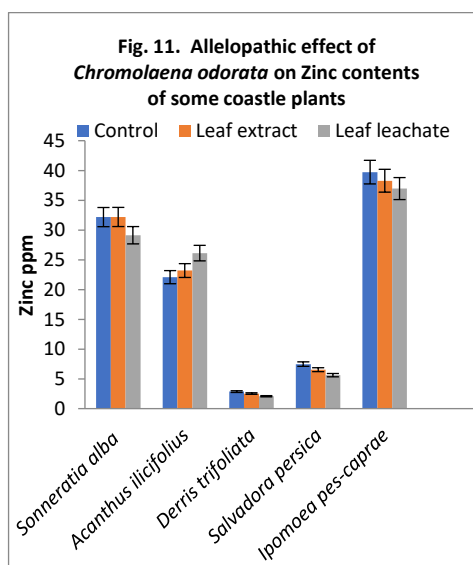
ilicifolius and *Sonneratia alba* respectively (i.e. loss of 500 ppm and 10 ppm Fe +3 content respectively). The percentage decline pattern of Fe +3 found as *Acanthus ilicifolius* > *Derris trifoliata* > *Ipomoea pes-caprae* > *Salvadora persica* > *Sonneratia alba* as compare with control one. In *Derris trifoliata* 45.55% decline, in *Salvadora persica* and that 35.04% decrease in Fe +3 content of *Ipomoea pes-caprae*.

In current study from fundamental observations, it can be concluded that rather than *Acanthus ilicifolius* all other studied plants in their natural state may have their utility in medicine to control iron deficiency anemia. As per reported by Curie and Briat (2003) in free state Fe in the cell iron interacts with oxygen and form hazardous oxygen species. Therefore, it may be concluded from finding that *Chromolaena odorata* will be useful to regulate generation of reactive oxygen species radicals. Hence it is useful to boost antioxidative potential of other plants. From overall results of Fe +3 content, it may be deduced that *Chromolaena odorata* impacts iron metabolism adversely. There it may be mentioned that plant competition of *Chromolaena odorata* may experience iron deficiency problem hence they back-off from competition. It also implies *Chromolaena odorata* extract or leachate may be useful as herbicide or weedicide directly or indirectly.



Zinc

Effect of *Chromolaena odorata* on zinc contents some coastal plants through leaf extract and leaf leachate treatments of it have been demonstrated in Fig. 11. Except *Acanthus ilicifolius* all other investigated plant exhibited unfavorable influence of these treatments regarding zinc accumulation.



Zinc is considered as the third most significant limiting nutrient (micronutrient) in crop yield after N and P. Zinc is needed for carbohydrate metabolism and regulation of ingestion of carbohydrates, nitrogen metabolism, protein synthesis, auxin production, notably IAA synthesis. It is necessary primarily for chlorophyll biosynthesis. As per mentioned by Skoog (1940) and Tsui (1948), zinc involve in biosynthesis of indole acetic acid (IAA) from its precursor, tryptophan. It is closely linked in nitrogen metabolism. Its significance in membrane stability by amendable the level of oxidizing O₂ species is documented by Pinton et al. (1994). Zinc acts either as a metal factor or as a functional, structural or regulatory cofactor of a large number of enzymes viz. superoxide dismutase, alcohol dehydrogenase, glutamic acid dehydrogenase, carbonic anhydrase, aldolases, isomerases, transphosphorylases and RNA and DNA polymerases as well as proteinases and peptidases (Ohki, 1976; Dell and Wilson, 1985, Vitosh et al., 1994, and Marschner, 1995).

Zinc deficiency is characterized by a reduction in internodal growth resulting into rosette habit of a plant. Zn deficiency in wheat plant decreases NR activity and NO₃ content (Harper and Paulsen, 1969). Deficiency of zinc is reported to cause chlorotic conditions of the mulberry leaves (Rangaswami et al., 1978). The activity of many enzymes is congested under zinc deficiency conditions. Ghildiyal et al. (1986) have observed a dwindle in protein, nitrogen substance and boost in free amino acid content of linseed varieties under Zn deficiency which indicates that Zn is

playing an outstanding role in plant metabolism. Epstein (1972) reported 0.002 g/100g (dry wt.) zinc essential for optimal growth of plant. The critical deficiency levels of Zn are below 15–20 mg kg⁻¹ dry weight of leaves and critical toxicity levels of zinc in leaves of crop plants are more than 400–500 mg kg⁻¹ dry weight basis (Marschner, 1986). According to Vitosh et al., (1994) the plants having lower than 20 ppm zinc in their tissues suffer from zinc deficiency. In case of present investigation, it is evident from result that highest 39.72 ppm zinc contents observed in *Ipomoea pes-caprae* and that lowest 2.86 ppm observed in *Derris trifoliata* under control condition in all studied plants. The pattern of zinc content in studied plant under control condition found as *Ipomoea pes-caprae* > *Sonneratia alba* > *Acanthus ilicifolius* > *Salvadora persica* > *Derris trifoliata* under control condition Zn content in *Sonneratia alba* as 32.17 ppm, in *Acanthus ilicifolious*, 22.08 ppm, in *Salvadora persica*. Therefore, from this result, it can conclude that coastal plants like *Salvadora persica*, *Crotalaria verrucosa* and *Derris trifoliata* may endure from zinc deficiency problems. But these plants haven't shown any kind of deficiency syndrome.

In leaf extract treatment of *Chromolaena odorata* except *Sonneratia alba* and *Acanthus ilicifolious* all other studied plant shows significant reduction in zinc concentration. In *Sonneratia alba* Zn concentration found elevated by 0.02 ppm and in *Acanthus ilicifolius* 1.08 ppm elevation / increase observed under this leaf extract treatment. While this treatment for other studied coastal plant found responsible to decrease zinc

concentration as 11.54% decline in *Derris trifoliata*, 12.57% decline in *Salvadora persica* and that lowest 3.63% decline in Zn concentration observed in *Ipomoea pes-caprae* as compare with control one of them.

Under leaf leachate treatment of *Chomolaena odorata* all plants studied except *Acanthus ilicifolius* shown decline in their zinc concentration (uptake and translocation). At this treatment maximum 41.51% reduction and minimum 6.95% reduction observed in *Crotalaria retusa* and *Ipomoea pes-caprae*. Under same treatment percentage decline Zn concentration pattern found as *Derris trifoliata* > *Salvadora persica* > *Sonneratia alba* > *Ipomoea pes-caprae*. While *Acanthus ilicifolius* under this treatment shown significant increase 18.30% in Zn concentration. It indicates that *Acanthus ilicifolius* is more tolerant to any kind of environmental stress than other studied plants. In *Sonneratia alba* 9.48% decline, in *Derris trifoliata* 27.27% decline, in *Salvadora persica* 24.87% decrease under this leaf leachate treatment of *Chromolaena odorata*.

From results it appears that zinc uptake and translocation is highly altered due to leaf leachate than leaf extract of *Chromolaena odorata*. Higher concentration of zinc indicates higher stress tolerance capacity of plant. Therefore, it can be concluded from result *Ipomoea pes-caprae* naturally more stress tolerant plant. It also can conclude that allelochemicals from *Chromolaena odorata* may positively or negatively alters this stress tolerance capacity of other plant by changing zinc content in them.

Conclusion

Chromolaena odorata is fast growing perennial ever green shrub native to south America and central America. It has become an aggressive invasive weed in tropical Asia, Africa and in some parts of Australia. Leaf leachate and leaf extract treatment of *Chromolaena odorata* both adversely affect nitrogen contents of all studied coastal plants. The allelochemicals of *Chromolaena odorata* hampers the net productivity of other plants and the nitrogen metabolism seems to be rather sensitive to allelochemicals of *Chromolaena odorata* in all studied plant species.

Phosphorous contents get decreased under both these treatment of *Chromolaena odorata* as compared to control. It can be concluded the allelochemical treatment of *Chromolaena odorata* adversely affect phosphorus uptake potential of other plants.

Potassium content was decreased in all studied coastal plants under both leaf extract and leaf leachate treatment. Nitrate reductase enzyme activities were reduced with decline in potassium contents. It can also be concluded that allelochemicals of *Chromolaena odorata* influences sodium contents and show adverse impact on growth and development of studied plants. *Chromolaena odorata* affects calcium uptake potential adversely which may lead to decline in activation of various enzymes. This directly or indirectly affects metabolic processes in those plants. The decline in calcium under studied treatment showed decline in productivity of those plants via decline in catalyzing rate of nitrate reductase, nitrogenase and other essential enzymes.

Due to allelopathic treatment of leaf extract of *Chomolaena odorata* there was decreased magnesium level observed in all studied plants. Leaf leachate treatment caused higher loss in magnesium level than that of leaf extract treatment among all studied plants. The treatment of *Chromolaena odorata* declines sulphur contents, due to this inhibition of protein synthesis and ultimately results in reduction of biomass production in influenced plant. *Chromolaena odorata* adversely affected micronutrient uptake potential of other plant and created scarcity of nutrient among them to minimize competition. Copper, manganese, iron and zinc contents were found decreased under both leaf extract and leaf leachate treatment among all studied plants. The allelochemicals from *Chromolaena odorata* may positively or negatively alters stress tolerance capacity of other plant by changing zinc content in them. Hence it is required to eliminate the *Chromolaena odorata* an invasive plant from coastal line vegetation. This will help to rebuild the mangrove vegetation over the coastal line and also aid to protect them in their natural habitat (in situ conservation).

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