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LUXURIANT GROWTH OF WEEDY SPECIES OF *CASSIA* SPECIES AND INORGANIC CONSTITUENTS

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Abstract

In the leaves of Cassia species higher level of macronutrients like nitrogen, potassium and calcium. Level of phosphorus in different parts of both the species of Cassia is relatively low. Level of magnesium found optimum in all parts of Cassia species. Micronutrients like chloride, zinc and cobalt higher in different parts of Cassia species. Level of sodium and copper recorded optimum concentration. Concentration of manganese and iron found lower in different parts of Cassia species. Macronutrients and micronutrients required for fast growth are present in higher concentration found suitable for luxuriant growth of Cassia species.

Keywords: *Cassia obtusifolia ,Cassiauniflora, inorganic constituents*

INTRODUCTION

The essential nutrients required by higher plants are exclusively of inorganic nature. Based on requirements these are classified as macronutrients (N, P, K, Ca,Mg, S, and Na) and micronutrients(Fe, Mn, Cu, Zn, Mo, B and Cl). Macronutrients are found and needed in plants in relatively higher amounts than micronutrients. But both are essential for physiological and biochemical processes. Most micronutrients are predominantly the constituents of enzyme molecules and are essential only in small amounts. In contrast, the macronutrients are either the constituents of organic compounds, such as proteins and nucleic acids or they act as osmotica. These differences in function are reflected in average concentration of mineral nutrients in plant shoots that are sufficient for adequate growth (Marschner, 1986). The values vary considerably depending on plant species, plant age and concentration of other mineral elements. The main factor controlling the mineral content of plant material is the specific, genetically fixed nutrient uptake potential for the different mineral nutrients (Mengel and Kirkby, 1982). It was thought that the status of these mineral nutrients may give an idea about adaptability and luxuriant growth of the *Cassia* species. Following account is regarding the status of mineral elements in different parts of *Cassia* species.

MATERIAL AND METHODS

Various inorganic constituents like K, P, Mg, Fe, Mn, Ca, Cu, Zn and Co from the different plant parts viz. leaves, root and stem, were estimated from oven dried plant material. 0.5 g oven dried plant material was acid digested following the standard method by Toth *et al*., (1948). Plant material was taken in a 150 ml clean borosil beaker and to that 10 ml concentrated HNO3 were added. It was covered with watch glass and kept for an hour till the primary reactions subsided. It was then heated on hot plate till all the material was completely dissolved. It was allowed to cool to room temperature and then 10 ml of Perchloric acid (60%) were added to it and mixed thoroughly. It was then heated strongly on the hot plate until the solution became colorless and

reduced to about 2-3 ml. While heating, the solution was not allowed to dry. After cooling, it was transferred quantitatively to 100 ml capacity volumetric flask, diluted to 100 ml with distilled water and kept overnight. Next day it was filtered through What man No. 44 filter paper. The filtrate was stored properly and used for analysis of inorganic constituents.

I. TOTAL NITROGEN

The spectrophotometric method described by Hawk *et al.,* (1948) was used to estimate total nitrogen. 0.5 g oven dried plant material was digested with 10 ml dilute sulphuric acid (1:1) in kjeldahl flask with a pinch of micro salt (anhydrous CuSO4 and K_2SO_4 mixed in the proportion of 1:400). When the digest became colorless, it was cooled to room temperature and transferred quantitatively to 100 ml volumetric flask and volume (100 ml) was made with distilled water. It was then filtered through dry Whatman No. 1 filter paper and filtrate was used to estimate total nitrogen. 2 ml of filtrate was taken in a Nesslor's tube (35 and 50 ml marked) and to it a drop of 8% KHSO4 and 1 ml dilute H2SO4 (1:1) were added and the volume was made to 35 ml with distilled water. For standards, different concentrations of ammonium sulphate (0.05 mg per ml) were taken in different Nesslor's tubes and after adding KHSO4 and H2SO4 the volume was made to 35 ml with distilled water. To all these tubes 15 ml Nesslor's reagent was added (Nesslor's reagent: A-7 g KI and 10 g HgI2 dissolved in 40 ml distilled water. B-20 % NaOH. A and B
39 were mixed in the proportion 4:5). The reaction between the sample and the reagent produced orange-brown coloration. The intensity of the color produced was measured at 520 nm on UV-VIS Spectrophotometer. The absorbance reading for plant extract was compared with those of standard ammonium sulphate and total nitrogen concentration was calculated.

II) PHOSPHORUS

Phosphorus was estimated from the same acid digest following the method described by Sekine*et al.* (1965). 2 ml of acid digest was pipetted out in a test tube, to which 2 ml of 2 N HNO3 were added followed by 1 ml of Molybdate-Vanadate reagent (Reagent A: 1.25 g ammonium vanadate dissolved in 1 N HNO3 and volume was made to 500 ml with 1 N HNO3. Reagent B: 25 g ammonium molybdate dissolved in distilled water and volume was made to 500 ml. Then reagent A and B were mixed in equal volumes). The volume was made to 10 ml with distilled water. The ingradients were mixed well and allowed to react for 20 min. After 20 min yellow colour intensity was measured at 420 nm using a reaction mixture blank containing no phosphorus. The colour developed by standards of known concentration of Phosphorus in KH2PO4 solution (0.025 mg P.ml-1) with Molybdate-Vanadate reagent was used for plotting the standard curve. With the help of standard curve, the concentration of phosphorus in the plant material was calculated.

III) CHLORIDE

Chlorides were extracted according to the method described by Imamul Huq and Larher (1983), with slight modification and estimated according to the method of Chapman and Pratt (1961). The chlorides were extracted in distilled water at 45^{o}C for 1 h with addition of hot distilled water to prevent drying. After cooling, the extract was filtered through a layer of cheese cloth. The filtrate was collected in 50 ml volumetric flask and volume was made with distilled water. From this, 10 ml filtrate was taken for titration against std. AgNO3 (Silver nitrate). Few drops of acetic acid solution (200 ml concentrated acetic acid +800 ml of distilled water) were added to

the filtrate until the pH of the solution was 6 to 7. Then 5 drops of 1% potassium chromate solution were added and titrated against std. 0.05 N Silver nitrate (8.5 g AgNO3 were dissolved in one liter of distilled water), until the first reddish brown colour appeared. For standardization, 10 ml of 0.1 N Sodium chloride was taken in an Erlenmeyer flask and 50 ml of distilled water were added. This was titrated with the prepared Silver nitrate solution (0.05N). The chlorides (mg. 100^{-1} g) were calculated with the help of correlation, 1ml 0.05 N AgNO3 = 1.77 mg Cl

VII) SODIUM

Sodium was estimated flame photometrically following the standard procedure on flame photometer (Model-Elico, ch-22A). For standardization, various concentrations of sodium were prepared ranging from 10 to 80 ppm by diluting stock solution of NaCl (100 ppm). The remaining inorganic elements viz. calcium, potassium, magnesium, iron, manganese, zinc, copper and cobalt were estimated using Atomic absorption spectrophotometer (Perkin-Elmer, 3030 A).

RESULTS AND DISCUSSION

i) Total Nitrogen

Among all the mineral nutrients nitrogen is the most important nutrient for the growth of plant. It is very essential for synthesis of much organic compounds. Absorbed nitrogen is rapidly converted into amino acids and amides. It is constituent of protein enzymes and chlorophyll. It is involved in all processes associated with protoplasm, enzymatic reactions and photosynthesis. Thus it forms an important constituent of plant. The weeds generally use twice the amount of nitrogen in comparison to normal crop plants (Sen, 1982).Nitrogen content of different parts of *Cassia* species is shown in Table 1. It is clear from the results that nitrogen content is more in leaves than in the stem and roots. Young leaves of both species contain higher amount of nitrogen than mature leaves. In *C. obtusifolia* the level of nitrogen is more in leaves (Average 4.68 $g100g^{-1}$of dry wt.) followed by stem (0.52 $g100g^{-1}$ of dry wt.) and then roots (0.42 $g100g^{-1}$ ofdry wt.). In case of *C. unifloral*it is more in leaves (Average 3.38 g100g-1 of dry wt.)Followed by roots (0.76 g100g-1 of dry wt.) and then stem (0.64 g100g-1of dry wt.).This trend of total nitrogen content observed in *C. obtusifolia*has also been recordedin *Phaseolus aconitifolius*(Kulkarni, 1984), *Psophocarpustetragonobolus*(Rajmane 1984), *Arachis hypogea* var. JL-24 and TMV-10 (Chavan, 1987) and *Euphorbiageniculata*(Patil, 1988). The pattern like that in *C. unifloral*has been observed in*Cicer arietinum* (Murumkar, 1986) and *Jatropha curcas*(Mane, 1993). High nitrogen content in young leaves is reported by several workers (Mohite, 1990; Upadhay,1986; Jadhav, 1984, Thombre, 1987). Total nitrogen content in the leaves ofleguminous plants such as *Phaseolus aconitifolius, Cicer arietinum, Psophocarpustetragonobolus*and *Arachis hypogea* was 1.01, 1.91, 1.82 and 1.5-2% dry wt. respectively. Patil (1988) has determined total nitrogen content in the leaves, stem androots of nitrophilus plant, *Euphorbia geniculata.* The nitrogen concentration was 5.1,4.0 and 1.6% dry wt. respectively in the leaf, stem and roots. In leaf, stem and rootsof *Jatropha curcas*it is 3.87, 0.59 and 0.60% of dry wt. respectively. Average nitrogen content of the leaves of *C. obtusifolia*and *C. uniflora*(4.68 and 3.38% drywt.), is in the range of the values of nitrogen content of leaves of several weed specieslike *Euphorbia geniculata*and *Jatropha curcas.* High level of nitrogen in the leaves of both *Cassia* species might be due to the high level of potassium and chloride in the tissue as repored by Karadge (1981) in case of *Portulaca oleracea.*

ii) Phophorus

In plant nutrition, demand for phosphorus is relatively great. Phosphorus forms integral part of AMP, ADP, ATP and NADP. It is involved in energy transfer metabolism. It is constituent of nucleic acids, phospholipids and phosphorylatedsugars. It is also linked with nitrogen metabolism. It regulates photosynthesis andcarbohydrate metabolism. Phosphorus deficiency reduces photosynthesis, growth andalso reduces activity of enzymes like nitrate reductase, glutathione reductase andglutamate dehydrogenase. According to Jacob and Lawlor (1992) sunflower with lowphosphorus had low photosynthetic rates and less carboxylation efficiency. Maturityis delayed in phosphorus deficient plants, while excess phosphorus induces early maturity and enhances root growth. Phosphorus induces anthocyanin synthesis. It is ahighly mobile element. So it can be easily translocated from one place to another.It appears from the Table 1 that the leaves of *C. obtusifolia*are rich inphosphorus while in *C. uniflora*there was no much difference in the level ofphosphorus in different parts. Such a trend of phosphorus content has been recordedin *Derris trifoliata*. Phosphorus content of young and mature leaves, stem and root of*C. obtusifolia*is 0.20, 0.16, 0.07 and 0.04 $g100g^{-1}$ of dry wt. respectively and that in*C. uniflora*it is 0.17, 0.14, 0.17 and 0.12 $g100g^{-1}$ of dry wt. respectively. Thus thelevel of phosphorus is higher in the young leaves than that in mature leaves. Highphosphorus content in the young leaves signifies the high metabolic activitiesassociated with young leaves. Similar observation has been made by several workers(Gokhale *et al.,* 1984; Upadhay, 1986; Thombre, 1987; Mohite, 1990). The optimumconcentration of phosphorus is 0.2% dry wt. (Stout, 1961 and Epstein, 1972). It isevident from the results that as compared to the optimum the level of phosphorus indifferent parts of both the species of *Cassia* is relatively low.

iii) Potassium:

Potassium is indispensable for plant growth. Plants require 1% potassium foroptimal growth (Epstein, 1972). It plays a key role in the process of stomatalbehaviour, in assimilate translocation and in osmoregulation. It works as a cofactor ofenzymes involved in translocation and stomatal opening. It is involved in wide rangeof metabolic activities such as carbohydrate metabolism, glycolysis, phosphorylationand adenine biosynthesis in plants. Potassiumdeficiency causes reduction in nitrate reductase activity, disturbance of proteinmetabolism and accumulation of amino acids and soluble organic nitrogenous compounds.

It is clear from the results that the level of potassium in both the species of*Cassia* is higher in leaves than in the stem and roots (Table 1). The young leavesshowed higher level of potassium than the mature leaves in both the species.Potassium content in young and mature leaves of *C. obtusifolia*is 2.04 and 1.49$g100g^{-1}$dry wt. respectively and that in *C. uniflora*is 1.61 and 1.04 $g100g^{-1}$dry wt.respectively. In the root tissue its concentration is low. Potassium content in roottissue of *C. obtusifolia*and *C. uniflora*it is respectively 0.84 and 0.67 $g100g^{-1}$ dry wt.There is no much difference in the level of potassium in the mature leaf and stemtissues of both species. Distribution of potassium in different parts of *Derris scandens*and *Derris trifoliata* has been recorded by Mohite, (1990). It has also been recorded in*Euphorbia geniculata*(Patil, 1988) and *Jatropha curcas*(Mane, 1993). High level ofpotassium in young leaves has been reported by several workers (Joshi and Mishra,1970; Ambike and Karmarker, 1975; Gokhale*et al.,* 1984; Upadhay, 1986; Thombre,1987). It has been suggested that this element is translocated to the young developingleaves which are rapidly growing and require more potassium. According to Soni(1970), during advancement of senescence due to the disruption of the membranesystem,

the active accumulation of potassium is hindered. The high level of potassiumin young leaves of both the *Cassia* species indicates its participation in activemetabolic processes. Level of potassium of all parts of both species except youngleaves (which are rich in potassium) of *C. obtusifolia*is enough to support normalgrowth as the optimum concentration of potassium suggested is 1% dry wt.(Epstein,1972). The concentration of potassium in young leaves of *C. obtusifolia*(2.04 % dry wt.) is almost equal to that in young leaves of *Derris trifoliata* (Mohite, 1990).

iv) Magnesium`

Magnesium is a mobile element and is found both in bound as well as free form (Gilbert, 1957). It is a part of ring structure of chlorophyll molecule, the photosynthetic pigment in chloroplast. It is a cofactor of several enzyme reactions involved in organic acid synthesis. It is commonly associated with transfer reactions involving phosphate reductive groups. Though magnesium participates in a number of physiological and enzymatic reactions, its requirement for the plant growth is relatively low.

Results shown in Table 1. indicate that the level of magnesium in leaves ishigher than that in the root and stem of both *Cassia* species. It is the highest in youngleaves than in mature leaves of both the species. Magnesium concentration of leaves(young and mature) of *C. obtusifolia*is higher than that in *C. uniflora*leaves.Magnesium concentration in the young and mature leaves, stem and root of *C.obtusifolia*is respectively 0.36, 0.37, 0.14 and 0.10 g100g-1 of dry wt. while that in *C.uniflora*is 0.28, 0.25, 0.19 and 0.15 g100-1g of dry wt. respectively. According toEpstein (1972), adequate level of magnesium for optimum growth of plant is 0.2%,while it is 0.5% as given by Mengel and Kirkby (1982). From the results it is evidentthat if its optimum level according to Epstein (1972) is considered then the level ofmagnesium is higher in leaves of both *Cassia* species. Magnesium concentration inleaf, stem and roots of *Euphorbia geniculata*(Patil, 1988) were 1.50, 0.14 and 0.77 %dry wt. respectively and that in *Jatropha curcas*1.92, 0.81 and 0.31% dry wt.respectively. Level of magnesium in all parts both *Cassia* species is lower than that in*Euphorbia geniculata*and *Jatropha curcas.*

v) Calcium

Calcium is an important mineral element which regulates the uptake ofmonovalent cations. It is immobile and plays an important role in cation exchange. Itfunctions both as structural component as well cofactor for certain enzymes. It isfound involved in number of enzyme systems like nitrate reductase (Poulsen andHarber, 1968), amylase (Charispeels and Varner, 1967), ATPase (Avron, 1967) andphospholipase (Davidson and Long, 1958). Calcium is also required for cellelongation and cell division (Burstorm, 1968). Calcium protects plants from the injurious effects of H^+ ions (Rains *et al.,* 1964), high salt in the environment (Rains,1972) and other potentially toxic ions present in the environment (Arnold, 1969). It isrequired for the normal functioning of plant membranes and has been implicated as asecond messenger for various plant responses to both environmental and hormonalsignals (Sanders *et al*. 1999). In its function as a second messenger, calcium may bindto calmodulin, a protein found in the cytosol of plant cells. The calmodulin–calciumcomplex regulates many metabolic processes. Calcium maintains level of superoxidedismutase and catalase, which control lipid peroxidation (Swami and Reddy, 1991). Itis also important in protein synthesis.

It is evident form Table 1 that calcium level is higher in the leaves than thatin stem and roots of both the *Cassia* species. Similar trend was observed in *Arachishypogea* (Chavan and Karadge, 1980), *Portulaca oleracea* (Karadge, 1981),*Phaseolus aconitifolius*(Kulkarni, 1984), *Derris scandensis*(Mohite, 1990),*Euphorbia geniculata*(Patil, 1988) and *Jatropha curcas*(Mane, 1993).

In case of *C.obtusifolia*there is no difference in the level of calcium in young (2.57 g100g-1 of dry wt.) and mature (2.55 g100g-1 of dry wt.) leaves while in *C. uniflora*the mature leaves(3.37 g100-1g of dry wt.) have shown higher level of calcium than that in youngleaves (1.61 g100g-1 of dry wt.). There are number of reports where an increase incalcium content has been observed with increase in leaf age (Madguick, 1964;Morrison, 1974; Tsujita*et al.,* 1978; Hocking *et al.,* 1980; Waughman and Bellamy,1981; Karadge, 1981; Pathan, 1982; Bhivare, 1984; Upadhye, 1986, Thombre, 1987).However, Arrooya-Anguila and Coward-Lord (1974) could not find any significantdifference in calcium content during advancement of plant age. Concentration ofcalcium in leaf, stem and root of *C. obtusifolia*is 2.56, 0.29 and 0.21 g100g-1 of drywt respectively, while that in *C. uniflora*it is 2.49, 0.79 and 0.11 g100g-1 of dry wt.respectively. According to Epstein (1972) the adequate level of calcium for optimumgrowth of plant is 0.5%. From the results it is found that level of calcium is higher inthe leaves of both *Cassia* species and in the stem of *C. uniflora*. The level of calciumis lower in case of roots of both the species of *Cassia* than that suggested by Epstein(1972). It appears that most of the calcium uptaken by these plants is efficientlytranslocated to the leaves where it is found accumulated. High level of calcium in theleaves may be involved in achieving the healthy and fast growth in both the species of*Cassia*.

vi) Chloride

Chloride is required for water splitting reactions in photosynthesis (Clarke andEaton-Rye, 2000). It may be required for cell division in both leaves and roots. Likepotassium it acts as osmoticum. Adequate level of chloride in plant for optimumgrowth is 100 ppm (0.01%) (Epstein, 1972). According to Osmond (1968), chlorideaccumulates in vacuoles and balances the concentration of monovalent cationspotassium and sodium. Chloride deficiency develops wilting of leaf tips followed bychlorosis and necrosis. The leaves may exhibit reduced growth.

Level of chloride in different parts of *Cassia* species is shown in Table 2. It isevident from the results that chloride concentration is higher in the leaves of both*Cassia* species than that in stem and roots. Its concentration is higher in young leavesthan that in mature leaves of both species. High concentration of chloride in the leavesindicates its mobile nature. Level of chloride is much higher as compared to thatsuggested by Epstein (1972). Higher level of chloride suggests its capacity to keep thewater level adequate for normal metabolism of the plants and to tolerate drought stress (Karadge, 1981). Chloride content in young and mature leaves, stem and roots of *C. obtusifolia*is 1.49, 1.20, 0.32 and 0.28% dry wt. and that in *C. uniflora*chlorideit is 0.35, 0.32, 0.14 and 0.07% dry wt. Level of chloride in all parts of *C. obtusifolia*is higher than that of *C. uniflora*, which indicates that probably *C. obtusifolia is* morestress tolerant than *C. uniflora*. Chloride content of leaves of *Portulaca oleracea*(Karadge, 1981) and *Phaseolus aconitifolius*(Kulkarni, 1984) is 1.40 and 1.59% drywt. respectively. These values are comparable to the values of concentration ofchloride in the leaves of *C. obtusifolia.*

vii) Sodium

Sodium is considered as nonessential element for glycophytes except for fewsaline angiosperms. However, recently it has been considered as an essential micronutrient partially replacing potassium for some metabolic activities (Woolhouse,1978). It can partly substitute for potassium as an osmotically active solute. Sodium stimulates growth when potassium supply is limited. It stimulates growth through enhanced cell expansion. It is also required in maintaining membrane integrity(Brownell, 1979). Under sodium deficiency the plants exhibit chlorosis and necrosis, or even fail to form flower. Many C_3 species also benefit from exposure to low levels of sodium ions. According to Epstein (1972) its level for optimum growth is 0.001%.According to

Chirputkar (1969) adequate level of sodium for glycophytes is 0.6 to1.4% of dry wt. The range of sodium in glycophytes as given by Gauch (1972) is 0.1to 1.4% of dry wt.Table 2 records the sodium content in different parts of *Cassia* species. It isevident that sodium content is higher in the roots followed by that in stem and then inthe leaves of both the species. Similar pattern of distribution of sodium has beenobserved in *Phaseolus vulgaris* (Bhivare, 1984), *Phaseolus aconitifolius*(Kulkarni,1984) and *Euphorbia geniculata*(Patil, 1988). Its concentration is higher in theyoung leaves of both the species of *Cassia*. Young and mature leaves, stem and rootsof *C. obtusifolia*contain 0.11, 0.09, 0.25 and 0.9 % (dry wt.) sodium, while that in *C.uniflora*it was 0.38, 0.21, 0.32 and 0.46% (dry wt) respectively. Level of sodium inall parts of *C. uniflora*was higher as compared to that in all parts of *C. obtusifolia*. Ifthis concentration of sodium is compared with the optimum suggested by Epstein(1972) the level of sodium in both the species is much higher. However, its level iscomparable with that given by Gauch (1972) and it is lower than that given byChirputkar (1969). Sodiumconcentration in leaf, stem and roots of *Euphorbia geniculata*is 0.2, 0.15 and 0.4% of dry wt. respectively (Patil, 1988) and these valuesare comparable with the concentration of sodium recorded here in different parts of*Cassia* species.

viii) Manganese

Manganese is associated with photosynthesis, respiration, oxidation ofcarbohydrates and IAA and activation of enzymes of nitrogen metabolism. It isessential in photosystem II (Bishop, 1971). Enzymes of Kreb's cycle require it as acofactor. It can replace magnesium in many of the phosphorylating and group transferreactions. Deficiency of manganese causes chlorosisassociated with necrosis.Manganese level in different parts of *Cassia* species is shown in Table 2. It isevident from the results that level of manganese is higher in the leaves of both *Cassia*species than that in stem and roots. It is also observed that mature leaves of both thespecies have high level of manganese. According to Stout (1961) and Epstein (1972),critical level of manganese is 50 ppm (i.e.0.005%) dry wt. Manganese content in theyoung and mature leaves, stem and roots of *C. obtusifolia*is 38.4 39.8, 29.4 and 24ppm dry wt. respectively while, that in *C. uniflora*it is 33.3, 45.2, 28.9 and 28.5 ppmdry wt. Concentration of manganese in all parts of *Cassia* species is lower ascompared to that suggested by Stout (1961) and Epstein (1972). According to Amberger (1973), younggrowing parts are rich in manganese content. Thombre (1987) observed same trend in*Cestrum noctrum, Aptenia cordifolia, Portulaca quadrifolia*, however, in *Setariaitalica*higher level of manganese was observed in mature leaves. On the contrary,Tanaka *et al.* (1966a, b) observed that manganese content is always higher in old riceand maize leaves. Similar trend is also observed in *Cassia* species.

ix) Iron

It functions both as a structural component as well as a cofactor for enzymaticreactions. It is mostly associated with chloroplast. It is involved in oxidation–reduction reactions, ferredoxin formation and chlorophyll synthesis (Spillar and Teny,1980). It plays an important role in photosynthesis and nitrogen metabolism. Irondeficiency causes reduction of nitrate reductase activity and chlorosis. The adequatevalue of iron for optimal growth of plants is 100 ppm (0.01%) (Stout, 1961 andEpstein, 1972). It is an immobile element.Distribution of iron in different parts of *Cassia* species is shown in Table 2. Itis clear from the results that in *C. obtusifolia*the iron concentration is higher in theyoung leaves (18.8 ppm dry wt.) followed by stem (18 ppm dry wt.) and then by roots(5.6 ppm dry wt.). In *C. uniflora*the iron concentration is higher in young leaves(18.8ppm dry wt.) followed by roots (15 ppm dry wt.) and then by stem (8.8 ppm drywt.). Theconcentration of iron found in different parts of *Cassia* species is lower than theoptimum suggested by Epstein (1972) and Stout (1961). Low level of iron was also

recorded in different parts of*Psophocarpustetragonobolus*(Rajmane, 1984).

x) Zinc

Many enzymes require zinc for their activity. It is required for chlorophyllbiosynthesis. It participates in synthesis of indole acetic acid from its precursor oftryphtophan (Skoog, 1940 and Tsui, 1948). It is the component of superoxidedismutase. In its function in enzyme systems it resembles manganese and magnesiumin that it brings about the binding and conformation between enzyme and substrate. Itis closely involved in nitrogen metabolism in plants. According toEpstein (1972) the level of zinc for optimal growth of plant is 20 ppm (0.002%) in drymatter.Zinc level in different parts of *Cassia* species is shown in Table 2. It is foundthat zinc level in the leaves of both *Cassia* species is higher than that in the stem androots. Its concentration is low in roots of *C. uniflora.* Young leaves of both species arerich in zinc (*C. obtusifolia,* 46 ppm i.e. 0.0046% dry wt. and *C. uniflora,* 39 ppm i. e.0.0039% dry wt.). High level of zinc in the leaves has been recorded in *Phaseolusaconitifolius*(Kulkarni, 1984) and *Derris scandensis*(Mohite, 1990). It is also foundthat level of zinc in the leaves of both thespecies of *Cassia* is higher than that (20ppm/0.02% dry wt.) suggested by Epstein (1972). Higher content of zinc in theleaves indicates its function in stress tolerance and also it acts as antioxidant as it is acomponent of antioxidative enzyme superoxide dismutase.

xi) Copper

According to Epstein (1972) the optimum level of copper is 6 ppm of dry wt.and according to Mengel and Kirkby (1982) the optimum level of copper is 2-20 ppm(i. e. 0.0002 to 0.002 %) dry wt. It is associated with enzymes involved in redoxreactions of photosynthesis (Haehnel, 1984). It participates in auxin synthesis (Skoog,1940). It is a component of several metallo-enzymes including ascorbic acid oxidase,tyrosinase and cytochrome oxidase. Hallsworth*et al.* (1960) suggested that copper isrequired in symbiotic nitrogen fixation. It is a constituent of chloroplast proteinplastocynin, which forms a part of electron transport chain in photosynthesis (Boardman, 1975).From the results (Table 2), it is evident that copper content of the leaves (average 14.5 ppm dry wt.) of *C. obtusifolia*is higher than that of stem (5.8 ppm drywt.) and roots (5.4 ppm), while in *C. unifloras*its level is higher in the stem (8.6 ppmdry wt.) and roots (6.6 ppm dry wt.) than in the leaves (average 5.2 ppm of dry wt.). Itis also observed that copper level in young leaves is higher than that in mature leaves. Young and mature leaves of *C. obtusifolia*contained 16.4 and12.6 ppm drywt. copper and that in *C. unifloras*it was 5.8 and 4.6 ppm dry wt. Copper is not readilymobile in plants although it can be translocated from older to younger leaves.Concentration of copper in the leaves of *C. obtusifolia*and stem tissue of *C. unifloras*is higher than that suggested by Epstein (1972). Copper content in different parts of*Cassia* species is also in the range given by Mengel and Kirkby (1982). Roots arefrequently higher in copper content (Hill, 1973). Copper content of the leaves of*Phaseolus vulgaris* (Bhivare, 1984) and stems of *Psophocarpustetragonobolus*(Rajmane, 1984) is 0.03 and 0.005%, respectively. These values of copperconcentration are higher than those recorded in *Cassia* species.

xii) Cobalt

Cobalt is prosthetic group of iron-porphyrin enzymes like catalase, peroxidaseand cytochromes (Shkolnik, 1984). It influences the synthesis of haem (Laforet andThomas, 1956). Wilson and Nicholus (1967) showed that cobalt is essential for thegrowth of clover and wheat. Deficiency of cobalt causes retardation of growth andchlorosis. It affects oxidative phosphorylation. Cobalt is essential for the nitrogenfixing microorganisms i. e. it is essential for legume plants (Reisenauer, 1960). Thecobalt concentration in the dry matter of plants grown in soil normally lies

between0.02 to 0.5 ppm (0.00002 to 0.0005 %) (Mengel and Kirkby, 1982).In *C. obtusifolia*, young leaves contain higher level of cobalt (8 ppm dry wt.)followed by stem tissue (6.2 ppm dry wt.) and then by mature leaves (5.6 ppm drywt.), while in roots its concentration (0.4 ppm of dry wt.) is low. In case if *C. uniflora*there is no difference in the level of cobalt in all parts. Cobalt content in young andmature leaves, stem and roots is respectively 5.2, 5.8, 4.6 and 4.8 ppm dry wt. It isfound that the level of cobalt in different parts of *Cassia* is much higher than the rangegiven by Mengel and Kirkby (1982).

Table 1: Inorganic constituents (macronutrients, g 100 g^{-1}dry wt) in different parts of *Cassia obtusifolia*and *C. uniflora*

Plant Name	Plant part	N	P	K	Mg	Ca
Cassia obtusifolia	Young leaves	4.97	0.20	2.04	0.36	2.57
	Mature leaves	4.39	0.16	1.49	0.37	2.55
	Stem	0.52	0.07	1.04	0.14	0.29
	Root	0.42	0.04	0.84	0.10	0.21
Cassia uniflora	Young leaves	4.03	0.17	1.61	0.28	1.61
	Mature leaves	2.73	0.14	1.04	0.25	3.37
	Stem	0.64	0.17	0.90	0.19	0.79
	Root	0.76	0.12	0.67	0.15	0.11

Note: N-Nitrogen, P- Phosphorus, K-Potassium Mg-Magnesium, Ca- Calcium

Table 2: Inorganic constituents (micronutrients, ppm i. e. mg 1000 g^{-1} dry wt) in different parts of *Cassia obtusifolia*and *C. uniflora*

Plant Name	Plant part	Cl	Na	Cu	Fe	Mn	Co
Cassia obtusifolia	Young leaves	46.0	11.00	16.4	18.8	38.4	8.00
	Mature leaves	45.2	9.00	12.6	10.2	39.8	5.60
	Stem	17.0	25.00	5.80	18.0	29.4	6.20
	Root	18.8	29.00	5.40	5.60	24.0	0.40
Cassia uniflora	Young leaves	39.2	38.00	5.80	18.8	33.3	5.20
	Mature leaves	25.6	21.00	4.60	18.0	45.4	5.80
	Stem	18.6	32.00	8.60	8.80	28.9	4.60
	Root	10.6	46.00	6.60	15.0	28.5	4.80

Note: Cl-Chloride, Na-Sodium, Cu-Copper, Fe- Iron, Mn- Manganese, Co- Cobalt

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