International Journal of Life science & Pharma Research

EFFECT OF VARIOUS INORGANIC MICRO-NUTRIENTS ON GROWTH, BIOMASS AND HYDROCARBON YIELD OF EUPHORBIA LATHYRIS L. A HYDROCARBON YIELDING PLANT

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ABSTRACT

Energy security is one of the most pressing challenges of the 21st century. A shift to next-generational fuels and increased use of renewable source of energy are increasingly being considered as viable options. *Euphorbia lathyris* L. is one of the most-suitable species that falls into the category of hydrocarbon yielding plants. This plant is suitable to grow in arid and semiarid climate. Fertilizer application plays a major role in the universal need to increase in agricultural production. Different mineral nutrients like boron (boric acid), copper (copper sulphate), iron (ferrous sulphate), magnesium (magnesium sulphate), manganese (manganous sulphate), molybdenum (ammonium molybdate) and zinc (zinc sulphate), were sprayed over the plants. There was an increase in the Hexane Extractables, Methanol Extractables and total extractable (Hexane Extractables and Methanol Extractables) at Mn, Zn, Fe, Cu, Mo, Mg and B in decreasing order over the control.

Key words: Energy security, renewable source of energy, biofuel, *Euphorbia lathyris L.,* hydrocarbons.

INTRODUCTION

Fuel plantations are a means of producing fuels by harvesting and storing solar energy in plants with a fuel value, for purposes. The hydrocarbons from petroleum plants have a molecular weight of about 10,000, which may be suitable for further cracking to gasoline materials. Such selected plants are grown for purposes of energy, either for direct use or as feedstock for more convenient liquid fuel or other energy chemicals. Following, this approach, plants may be either used to get diesel fuel or, after their conversion, for high quality fuel. Calvin Group has found that the family Euphorbiaceae in general, and the genus *Euphorbia*(2,000 species) in particular, is one that reduces Carbon Di Oxide beyond carbohydrates, and concentrated primarily on two species, the annual mass of 25 tonnes/hectare/year. *Euphorbia lathyris* and the perennial *Euphorbia tirucalli*, particularly. *Euphorbia lathyris* is a common weed in California. According to Nemethy et. al. (1981a, 1981 b), this species can produce biofuel on commercial level. The best solar converting machine available today is the green plant which can produced fuel and material on renewable basis (Szego and Kemp, 1973; Calvin, 1976, 1977, 1978a, 1979a, 1979b, 1980, 1983a, 1983b, 1984, 1985; Calvin *et al.,* 1981, 1982; Buchanan and Otey, 1979; Buchanan et al., 1978a, 1978b; Vergara and Pimental, 1978; Weisz and Marshall, 1979; Bagby *et al.,* 1980; Hall, 1980; 1982; Johnson and Hinman, 1980; Coffey and Halloran, 1981; Lipinsky, 1981; Lipinsky *et al*., 1980;

Tideman and Hawaker, 1981; Wang and Huffman, 1981; Khoshoo, 1982; 1984; McLaughiin and Hoffman, 1982; McLaughiin *et al*., 1983; Stewart *et al*., 1982; Adams and McChesney, 1983; Bhatia and Srivastava, 1983; Hoffman, 1983; Nemethy, 1984; Nemethy et. al.,1981a; 1981b ; Vimal, 1986; Garg and Kumar, 1989; 2011a; 2011b). Biomass energy is thus, environmentally a very acceptable resource. The wide use of biomass for development offers minimal ecological imbalance and provide means of recycle nutrients and carbon dioxide from the atmosphere (Dayal, 1986 and Vimal, 1986).Calvin (1977) conducted detailed investigations on the *E. lathyris* and *E. tirucalli.* Large scale cultivation of *E. lathyris* has been carried out in different parts of the world (Hinman *et al.,* 1980; Johnson and Hinman, 1980; Sachs and Nock, 1980; Sachs et al., 1981; Peoples *et al*., 1981; Kingsolver, 1982; McLaughlin and Hoffman, 1982; McLaughlin et al., 1983; Ayerbe *et al.,* 1983a, 1983b, 1984a 1984b; Calvin, 1984 Nemethy, 1984; Garg and Kumar, 1989; 2011a; 2011b). When examined with local plant species in semiarid climatic conditions of Rajasthan in India, it showed maximum potential for per cent dry weight and latex yield. *Euphorbia lathyris* L. can be grown as biofuel crop in India(Garg and Kumar 1989; 2011a; 2011b).

Euphorbia lathyris can yield upto 20,000 kg dry matter per ha (Ayerbe *et al.,* 1983a, 1983b, 1984a, 1984b of which between 5 to 8 per cent are hydrocarbons and 20 per cent are fermentable sugars (Nemethy *et al.,* 1981a, 1981b). The process to recover terpenoids and sugars from *E. lathyris* has been calculated on a 1000 tons of dry matter/day basis (Calvin, 1983a). The product from 1000 tons is 80 tons of oil extract in the same way as soybean oil. In addition to oil the residue on extraction with methanol/water to remove fermentables, gives 200 tones of sugars. The 200 tons of sugars is equivalent to 100 tons of alcohol. Therefore, there are two liquid products obtainable from 1000 tons of dry matter, 80 tons of oil and 100 tons of alcohol. Besides this, 200 tons of bagasse is also obtained. Thus the combination of these products makes cultivation of hydrocarbon yielding plants as attractive proposition (Calvin, 1977).

There are currently plantations of *E. lathyris* in mediterranean countries, Africa, the Canary islands and Australia (Coffey and Halloran, 1981). Its water requirement ranges from 30-37.5 cm annually and can grow in land which has poor soils not suitable for food production. The plant attains the harvest size in 5 to 7 months and the extraction process is standard for chemical industry. Besides oil, the plant contains a substantial quantity of sugars, fermentable to alcohol. It may give yield of 6 to 10 barrels of oil acre^{-1} year^{-1} using seeds of wild plants (Calvin, 1979a).

Fertilizer application plays a major role in the universal need to increase in agricultural production. The extent to which fertilizers are used, differs considerably between various regions of the world (Mengel and Kirkby, 1978). Rajasthan soils are generally poor in macro-and micro-nutrients as well as organic contents (Anonymous, 1970). Although a large number of *Euphorbia* species are able to grown on marginal soils with minimal supply of nutrients, addition of fertilizers is reported in increase their yield (Kumar and Kumar, 1985, 1986). However, higher dosages of nitrogen are reported to inhibit growth. But phosphorus favoured increase in dry matter production in *Euphorbia* species (Hinman *et al.,* 1980; Peoples *et al.,* 1981). Ayerbe *et al.* (1984a), suggested that moderate amounts of nitrogen enhanced the growth in *E. lathyris.* Similarly Kingsolver (1982) also recorded increase in growth and dry matter production due to nitrogen and phosphorus application in *Euphorbia* species. Increase in latex yield has also been reported due to nitrogen application (Sachs and Mock, 1980 and Sachs *et al.,* 1981).Although investigations on the role of mineral nutrients on the growth and latex yield of *Euphorbia* species are lacking, several studies have shown are lacking, several studies have shown positive effect of mineral nutrients on the oil yielding crops like coconut (Patel, 1938), linseed (Khan and Gupta, 1959), saffower (Soboleva 1959; Surajbhan, 1976), Sesamum (Singh, 1960), castor (Prashar and Benl, 1968) and groundnut (Shiv Raj, 1978). The present investigations were undertaken with an object to study the influence of inorganic and organic fertilizers and mineral nutrients on growth and hydrocarbon production of *E. lathyris.*

METHODS

Different soil samples were analysed from experimental fields. Cationic and anionic fractions were separated. They were further analyzed for different elements in all the three soil fractions i.e. (a) in soil solution, (b) in aborded ions and (c) fixed in colloids (Anonymous, 1979).

The humusless soil obtained from 1 to 2 m depth in the uncultivated regions was taken for the experiments. The detailed physical and chemical characteristics of soil were analysed. 4 kg of soil was filled in the thoroughly washed and cleaned earthen pots after mixing with the proper amount of nutrients. The pots were lined with the polythene and watered to the 60 to 80 per cent of the field capacity. Experiments of inorganic fertilizers were harvested after six months growth period. Following mineral nutrients were applied as follows, boron (boric acid), copper (copper sulphate), iron (ferrous sulphate), magnesium (magnesium sulphate), molybdenum (ammonium molybdate), managanese (manganous sulphate) and zinc (zinc sulphate). 10 ppm solutions of these mineral nutrients were sprayed over the plants, at the age of one month. The control plants were sprayed with distilled water. Subsequent sprays were done at one-month intervals. In all, four sprays were done. Harvesting was done after 3 months of last spray. The plants were harvested after seven months periods.

RESULTS AND DISCUSSION

Analysis of soil: Soil has a texture of sand to loamy sand with a particle density ranging between 2.5 to 2.70 g/cc. Soil has a saturation percentage of 25 to 30 (on dry weight basis). The soil pH was about 7.4, electric conductivity was 0.58 mmhos/cm. The data obtained from soil analysis are given in Table 1.

TABLE- 1

Analyris of typical

Sandy soil for experimental field of the department of botany, university of rajasthan, jaipur. India.

DISTRIBUTION	**NUTRIENTS IN SOIL (Mg/100 g)**										
	K	**Na**	**Ng**	**Ca**	**NH_4**	**Cl**	**SO_4**	**PO_4**	**NO_3**	**P_2O_5**	**K_2O**
a. Soil solution	1.46	15.01	8.99	3.36	-	6.09	2.10	-	1.01		
b. Absorbed ions	2.07	27.66	0.67	8.19	-	5.92	2.27	0.91	1.08		
c. Colloidal form	4.05	8.39	0.20	00.29	-	3.49	1.25	1.71	0.48		
Total	7.50	51.06	1.86	20.11	-	15.50	5.62	5.52	2.57	5.74	9.25
DISTRIBUTION	MICRO-NUTRIENTS IN SOIL (mg/100 g)										
	Cu		Zn		Mn						
a. Soil solution											
b. Absorbed ions											
c. Fixed in colloids											
Total	**0.001**		**0.013**		**0.058**						

Potassium: Total potassium was 7.58 mg/100 g of which the maximum was fixed in colloids (4.05 mg/100g), followed by absorbed ions (2.07 mg/100g) and soil solution (1.46 mg/100g).

Sodium: Total sodium was 51.06 mg/100g. Major part of it was in the form of absorbed ions (27.66 mg/100g), followed by soil solution form (15.01 mg/100g) and fixed in colloids from (8.39 mg /100g).

Magnesium: Total magnesium was 1.86 mg/100g soil. The soil solution phase contained the major part (0.99 mg/100g), followed by absorbed ions (0.67 mg/100g) and the remaining (0.20 mg/100 g) was fixed in colloids.

Calcium: The calcium was 20.11 mg/100g, maximum being fixed in colloids (8.29 mg/100g), while absorbed ions consisted of 8.19 mg / 100g, followed by soil solution (3.63 mg/100g).

Ammonium: Ammonium was not detectable in the soil samples in any of the three forms.

Chlorides: The chloride content was 15.50 mg / 100 g. The maximum chlorides (6.09 mg/100g soil) were dissolved in soil solution, 5.92 mg/100g in ionic form and 3.49 mg/100 g fixed in colloids form.

Sulphates: Total sulphate were 5.62 mg/100g soil, 2.27 mg/100g was in the form of absorbed ions, 2.10 mg/100g in soil solution and 1.25 mg/100g fixed in colloids form.

Phosphates: Phosphates were in the range of 2.52 mg/100g, 1.71 mg/100g was fixed in colloids, 0.81 mg/100 g was in absorbed ionic form, while phosphates were exclusively absent in soil solution phase.

Nitrates: Total nitrates were 2.57 mg/100g. Soil solution phase consisted of 1.01 mg/100g, followed by absorbed ions form (1.08 mg/100g) and fixed in colloidal form (0.48 mg/100g).

Various other nutrients recorded were as follows: Phosphorus pentaoxide (5.74 mg/100g), potassium dioxide (9.25 mg/100g), iron (0.21 mg/100g), copper (0.001 m/100g), zinc (0.013 mg/100 g) and manganese (0.058 mg/100g).

Effect of mineral nutrients: Sprays of B, Cu, Fe, Mg., Mn, Mo and Zn resulted in increased plant growth (Fig. 1). Maximum increase in the above ground and under-ground fresh weight and dry weight was recorded in Mg. followed by Cu, B, Fe, Mo., Zn and Mn, and control. In general, the plant height was correlated with fresh weight except in the case of Zn. There was an increase in the Hexane Extractables, Methanol Extractables and total extractable(Hexane Extractables and Methanol Extractables) at Mn, Zn, Fe, Cu, Mo, Mg and B in decreasing order over the control. In general, there was a direct correlation between increase in HE and ME (Fig. 2). There was an increase in chlorophyll contents on different mineral nutrients (Fig. 3). Mixed chlorphyll contents were recorded on Mn followed by B, Mo, Mg, Zn, Fe and Cu The highest amount of chlorophyll b was recorded in Mn sprayed plants.The total sugars also showed increase on different mineral nutrients. Maximum sugars were recorded on Mn followed by Zn, Mg, Fe, Mo, Cu, B and control (Fig. 4).

Although several nutrients might be present in the soil, their absorption is influenced by various factors such as (i) growth rate of aerial parts, (ii) location and spread of root system, (iii) availability of nutrients in soluble phase and (iv) soil moisture. The plants require large amounts of N,P,K,Ca, Mg, S and significant amounts of minor elements (Verma and Bajpai, 1964). In general, there is lack of information about the role of nutrients in hydrocarbon yields of laticiferous plants but considerable work has been done on oil yielding plants. Sanjeevaiah (1969)obtained high yield of peanut with the application of N.,P.,K. in combination with Mn, Mg, S, Ca, Fe and Mo Out of these Mn gave the highest yield followed by S. and B. whereas Ca. and Zn. brought about decrease in yield. Reddy and Rao (1965) obtained the highest yields by applying 40 lb each of N and P per acre in peanut. While N, P and K each at 20 lb. per acre increased the number of flowers, number of pods and the shelling percentage. The oil content in groundnut was also increased by addition of P. and K. In contrast to this, nitrogen deficiency lead to a general chlorosis of leaves. Phosphorus increased the weight and per plant yield by 33 per cent. Reddy and Rao (1965) obtained high yields of groundnut with 40 lb P_2O_5 per acre applied in the form of super phosphate. Soboleva (1959) reported combined effect of the trace elements Mo, Mn And Co on photosynthesis and n content in the leaves of *Helianthus annus* and oil formation in seeds. Kumar and Kumar (1985, 1986) studied the role of N,P, K on the growth of *E. lathyris* and reported increase in growth due to addition of N,P and K. These investigations were further supported by the extensive work which also included characterization of hexane extractable, methanol, extractables, chlorophyll contents and sugars. *E. lathyris* seedlings showed a positive response to increased levels of both phosphorus and nitrogen in hydroponic nutrient solutions. When grown in nutrient solutions with 0, 1 and 2 mM phosphorus. the dry weight of plants increased linearly (Kingsolver, 1982). The increase due to nitrogen application was assigned to the increased growth of foliar parts namely leaves, rather than to the increased synthesis of hexane and methanol extractable. However, the present observations made on a soil type poor in nitrogenous matter, the possibility that exogenous supply of nitrogen promotes hydrocarbon yield cannot be rules out. But a critical examination of the role of nitrogen in biosynthesis of hexane and methanol extractables deserves attention in further studies.

Indian soils are usually very poor in organic matter as well as nitrogen. The phosphate deficiency is less widespread and potash deficiency occurs in compact areas (Anonymous, 1970). During the present investigations the sandy soils of Rajasthan showed increased yields in terms of fresh weight and dry weight, hexane, methanol extractables, chlorophyll contents and sugar contents due to addition of P to a certain level followed by a decline at higher dosages. Apparently plants have high metabolic activities and rapid turnover of enzymatic reactions requiring ATP and possibly the phosphate translocator might play in increasing the growth of the plants due to additional supplies of phosphorus. Although K. might play a direct role in plant metabolism, it is reported to increase contents of P, K and Ca in the leaves. Nakagawa (1966) and Roche (1956) reported that application of K influences oil contents. During the present investigations also K showed increased growth, H.E. and M.E. to certain level. Whether this was due to direct role of K in the plant or indirect role by affecting the uptake of ions which favoured growth and HE and ME needs to be further examined.

The response of Nitroge also depend on how well the crop is supplied with other nutrients (Gartner, 1969). Without Phosphorus and potassium applications, the yield response to increasing Nitrogen levels was smaller than when adequate amount of P and K were applied. A combination of micronutrients may further promot growth and HE and ME by possible interaction of all these nutrients. This is also supported by large number of studies on oil yielding plants (Shiv Raj, 1978). Shankaran *et al.* (1973) reported the increase in chlorophyll contents of groundnut due to calcium and boron nutrition. Iron is essential for chlorophyll biosynthesis. Its deficiency leads to severe reduction in growth of plants and this could be correlated by spraying ferrous sulphate on the plants. Boron application reduced the chlorophyll components 'a', 'b' and total chlorophyll at higher concentrations in peanut (Shankaran *et al.,* 1973).However, application of six kg. of boric acid on sandy loam was found to increase yield significantly. Molybdenum is a metal constituent of nitrate reductase enzyme of all plants essential for the reduction of nitrate (Asokan and Raj, 1974). Khan and Gupta (1959) reported that application boron decreased, seed yield and oil percentage, while Mn increased seed yield and oil percentage in linseed. Jones and Tucker (1968) reported that oil content of safflower was little affected by N application. Application of Ntrogen with P_2O_5 is very effective in increasing the seed yield as well as total output of oil (Dhote and Ballal, 1964). Boron occurs in the soil primarily as boric acid or borate. The boron content of soils in arid and semi-arid climates is in general higher than in humid climatic zones (Kanwar and Shah Singh, 1961). The borate ion influences plant metabolism reacting with OH – groups form sugars, alcohols and organic acids to form esters of boric acid (Mengel and Kirkby, 1978) Boron is of considerable importance in the synthesis of nucleic acids and proteins (Johnson and Albert, 1967).

Boron deficiency also influences phytohormone balance. Boron deficiency depressed the cytokinins synthesis (Wagner and Michael, 1971). Shkolink (1974) proposed that accumulation of excess of auxins and phenols is the primary cause of necrosis in plants associated with B deficiency. Price and co-workers (1972) discussed the possible roles of B in auxin metabolism, protein synthesis and phosphate utilization. At less than 1 ppm water soluble B, soils may not supply sufficient Boron to support plant growth, whilst values above 5.0 ppm may be toxic (Reisenauer *et al.,* 1973). During the present investigation Boron showed positive effect.

Copper in earth crust occurs chiefly as sulphides and the most abundant mineral oil copper is chalocopyrite. Total copper in Indian soils varies between 1.8 to 960 ppm whereas the available copper is in the range of traces to 16.8 ppm (Katyal and Deb, 1982). In addition copper occurs in organic compounds, is present as an exchangeable cation on soil colloids and is a constituent of soil solution (Mengel and Kirkby, 1978). Copper is taken up by the plants in very small quantities. The content of most plants is generally between 2 to 20 ppm in the dry plant material. Copper strongly inhibits the uptake of Zn and vice-varsa (Schmid *et al.,* 1965). Copper plays a part in photosynthesis (Arnon, 1950). It is a constituent of the chloroplast protein plastocyanin which forms part of the electron transport chain linking the two photochemical systems of photosynthesis (Bishop, 1966; and Boardman, 1975). In Copper deficient plants the protein N-compounds (Possingham, 1956; Possinghamet al., 1964). In young growing organs, where protein synthesis is most active, lower levels of DeoxyriboNucleicAcid have been observed in Copper deficient tissues (Ozolina and Lapina, 1965). The level of reducing sugars also declined, whilst organic acids and Asparagine accumulated (Brown *et al.,* 1958). Addition of Copper promoted growth and HE and ME, chlorophyll and sugar contents during the present investigations.

Magnesium content of sandy soils are around 0.05 per cent. The distribution of Mg. is divided into bound, colloidal and water soluble forms. Some Mg occurs in soil in association with organic matter. The content of the Mg in plant tissue is usually in the order of 0.5 per cent of the dry matter 15 to 20 per cent of the total Mg in plant material is associated with chlorophyll (Neales, 1955). Mg activates phospho-kinases and phosphorus transferases (Hewitt, 1958 ;1963; Hewitt and Agarwal;52). Werner (1959) reported lower starch contents in Mg. deficient potatoes and a decrease in carbohydrate content in the grain of Mg. deficient oats (Stenuit and Piot, 1957). Increase in Mg levels increased yield of potatoes on the sandy soils in Dermark (Dam Kofoed and Hjmark, 1971).

Mangnese is relatively immobile in plants (Wittwer and Teubner, 1959). According to Bishop (1971), Mn is essential in photosystem II where it participates in photolysis of water (Anderson and Pyliotis, 1969). When Mn. is deficient, the structure of chloroplasts is markedly impaired even when other organelles show no visible alteration (Possingham *et al.,* 1964). Hewitt (1963) suggested that there is clear indirect relationship between the influence of Mn. on photosynthesis and NO_2 reductase. Chloroplasts are the most sensitive of all cell organelles to Mn. deficiency (Homann, 1967). However, most soils contain adequate levels of available Mn so that Mn applications are unnecessary. The total amount of Mn taken up by available crops is low and ranges from 500 to 100 g Mn. per ha. (Schachtschabel, 1955). However, during the present investigations Mn. application promoted growth, chlorophyll, HE, ME and sugars.

Zinc in the soils is usually present in the range 10 to 300 ppm. occuring in a number of different minerals. The levels of Zn in plant material are very low and generally in the order of up to 100 ppm in dry matter. Zn. plays important role in Zn. metallo enzymes like Glutamic acid dehydrogenase as well as proteinases and peptidases (Vallee and Wacker, 1970). Zink deficiency caused sharp decrease in the level of Ribonucleicacid and ribosome content of cells (Price *et al.,* 1972). Thus reduction in RNA synthesis leads to an inhibition of protein formation whilst glucose, non-protein Nitrogen and DNA are relatively increased (Price *et al.,* 1972). Praske and Plocke (1971) have observed extremely unstable cytoplasmic ribosomes in *Euglena gracilis* with Zinc deficiency. Zinc is required in the synthesis of tryptophan (Tsui, 1948), a precursor of Indole-3yl-acetic acid. In Zinc deficient tomato plants, Tsui (1948) observed low rates of stem elongation, low auxin activities and low tryptophan contents. Jyung and Co-workers (1975) suggested that Zinc has a possible role in plant metabolism involved in search formation. During the present investigations Zinc promoted growth, HE, ME, chlorophyll and sugars in *E. lathyris.*

Molybdenum(Mo) content of most agricultural soils is between 0.6 to 3.5 ppm (Swaine, 1955) with an average total Mo. content of 2.0 ppm and an average available content about 0.2 ppm (Cheng and Oullette, 1973). Mo largely occurs in the soil as an oxycomplex (MoO_4^{2-}) and is absorbed by soil minerals and colloids (Barrow, 1970).Mo content of the soil solution may vary considerably. Mo. is absorbed as molybdate in plants (Mengel and Kirkby, 1978) and is located primarily in the phloem and vascular parenchyma (Hewitt and Agarwal, 1952). The physiological requirement of Mo. is very low and less than 1 ppm in the dry matter (Stout and Meagher, 1948). Activity of the intratereductase in cauliflower was reported to be enhanced by increasing levels of Mo. supply (Candela *et al.,* 1957). Nicholas and Nason (1955) also observed that Mo. influenced the enzyme activity. Mulder (1948) suggested that Mo is essential for microbial denitrification. Mo deficiency can give rise to secondary effects such as the reduction in phtosynthetic rate because of low chlorophyll levels an enhanced respiration (Loneragam and Arnon, 1954). During the present investigation Mo. application increased the yield of *E. lathyris.*

EFFECT OF MINERAL NUTRIENTS: Different mineral nutrients like boron (boric acid), copper (copper sulphate), iron (ferrous sulphate), magnesium (magnesium sulphate), manganese (manganous sulphate), molybdenum (ammonium molybdate) and zinc (zinc sulphate), were sprayed in solution form over the plants.

Maximum increase in the above-ground, under-ground fresh and dry weights was recorded in magnesium treatment. Application of mineral nutrients favoured plant height and vegetative growth.

There was an increase in the hexane extractables, methanol exractables and total extractables(hexane extractables and methanol exractables) at Mn, Zn, Fe, Cu, Mo., Mg and B in decreasing order over the control. The hexane extractables and methanol extractables were directly correlated to each other.

Mineral nutrient application also increased the chlorophyll contents, maximum being in Mn followed by B, Mo, Mg, Zn, Fe. and Cu. Maximum chlorophyll b and total sugar contents were obtained by Mn application.

SOIL ANALYSIS : Analysis of the soil samples, collected from experimental field revealed that it was a sandy soil having a pH. 7.4, and electric conductivity 0.58 mmhos/cm. It consisted of 7.58 mg/100 g potassium, 51.06 mg/100g sodium, 1.86 mg/100 g magnesium, 20.11 mg/100 g calcium, 0.50 mg/100 g chloride,s 5.62 mg./100 g. nitrates, 5.74 mg./100 g. P_2O_5, 9.25 mg/100 g K_2O, 0.21 mg/100 g iron, 0.001 mg/100 g copper, 0.013 mg/100 g Zinc and 0.058 mg/100 g manganese. The ammonium content was not detectable in the soil. Cu- copper, Fe- iron Mg – magnesium Mn – manganese; Mo – molybdenum and Zn – zinc.

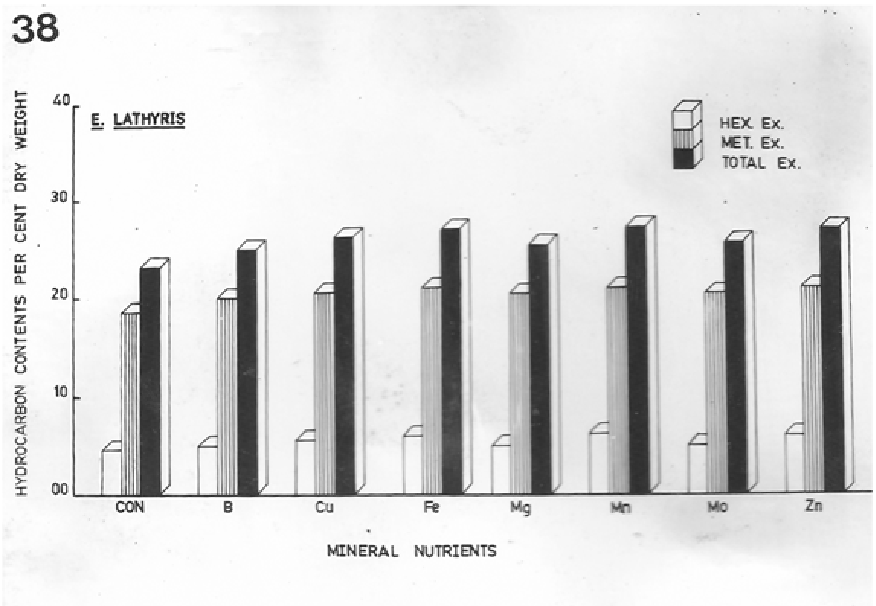

Fig.1 ***Effect of mineral nutrients (B, Cu, Fe, Mg, Mn, Mo and Zn), 10 ppm, on plant height, above-ground and under-ground fresh weight and dry weight of E. lathyris L. CON – Control, plants sprayed with distilled water.***

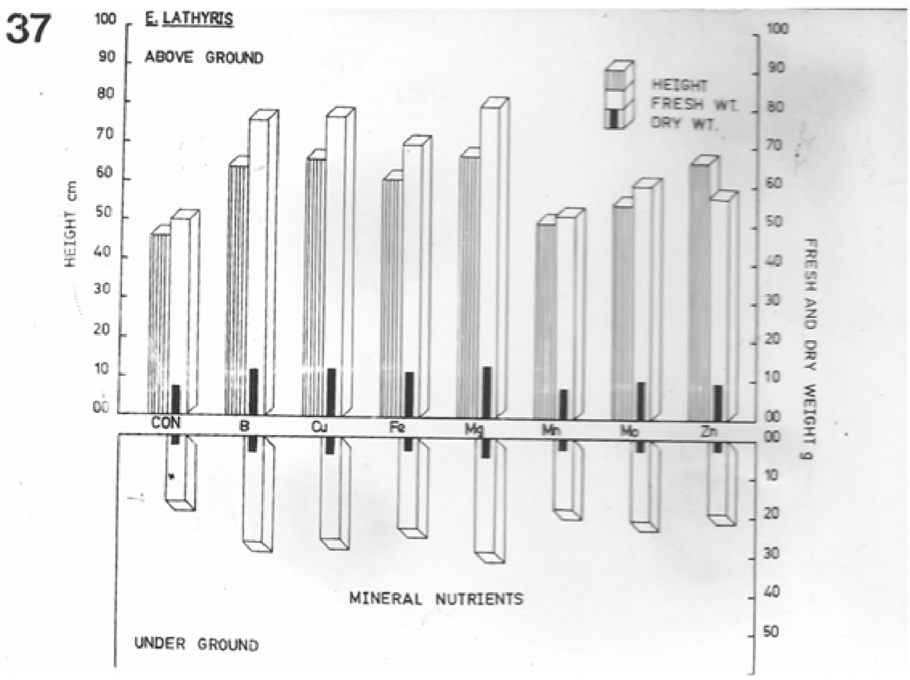

Fig. 2 ***Effect of mineral nutrients (B, Cu, Fe, Mg, Mn, Mo and Zn), 10 ppm, on hexane, methanol and total extractables in above ground parts of E. lathyris L. expressed in percent dry weight basis. CON – Control, plants sprayed with distilled water. B – boron; Cu – copper; Fe – iron; Mg – magnesium; Mn– manganese; Mo – molybdenum and Zn – zine.***

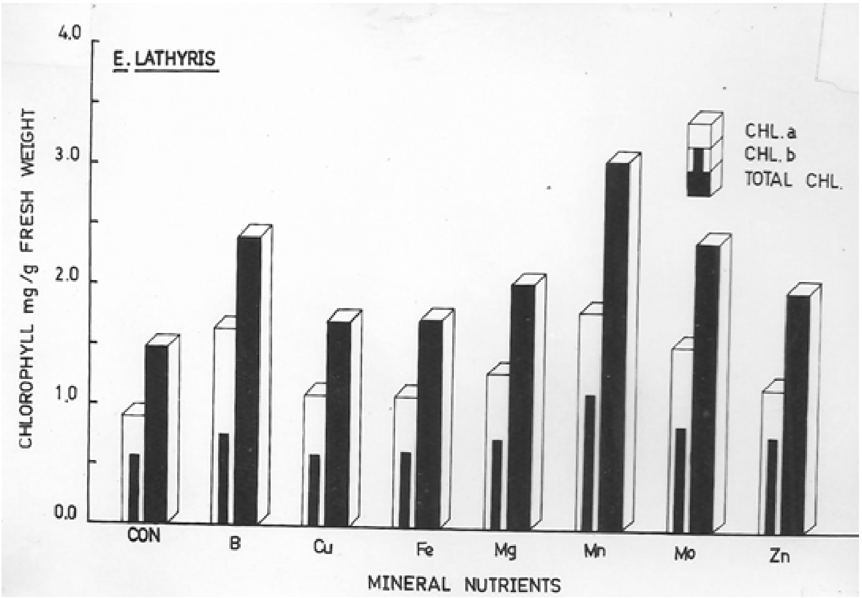

Fig. 3 ***Effect of mineral nutrients (B, Cu, Fe, Mg, Mn, Mo and Zn). 10 ppm, on chlorophyll a, chlorophyll b and total chlorophyll contents mg/g fresh weight basis. CON – Control, plants sprayed with distilled water.***

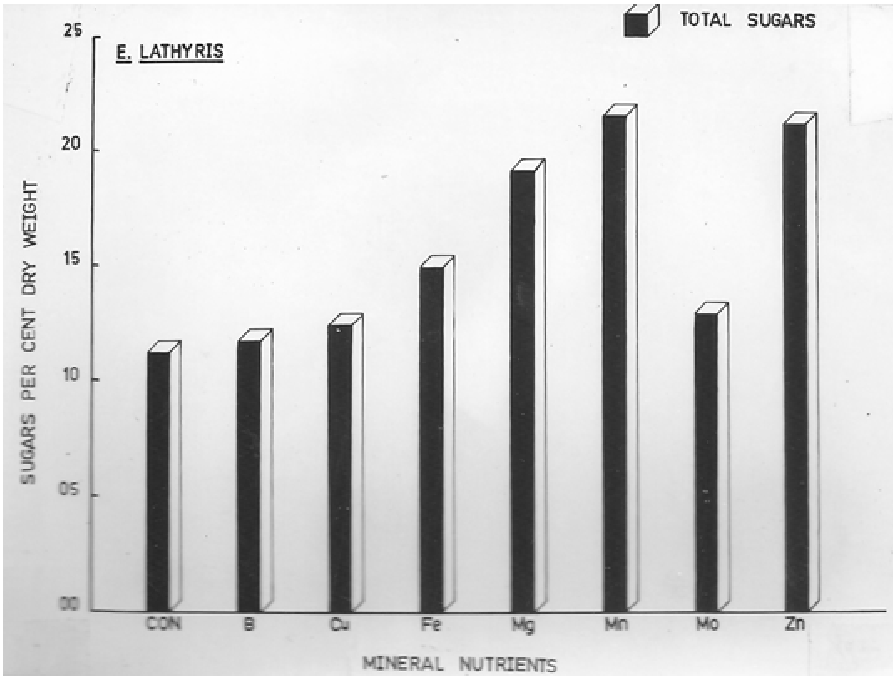

Fig. 4 ***Effect of mineral nutrients (B, Cu, Fe, Mg, Mn, Mo and Zn) 10 ppm, on sugar contents in above-ground parts of E. lathyris L. expressed in percent dry weight basis. CON – Control, plants sprayed with distilled water. B – boron; Cu***

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