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EFFECT OF VARIOUS ORGANIC NUTRIENTS ON GROWTH, BIOMASS YIELD AND HYDROCARBON PRODUCTION 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. Maximum increase in above ground fresh weight and dry weight, per cent dry weight; hexane extractables, methanol extractables, total hydrocarbon extractables (hexane extractables and methanol extractables); chlorophyll a, chlorophyll b and total chlorophyll contents were recorded at 14,000 kg/ha of farm yard manure. Maximum under-ground fresh and dry weights, under-ground percent dry weight; chlorophyll b, total chlorophyll; hexane, methanol and total hydrocarbon contents were maximum at 14,000 kg/ha of compost.

Key words: Energy security, renewable source of energy, biofuel, *Euphorbia lathyris L.,* hydrocarbons, semi arid climate, growth, productivity, chlorophyll. hexane extractables, methanol exctactables, organic fertilizer, compost , farm yard manure

INTRODUCTION

Energy security is one of the most pressing challenges of the 21st century. The last decades have witnessed rising fuel prices and shortages, pushing energy security to the top of the policy agendas. The period was marked with a sharp rise in oil prices from 18 dollars/barrels in November 2001 to 67 dollars/barrel in early September 2005. India's domestic crude oil production in 2004/05 was 34 MT (million tons). In 2004/05, India imported about 75% of the total oil needs amounting to 95.86 MT. The International energy Agency has projected India's oil import to rise to 94% by 2030. Current world economy runs on fossil fuels. This is especially true for the transport sector that accounts for around 20% of the total world delivered energy consumption and is dependent on petroleum fuels for 98% of its energy requirement (EIA a, 2007). With the emergence of China and India as new growth centers in the world, scrambling for fossil fuels has become intense (IEA, 2007). An emphasis on energy security has also led to the quest for alternative sources of energy that can replace petroleum dependence. Biofuels are one such alternative that has been emphasized by various countries and international institutions as fuels for the future. The current import dependence in petroleum is to the tune of 70%, and the World Energy Outlook has projected that, by 2030' India would be consuming 5.6 million barrels of oil/day. Given this dependence on imported oil, the rising international oil prices are bound to affect the overall economy of the country. In such a situation, a shift to next-generational fuels and increased use of renewable source of energy are increasingly being considered as viable options. The Government of India has also taken a major initiative towards promoting biofuels from plants. Though bio-fuels are emerging as an option, their potential to supplement fossil fuel supply needs to be looked into carefully.

Bio-fuel energy is environmentally a very acceptable resource (Schego and Kemp, 1973, Calvin, 1976, 1977, 1978a, 1979a, 1979b, 1980, 1983a, 1983b, 1984, 1985; Calvin *et al.,* 1981, 1982; Vergara and Pimetal, 1978; Buchan and otey ,1979, Buchan at al.,1978a, 1978b; Weisz and Marshall , 1979; Hall 1980, 1982; Lipinsky , 1981; Lipunsky et al., 1980; Tideman and Hawker, 1981; Wang and Michael, 1981; Khoshoo,1982, 1984; Stawart et al., 1982; Bhatia and Srivastava,1983; McLaughlin et al.,1983; Dayal, 1986 ; Vimal, 1986; Garg and Kumar, 1989, 2011a, 2011b). The wide use of biomass for development offers minimal ecological imbalance and provide means of recycling nutrients and carbon dioxide from the atmosphere. The World energy Outlook (2005) has projected that, by 2030, India will be consuming 5.6 million barrels of oil per day, of which 94% will be met through imports. At this stage, India would have become a major importer in the global oil market and any fluctuations in price or any problem that affects the continuous supply of oil will have a severe impact on its economy. The country's recent experience with the spurt in oil prices has revealed serious economic impacts of fluctuating oil prices and forced the country to examine various options in petroleum substitution. The choice of these options is conditioned not only by the need to address the issue of rising oil import bill and to reduce import dependence, but also to address the growing public concern on the persistent deterioration of the environment due to harmful emission. Thus, bio-fuels (which are produced in the country) become strategically important for the nation. The report of Planning Commission (2003) was made public in July 2003. It highlighted the increased acceptance and usage of bio- diesel worldwide as a solution to the problem of environmental pollution and energy security, reducing the imports of petroleum, rural unemployment, and the demands of an agricultural economy. Since then, a number of initiatives have been taken up by many stakeholders and corporate organization, NGOs (non- governmental organization), and individuals; in India for the promotion of bio-diesel.

Calvin (1977) conducted detailed investigations on the *Euphorbia lathyris* and *Euphorbia 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 Mock, 1980; Peoples *et al*., 1981; Kingsolver, 1982; McLaughlin and Hoffman, 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). 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 per acre per year 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 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 favored increase in dry matter production in *Euphorbia* species (Hinman *et al.,* 1980 and 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, sevaral 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 and 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 organic fertilizers on growth and hydrocarbon production of *Euphorbia lathyris.*

METHODS

Different soil samples were analyzed 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 absorbed ions and (c) fixed in colloids (Anonymous, 1979) as organic manure. These were applied as single basal dosages.

Experiments of organic fertilizers were harvested after six months growth period. The humus-less 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 analyzed. 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. Farm yard manure and compost (3,500, 7,000, 10,000 and 14,000 kg/ha) were applied separately.

RESULTS

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

Analysis of typical Sandy soil for experimental field of the department of botany

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 Farm Yard Manure (FYM): Addition of FYM increased the plant height, fresh weight and dry weight to varying degrees (Fig. 1). There was linear increase from 3,500 kg/ha to 14,000 kg/ha in the above ground fresh weight and dry weight. However, slight inhibition in root growth was recorded at 14,000 kg/ha. Control showed comparatively poor growth. There was general increase in per cent dry weight with increasing dosages of FYM.

Application of FYM resulted in linear increase in the Hexane Extractables and Methane Extractables as well as total extractables(Hexane Extractables and Methane Extractables) up to 14,000 kg/ha as compared to the control (Fig. 2).

Chlorophyll contents were also increased with the addition of FYM up to 14,000 kg/ha over the control. There was increase in chlorophyll a, chlorophyll b and total chlorophyll due to FYM application, but chlorophyll b showed significant increase (Fig. 3).

An increase in total sugars was recorded at 3,500 kg/ha and 7,000 kg/ha of FYM followed by a decline at 10,000 kg/ha and 14,000 kg/ha. However, increase of total sugar contents was recorded at all the dosages of FYM as compared to the control (Fig. 4).

Effect of Compost : Addition of compost resulted in increase in plant height, above ground and under- ground fresh weight an dry weight with increasing dosages of compost up to 10,000 kg/ha. There was also an increase in percent dry weight with the increasing dosages of compost. The root also showed positive increase in fresh weight and dry weight with increasing dosages of compost (Fig. 5).

Increase in Hexane Extractables and Methane Extractables as well as total extractables(Hexane Extractables and Methane Extractables) was recorded with increasing dosages of compost over the control (Fig. 6).

A linear increase in chlorophyll a, chlorophyll b, and total chlorophyll was recorded with increasing dosages of compost up to 14,000 kg/ha. There was considerable increase in chlorophyll at all the dosages applied (Fig. 7).

There was general increase in the total sugar contents over the control in all the dosages of compost applied. However, there was linear increase up to 10,000 kg/ha followed by slight decline at 14,000 kg/ha (Fig. 8).

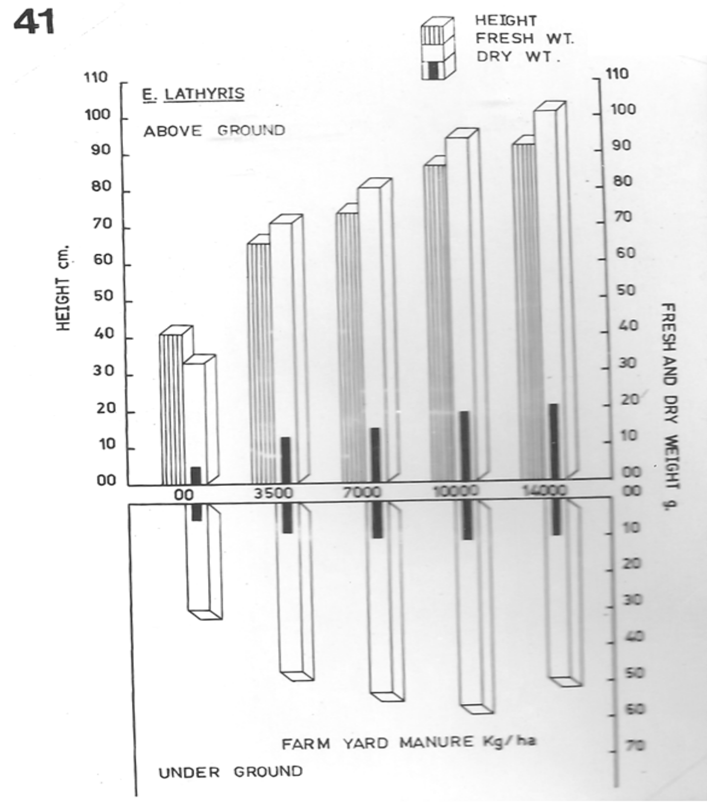

Figure 1 ***Effect of different dosages of farm yard manure (3,500 to 14,000 kg/ha) on plant height, above-ground and under-ground fresh weight and dry weight of E. lathyris L. CON – Control, without farm yard manure supplement***

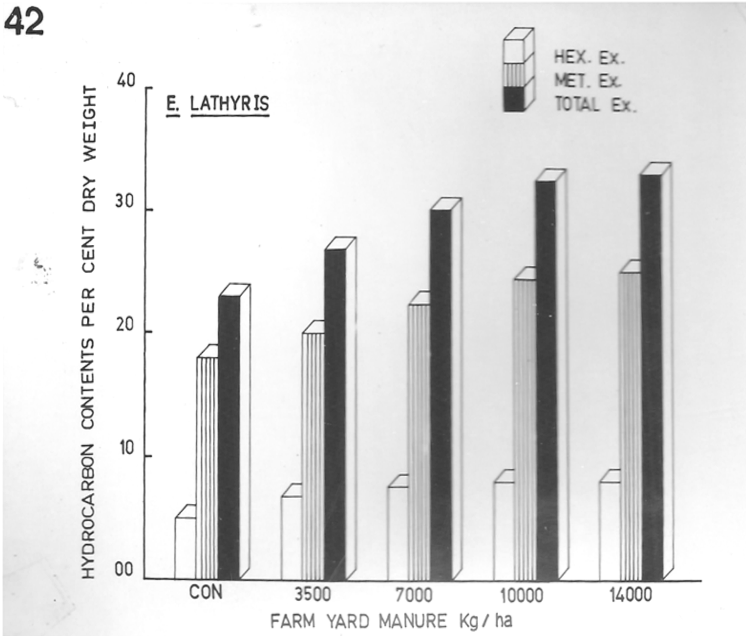

Figure 2 ***Effect of different dosages of farm yard manure (3,500 to 14,00 kg/ha) on Hexane Extractables and Methane Extractables as well as total extractables (Hexane Extractables and Methane Extractables) in above-ground parts of E. lathyris L. expressed in percent dry weight basis. CON–Control, without farm yard manure supplement.***

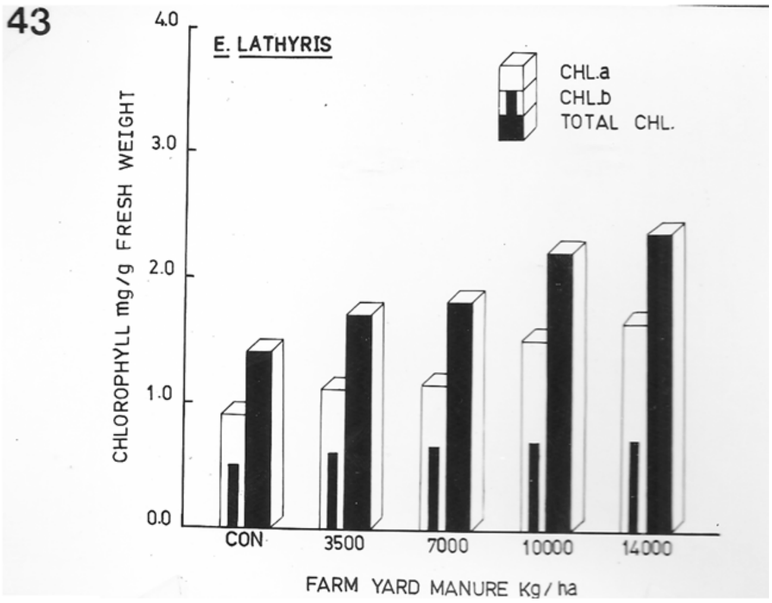

Figure 3 ***Effect of different dosages of farm yard manure (3,500 to 14,000 kg/ha) on chlorophyll a chlorophyll b and total chlorophyll contents in leaves of E. lathyris L. expressed in mg/g fresh weight basis.CON – Control , without farm yard manure supplement.***

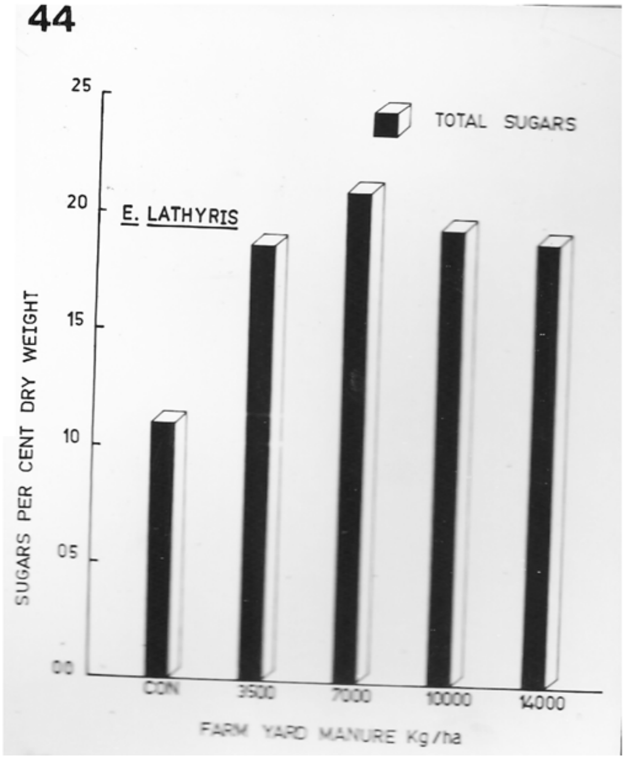

Figure 4 ***Effect of different dosage of farm yard manure (3,500 to 14,000 kg/ha) on sugar contents in above ground parts of E. lathyris L. expressed in percent dry weight basis. CON – Control, without farm yard manure supplement.***

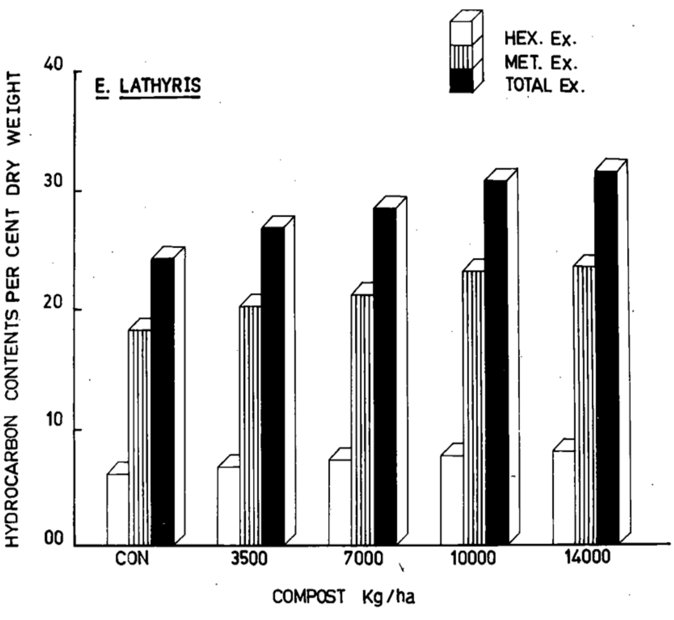

Figure 5 ***Effect of different dosages of compost (3,500 to 14,000 kg/ha) on plant height, above ground and under ground fresh weight and dry weight of E. lathyris. L. CON– Control, without compost supplement.***

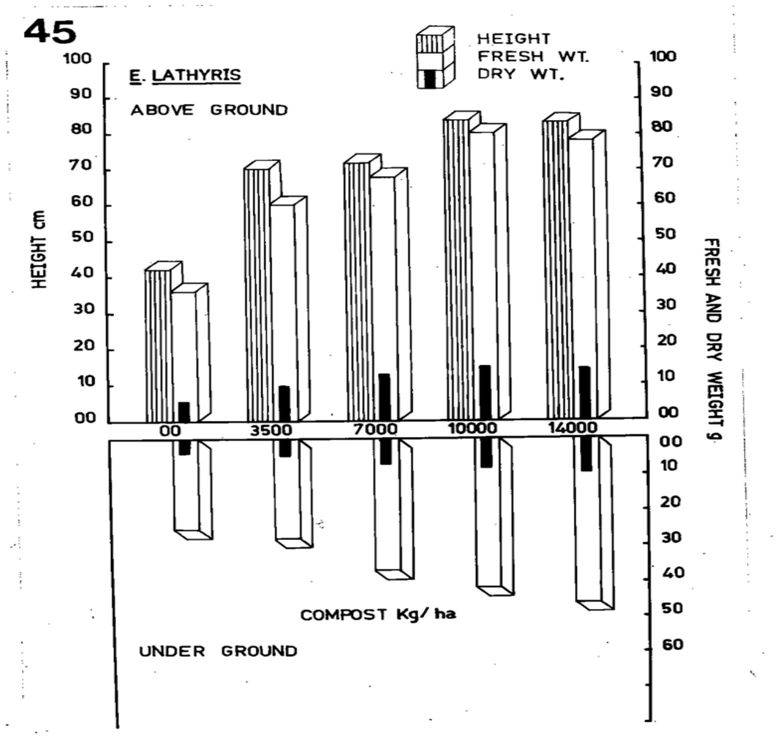

Figure 6 ***Effect of different dosages of compost (3,500 to 14,000 kg/ha) on hexane, methanol and total extractables in above ground parts of E. lathyris L. expressed in percent dry weight basis. CON – Control, without compost supplement.***

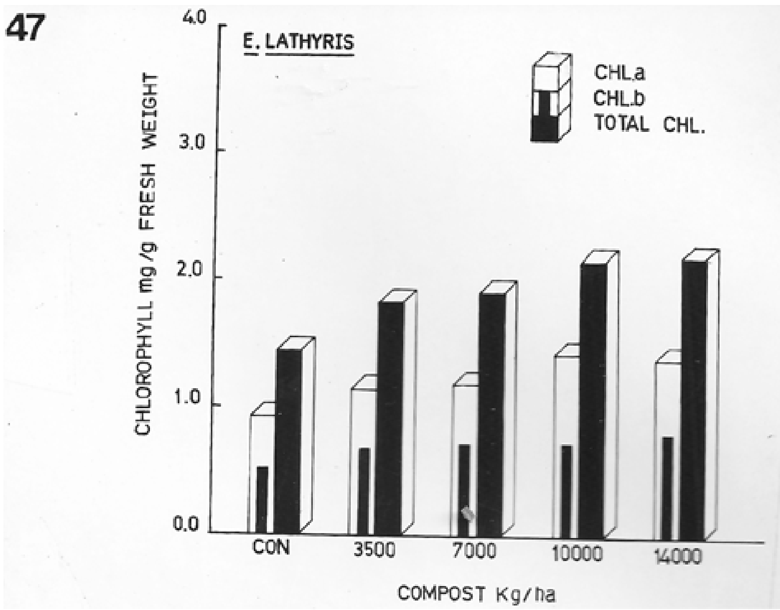

Figure 7 ***Effect of different dosages of compost (3,500 to 14,000 kg/ha) on chlorophyll a, chlorophyll b and total chlorophyll expressed in mg/g fresh weight basis. CON – Control, without compost supplement.***

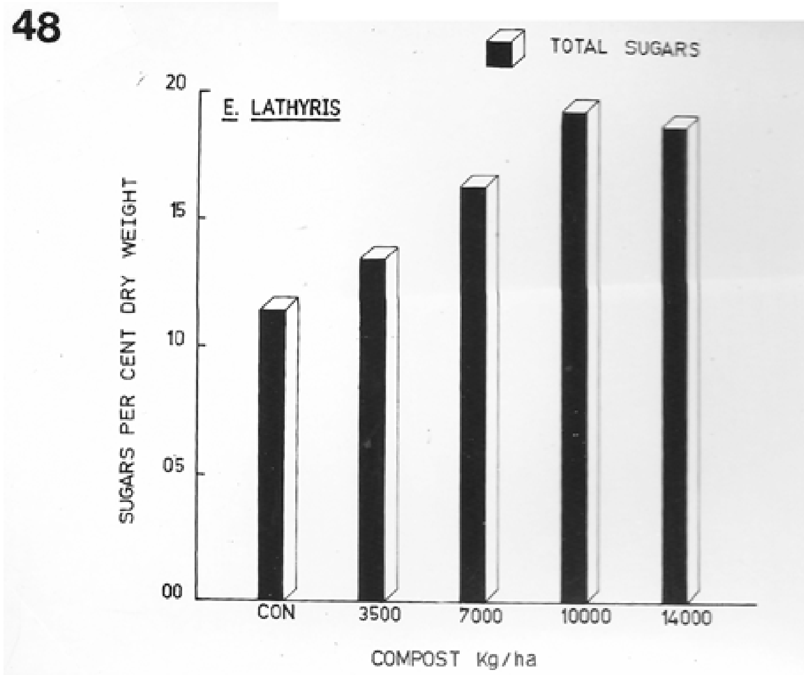

Figure 8 ***Effect of different dosages of compost (3,500 to 14,000 kg/ha) on sugar contents in above ground parts or E. lathyris L. expressed in percent dry weight basis. CON – Control, without compost supplement***

DISCUSSION

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. P 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.

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,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 ruled out.

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 extractables, methanol extractables, chlorophyll contents and sugar contents due to addition of P present in organic manures 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 by adding organic manures.

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. The response of N also depend on how well the crop is supplied with other nutrients (Gartner, 1969). 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 Boron application reduced the chlorophyll components 'a', 'b' and total chlorophyll at higher concentrations in peanut (Shankaran *et al.,* 1973). 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 N 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. B 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 B to support plant growth, whilst values above 5.0 ppm may be toxic (Reisenauer *et al.,* 1973). 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-versa (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; Boardman, 1975). In cu deficient plants the protein synthesis is disturbed and there is a build up of soluble amino-N-compounds (Possingham, 1956). In young growing organs, where protein synthesis is most active, lower levels of DNA have been observed in

Cu deficient tissues (Ozolina and Lapina, 1965). The level of reducing sugars also declined, whilst organic acids and asparagine accumulated (Brown *et al.,* 1958). 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). 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). Mn 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). Zinc in the soils is usually present in the range 10 to 300 ppm occurring 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). Zn deficiency caused sharp decrease in the level of RNA and ribosome content of cells (Price *et al.,* 1972). Thus reduction in RNA synthesis leads to an inhibition of protein formation whilst glucose, nonprotein N and DNA are relatively increased (Price *et al.,* 1972).

Praske and Plocke (1971) have observed extremely unstable cytoplasmic ribosomes in *Euglena gracilis* with Zn deficiency. Zn is required in the synthesis of tryptophan (Tsui, 1948), a precursor of Indole-3yl-acetic acid. In Zn 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 Zn has a possible role in plant metabolism involved in search formation. Molybdenum 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 Qullette, 1973). Mo largely occurs in the soil as an oxycomplex (MoO_4^{2-}) and is adsorbed 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

Activity of the intrate-reductase in cauliflower was reported to 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).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).

Summary

Farm yard manure- Different dosages of farm yard manure (3500, 7,000, 10,000 and 14,000 kg/ha) were added in the soil. Maximum increase in above ground fresh weight and dry weight, per cent dry weight; hexane extractables , methanol extractables , total hydrocarbon extractables(hexane extractables and methanol extractables); chlorophyll a, chlorophyll b and total

chlorophyll contents were recorded at 14,000 kg/ha of farm yard manure. Maximum under-ground fresh and dry weights were recorded at 10,000 kg/ha. Maximum sugar contents were recorded at 7,000 kg/ha of farm yard manure.

COMPOST- Different concentrations of compost from 3,500 to 14,000 kg/ha were added to the soil. Addition of compost up to 10,000 ka/ha increased the plant height, above ground fresh and dry weights, chlorophyll a and total sugar contents. Maximum under-ground fresh and dry weights, under-ground percent dry weight; chlorophyll b content, total chlorophylls; hexane extractables, methanol extractables and total hydrocarbon contents(hexane extractables, methanol extractables) were maximum at 14,000 kg/ha of compost.

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.

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