Effect of Different Soil Types on Plant growth in *Jatropha:* A Biodiesel Plant

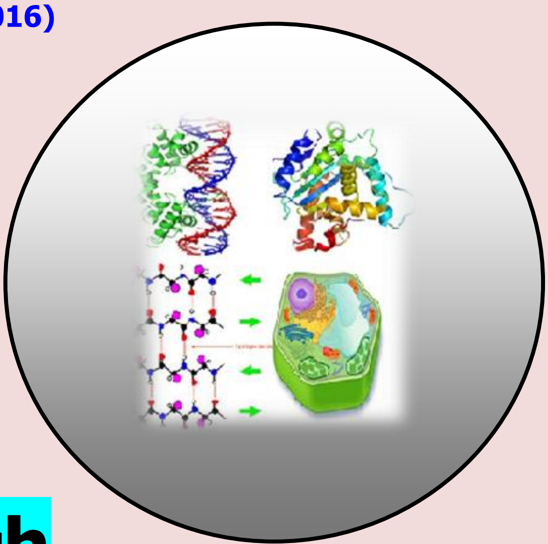
By

Sapna La'Verne, P.K. Tandon and V. Rai

ISSN 2319-3077 Online/Electronic
ISSN 0970-4973 Print

UGC Approved Journal No. 62923
MCI Validated Journal
Index Copernicus International Value
IC Value of Journal 82.43 Poland, Europe (2016)
Journal Impact Factor: 4.275
Global Impact factor of Journal: 0.876
Scientific Journals Impact Factor: 3.285
InfoBase Impact Factor: 3.66

J. Biol. Chem. Research
Volume 35 (2) 2018 Pages No. 339-348



Journal of Biological and Chemical Research

An International Peer Reviewed / Referred Journal of Life Sciences and Chemistry

Indexed, Abstracted and Cited in various International and National Scientific Databases

Published by Society for Advancement of Sciences®

J. Biol. Chem. Research. Vol. 35, No. 2: 339-348, 2018
(An International Peer Reviewed / Refereed Journal of Life Sciences and Chemistry)
Ms 35/02/4050/2018
All rights reserved
ISSN 2319-3077 (Online/Electronic)
ISSN 0970-4973 (Print)

Sapna La'Verne, P.K. Tandon and V. Rai
http:// www.sasjournals.com
http:// www.jbcr.co.in
jbiolchemres@gmail.com

RESEARCH PAPER

Received: 10/06/2018 **Revised: 18/06/2018** **Accepted: 20/06/2018**

Effect of Different Soil Types on Plant growth in *Jatropha:* A Biodiesel Plant

Sapna La'Verne, P.K. Tandon and V. Rai
Department of Botany, University of Lucknow, Lucknow, 226007, U.P., India
Department of Geology, University of Lucknow, Lucknow, 226007, U.P., India

ABSTRACT

Agriculture is one of the most important components of our society. Soil is a critical part of successful plant growth and is the original source of the nutrients that are required for healthy growth of plants. In India, different types of soils are found and they differ widely in their physico-chemical characteristics. Clay pots were used to carry experiment in order to study the effect of different soil types on plant growth in Jatropha: a biodiesel plant. The different soils used were Alluvial, Mountain, Desert and Red soil. These four different soil types showed lot of variation in plant growth pattern which are dicussed in the light of physico chemical properties of soil. The present paper summarizes the results.
Key words: Soil, Jatropha curcus and Plant growth.

INTRODUCTION

Soil is the thin layer of material covering the earth's surface and is formed from the weathering of rocks. It is made up mainly of mineral particles, organic materials, air, water and living organisms-all of which interact slowly yet consistently. Soil provides a base which the roots hold on to as plant grows. It also provides plants with water and essential nutrients for their healthy growth. Healthy soil results in a more stable plant growth. Climate directly and indirectly affects the formation of the soil. Different soil types differ in their properties resulting in the variation in plant growth pattern. How well the plant grows depends upon the soil types and the way they support the plants. Soil is a product of the influence of climate, geographic factors, organisms and its parent materials (original minerals) interacting over times (Gilluly et al, 1975).

Jatropha curcus is a perennial shrub with spreading branches and stubby twigs, with a milky or yellowish exudates belonging to the Euphorbiaceae or Spurge family. Leaves are deciduous , alternate but apically crowded , ovate , acute to acuminate , basally cordate , 3 to 5 lobed in outline , 6-40 cm long , 6-35 cm broad and petioles 2.5-7.5 cm long. The name is derived from Greek words, jatros= physician and trophe = nutrition hence the common name is physic nut. It grows well under adverse climatic conditions because of its low moisture demands, fertility requirements and tolerance to high temperature. Its cultivation is uncomplicated.

Jatropha curcus which is an important petro crop grows in tropical and subtropical regions. There are a number of alternative sources of energy and environmentally friendly fuels available to combat the damage of the environment caused by fossil fuels. Since Jatropha is considered to be an important alternative to fossil fuel hence this crop is taken for this study.

MATERIALS AND METHODS

Experiments were conducted in pot culture under the natural environmental conditions in replicates. The plant *Jatropha curcus* was grown in earthen pots having different types of soils namely Alluvial, Mountain, Desert and Red.

The soils collected from different places were dried, powdered and further purified with the help of sieve. A drainage hole was made in these containers for leaching purpose and covered with inverted piece of watch glass. Optimum quantities of soils were filled in pots. The ordinary tap water was supplied a couple of times in a week to the plants as per the requirement. Vegetative growth was assessed at monthly intervals spanning for twenty five months. The growth was assessed in terms of height of plant and diameter of stem.

The following analysis was done in four different types of soil viz. Alluvial, Mountain, Desert and Red soil respectively. The estimation of $CaCO_{3,}$ pH, Organic matter and EC in the soil samples were measured by the method of (Jackson,1973) and DTPA was estimated by the method of (Lindsay and Narvell,1978).

The statistical analysis was done using SPSS (Statistical Package for Social Sciences) Version 15.0 statistical Analysis Software. The values were represented in Number (%) and Mean±SD.The following Statistical formulas were used:

(a) Mean: $\overline{X} = \dfrac{\Sigma X}{\text{No. of observations (n)}}$

(b) Standard Deviation: If a sample is more than 30 then $\sigma = \sqrt{\dfrac{\Sigma(X-\overline{X})^2}{n}}$

When sample is less than 30 then.

$$\sigma = \sqrt{\frac{\Sigma(X-\overline{X})^2}{n-1}}$$

(c)Analysis of Variance: Analysis of Variance (ANOVA):

$$F = \frac{\text{Mean of Sum of Between Group Differences}}{\text{Mean of Sum of within Group Differences}}$$

(d)Post-Hoc Tests (Tukey-HSD)

(e)Level of significance: "p" is the level of significance

RESULT AND DISCUSSION

During the first month, mean plant height (Table 1) (Fig.-1), (Fig.-2),(Fig.-3), (Fig.-4) was found to be minimum for alluvial soil (11.500±1.472 units) and maximum for mountain soil (14.575±2.204), for desert and red soil the mean plant height was 13.325±3.097 and 11.625±2.562 units respectively, however, on comparing the data statistically, no significant intergroup differences could be seen (p=0.266). However, trends started to change from second months onwards and on third month's time, desert soil showed the maximum height while red soil showed the minimum. During fifth month, the mean height in mountain soil was next only to alluvial soil in ascending order while desert soil and red soil had the maximum values. In thirteen months interval the mean height of plants in mountain soil became minimum while alluvial, red and desert soils maintained higher values of this parameter. On twenty fifth month the mean height of plants in desert soil was maximum while that of mountain soil was minimum. After the completion of twenty five months the mean height of plants in different soils was in the following order:

Desert Soil > Red Soil > Alluvial Soil > Mountain soil

The histogram (Fig.5) shows that the mean plant growth showed varied pattern. On the first month, plants in mountain soil showed maximum growth, but on sixth month and twelfth month it was red soil where the maximum growth was seen. But on the completion of eighteen months and twenty four month desert soil showed maximum growth. However, at none of the above time intervals, there was a statistically significant difference among the groups. At the completion of first month, the mean stem diameters (Table-2) ranged between 0.663±0.118 sq units (red soil) to 0.907±0.029 (mountain soil) while the mean stem diameter of alluvial and desert soil remained in between.

On comparing the data statistically, a significant difference among the groups was seen (F=5.271; p=0.015). However, at the completion of second month, it was the desert soil that had the stem with maximum mean diameter (1.191±0.078) while the mean stem diameter of mountain soil (1.036±0.094) was minimum thus showing a complete reversal from first month interval findings, however, at this point of time there was no statistically significant difference amongst the groups (F=2.252; p=0.135).

Figure 1. Thirteen months old plants of *Jatropha curcus* sown in Alluvial soil.

Figure 2. Thirteen months old plants of *Jatropha curcus* sown in Mountain soil.

Figure 3. Thirteen months old plants of *Jatropha curcus* sown in Desert soil.

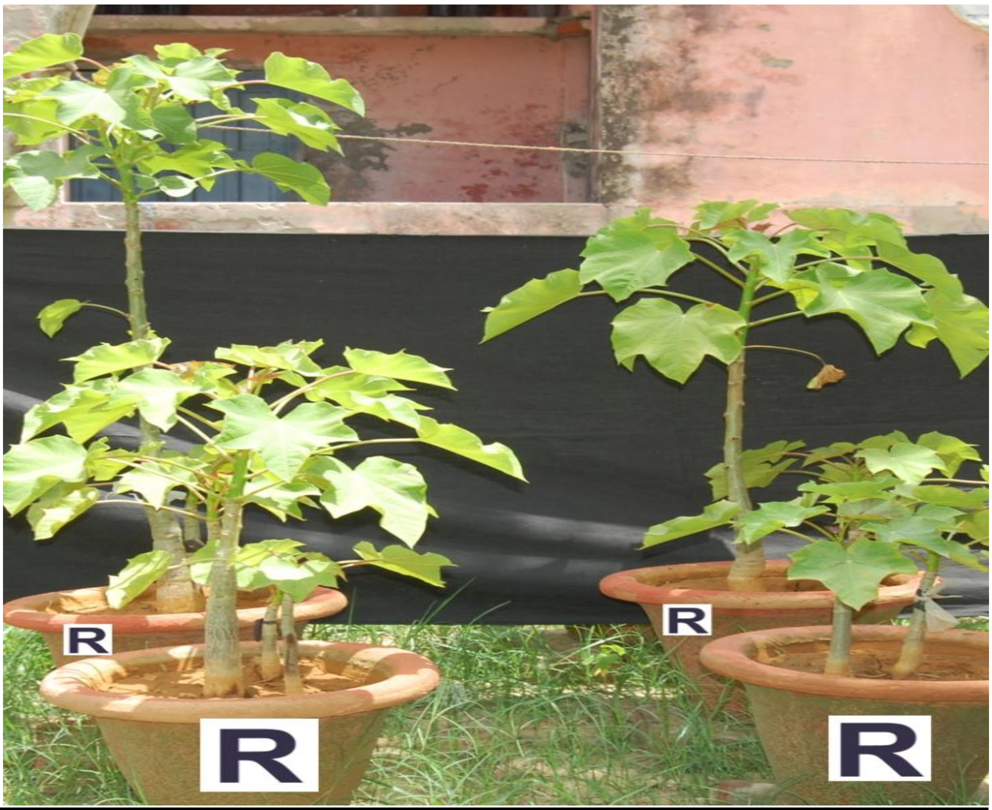
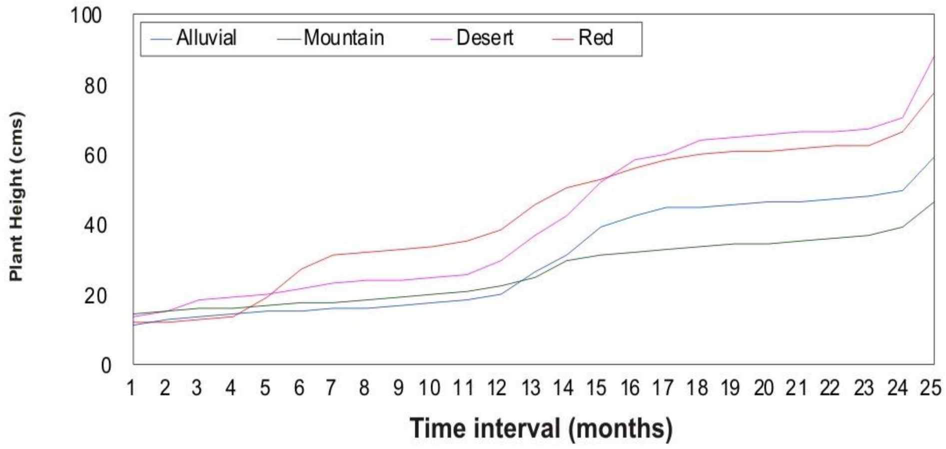


Figure 4. Thirteen months old plants of *Jatropha curcus* sown in Red soil.

Indexed, Abstracted and Cited in Indexed Copernicus International and 20 other databases of National and International repute



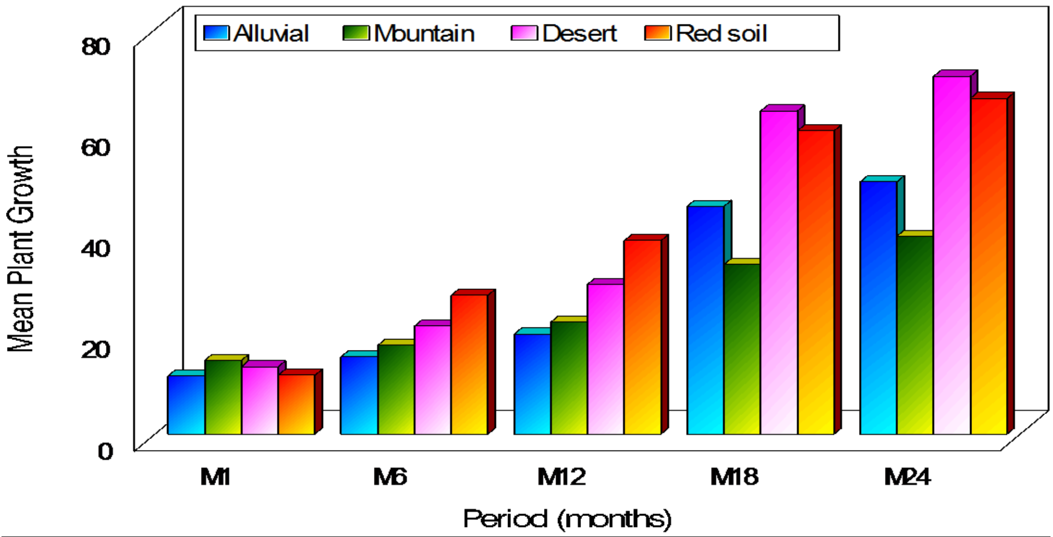
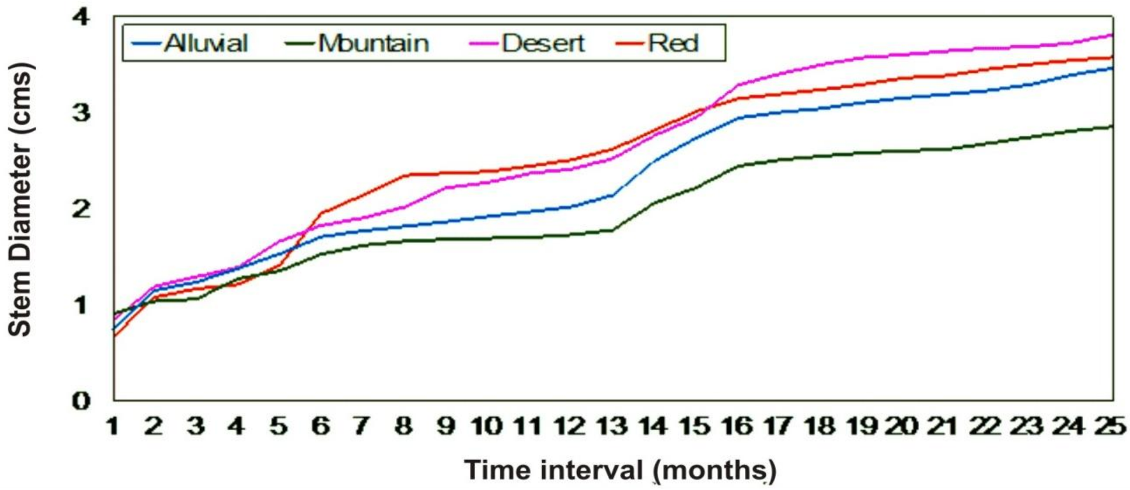


Figure 5. Comparative study of different soils on the height of *Jatropha curcus*



Indexed, Abstracted and Cited in Indexed Copernicus International and 20 other databases of National and International repute

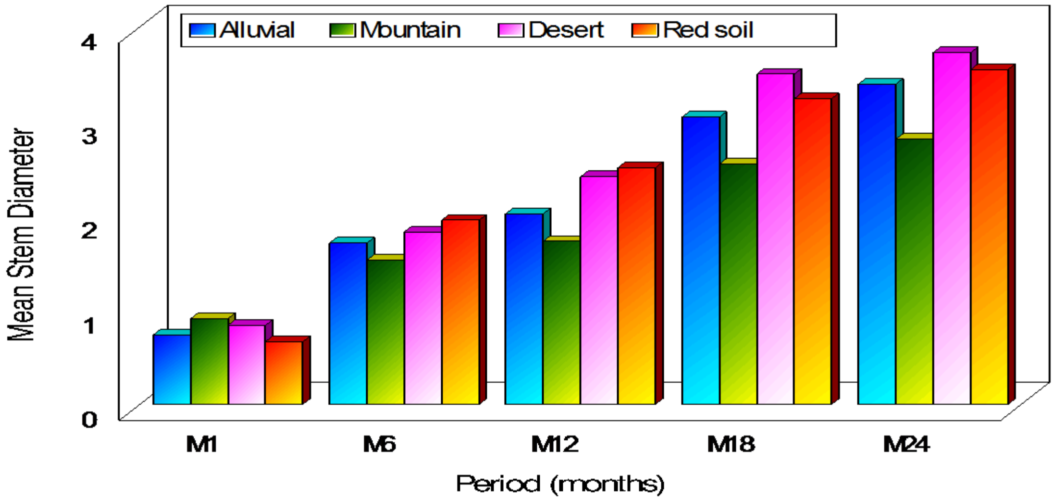


Figure 6. Comparative study of different soils on stem diameter of *Jatropha curcus.*

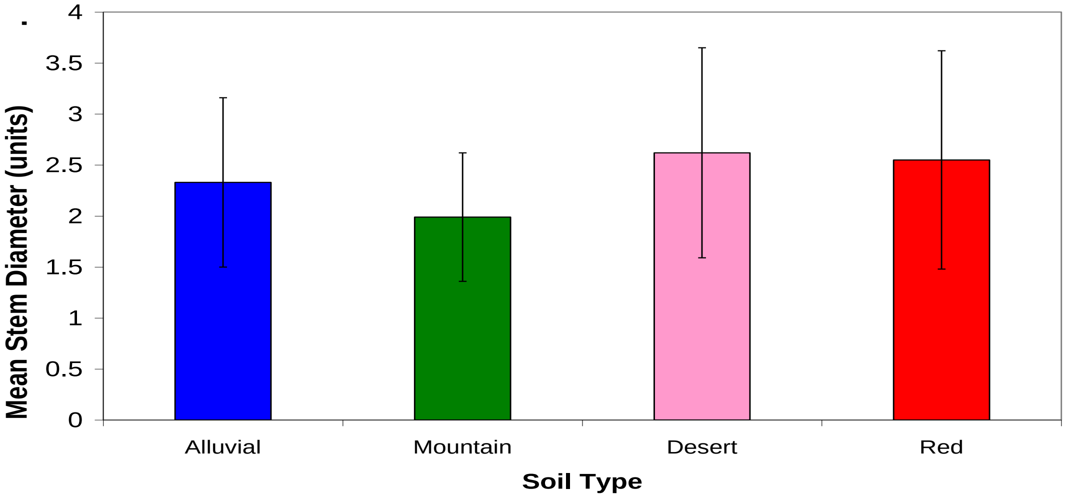


Figure 7a. Comparison of stem diameter of Jatropha curcus in different groups

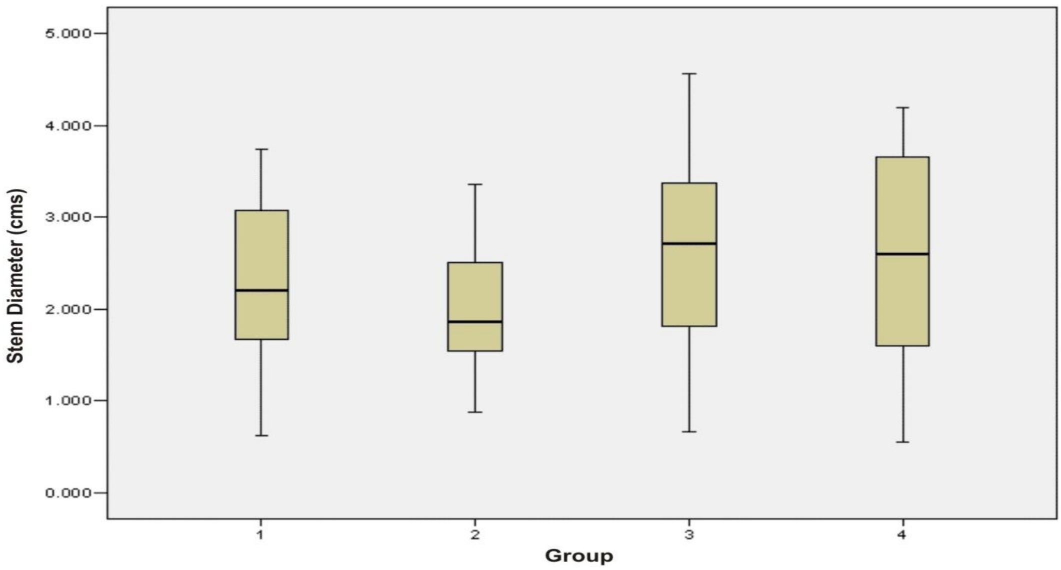


Figure 7b. Multiple comparison of stem diameter of *Jatropha curcus* in different groups.

Table 1. Plant growth at different time intervals (Height of Plant in cms).

S. No.	Time interval (months)	Alluvial (n=4)		Mountain (n=4)		Desert (n=4)		Red soil (n=4)		F	"p"
		Mean	SD	Mean	SD	Mean	SD	Mean	SD		
1	1	11.500	1.472	14.575	2.204	13.325	3.097	11.625	2.562	1.493	0.266
2	2	12.875	1.931	15.250	2.327	15.150	4.315	12.000	2.972	1.168	0.362
3	3	13.825	2.011	15.650	2.228	17.950	3.283	12.550	3.226	2.916	0.078
4	4	14.225	2.082	16.275	2.288	18.850	3.961	13.650	3.722	2.266	0.133
5	5	14.875	1.931	16.975	2.037	19.675	4.605	19.050	10.917	0.511	0.682
6	6	15.300	1.878	17.550	2.222	21.375	6.047	27.450	17.291	1.314	0.315
7	7	15.750	1.848	17.825	2.211	23.000	8.278	31.125	20.994	1.450	0.277
8	8	16.250	1.636	18.450	2.170	23.650	8.278	32.075	21.273	1.498	0.265
9	9	16.625	1.797	19.000	2.198	24.125	8.230	32.750	21.469	1.519	0.260
10	10	17.250	1.848	19.750	2.217	24.900	8.176	33.375	21.395	1.523	0.259
11	11	18.050	2.092	20.500	1.826	25.500	8.114	35.250	21.129	1.782	0.204
12	12	19.750	2.630	22.125	1.702	29.625	6.957	38.250	22.187	2.025	0.164
13	13	26.000	1.414	24.800	0.812	37.125	9.852	45.750	24.676	2.221	0.138
14	14	30.875	3.065	29.625	1.493	42.625	12.632	50.000	26.118	1.787	0.203
15	15	39.250	4.941	31.375	3.637	52.250	17.500	52.750	26.323	1.680	0.224
16	16	42.500	5.323	32.000	3.536	58.250	21.747	56.000	26.758	1.963	0.173
17	17	44.425	5.977	32.650	3.458	59.875	22.717	58.125	27.888	1.946	0.176
18	18	45.025	5.854	33.525	3.322	63.875	26.939	59.975	28.584	1.970	0.172
19	19	45.500	5.874	34.025	3.347	65.025	26.865	60.500	28.769	2.023	0.164
20	20	46.125	5.706	34.625	3.250	65.625	26.681	61.125	28.727	2.043	0.162
21	21	46.625	5.706	35.500	3.082	66.125	26.681	61.625	28.727	2.001	0.168
22	22	47.200	5.952	35.925	3.102	66.525	26.565	62.025	28.731	1.995	0.169
23	23	47.875	5.977	36.625	3.351	66.875	26.578	62.625	28.753	1.953	0.175
24	24	49.875	6.142	39.125	4.049	70.750	26.900	66.375	30.701	2.004	0.167
25	25	58.875	7.465	46.000	5.715	88.250	31.192	77.200	32.330	2.687	0.094

SD=Standard Deviation, n=No. of observation, F=F ratio, p=significance

Table 2. Stem growth at different time intervals (Diameter of stem in cms).

S. No.	Time interval (months)	Alluvial (n=4)		Mountain (n=4)		Desert (n=4)		Red soil (n=4)		F	"p"
		Mean	SD	Mean	SD	Mean	SD	Mean	SD		
1.	1	0.735	0.079	0.907	0.029	0.837	0.120	0.663	0.118	5.271	**0.015**
2.	2	1.149	0.055	1.036	0.094	1.191	0.078	1.078	0.129	2.252	0.135
3.	3	1.235	0.105	1.056	0.084	1.290	0.100	1.165	0.127	3.695	**0.043**
4.	4	1.376	0.141	1.272	0.178	1.387	0.261	1.209	0.145	0.834	0.501
5.	5	1.529	0.073	1.351	0.135	1.659	0.381	1.412	0.252	1.275	0.327
6.	6	1.708	0.105	1.526	0.122	1.826	0.441	1.951	0.489	1.141	0.372
7.	7	1.768	0.122	1.616	0.127	1.903	0.429	2.141	0.581	1.438	0.280
8.	8	1.816	0.173	1.659	0.107	2.019	0.448	2.346	0.650	2.124	0.151
9.	9	1.862	0.187	1.680	0.105	2.217	0.555	2.370	0.642	2.100	0.154
10.	10	1.918	0.216	1.690	0.108	2.274	0.545	2.386	0.649	2.121	0.151
11.	11	1.966	0.211	1.700	0.109	2.366	0.505	2.442	0.615	2.819	0.084
12.	12	2.019	0.213	1.727	0.133	2.411	0.513	2.508	0.650	2.786	0.086
13.	13	2.141	0.150	1.778	0.123	2.523	0.543	2.620	0.680	2.986	0.074
14.	14	2.499	0.255	2.060	0.076	2.764	0.325	2.817	0.723	2.739	0.090
15.	15	2.738	0.240	2.220	0.129	2.950	0.339	3.014	0.834	2.345	0.124
16.	16	2.946	0.362	2.442	0.223	3.288	0.706	3.147	0.901	1.471	0.272
17.	17	3.004	0.324	2.508	0.228	3.404	0.669	3.193	0.879	1.701	0.220
18.	18	3.043	0.310	2.547	0.263	3.499	0.676	3.238	0.890	1.829	0.196
19.	19	3.106	0.329	2.580	0.262	3.574	0.725	3.296	0.907	1.845	0.193

20.	20	3.155	0.294	2.602	0.244	3.604	0.704	3.363	0.923	1.959	0.174
21.	21	3.190	0.264	2.617	0.235	3.643	0.667	3.386	0.924	2.137	0.149
22.	22	3.231	0.238	2.680	0.284	3.672	0.663	3.453	0.910	2.065	0.158
23.	23	3.291	0.260	2.743	0.319	3.685	0.663	3.503	0.918	1.836	0.194
24.	24	3.392	0.272	2.808	0.329	3.726	0.584	3.546	0.914	1.859	0.190
25.	25	3.465	0.306	2.855	0.366	3.811	0.583	3.577	0.902	1.925	0.179

SD=Standard Deviation, n=No. of observation, F=F ratio, p=significance

Table 3. Comparison of stem diameter in different groups.

S.No.	Group	No. of observations	Mean (cms)	SD
1.	Alluvial	100	2.33	0.83
2.	Mountain	100	1.99	0.63
3.	Desert	100	2.62	1.03
4.	Red	100	2.55	1.07

Analysis of Variance

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	24.510	3	8.170	9.952	<0.001
Within Groups	325.082	396	.821	----------	-----------
Total	349.592	399	-----------	------------	-------------

df=degree of freedom, F=F ratio

Table 4. Properties of specimen of soil varieties studied.

SN	Property	Soil Type			
		Alluvial	**Mountain**	**Desert**	**Red**
Physical Properties					
1.	pH (1:2 H_2O)	8.02	7.22	7.5	8.33
2.	EC_2 (dsm^{-1})	0.23	0.25	0.54	0.25
3.	$CaCO_3$ (%)	1	1.25	2	1.5
4.	OC (%)	1.005	0.124	0.067	0.402
Nutrient Concentration (ppm)					
1.	Zn	0.408	1.036	0.446	0.662
2.	Fe	6.064	9.064	4.488	13.35
3.	Mn	7.3	18.42	7.3	37.22
4.	Cu	0.256	0.116	0.418	0.026
5.	S	112	88	72	92

The stem diameter recorded at an interval of thirty days in different soils is presented in (Table 2).

On the completion of third month, once again the mean stem diameter of desert soil (1.290 ± 0.100) was maximum while that of mountain soil (1.036 ± 0.094) was minimum. At this time interval, statistically significant differences were seen amongst the groups (p=0.043). At the subsequent time intervals though slight change in growth pattern was seen yet it was not found to be significant. On the completion of twenty fifth month, the mean stem diameter of desert soil (3.811 ± 0.583) was maximum while that of mountain soil was minimum (2.855 ± 0.366) yet the difference amongst the groups were not significant (F=1.925; p=0.179). The histogram (Fig 6) shows that at all time intervals mean stem diameter of desert soil specimen was maximum, however, except for first month the minimum value was obtained for mountain soil. On the first month the minimum value was obtained for red soil. However, the differences in stem diameter of different soil types were found to be statistically significant only at one month, at none of the other time intervals the intergroup differences were found to be statistically significant.

As we have been encountering differences in the mean values yet there was no statistically significant difference among the groups, the data was compared with cumulative observations, thus for 25 observations of 4 replicates of each series the sample size became 100. The analysis of cumulative data is given under (Table 3). The comparisons of stem diameters in different soils are depicted in Fig 7a and Fig. 7b.

Analysis of variance revealed statistically significant differences amongst the groups ($p<0.001$). On applying post-hoc tests, significant differences were seen between Mountain soil and all the other three soils ($p<0.05$). No statistically significant difference was seen when Alluvial, Desert and Red soils were compared with each other ($p>0.05$).

The properties of the different soils taken for the present research work are depicted in (Table-4).

It has been observed by the review of various earlier literatures that soil properties and nutrient concentration plays a very important role in the growth of *Jatropha curcus* plant which likes sunlight and hates water logging. Therefore proper soil texture, proper pH and ample calcium carbonate are critical for *Jatropha curcus* plantation. This plant although can grow outside its natural habitat but it can survive extreme conditions of dryness.

The present study of growth of *Jatropha curcus* was in the decreasing order i.e. desert > red > alluvial > mountain. This finding supports the previous studies that in more alkaline conditions the nutrients are less available, and symptoms of nutrient deficiency may result, thin plant stem, yellowing or mottling of leaves, a slow and stunted growth. Thus alluvial and mountain soils being alkaline in nature as compared to desert and red soil had less nutrients resulting in restricted growth.

This study also supports that the increased percentage of $CaCO_3$ also results in better growth. When Calcium carbonate incorporated nutrient solution containing ammonium sulphate was added to sand in pots it resulted in improved growth of tea plants and the toxicity effects of ammonium ions were completely eliminated. *Jatropha* plants sown in desert soil perform the best growth as its $CaCO_3$ percentage is highest.

Growth suppression was already reported by several workers (Dixit et al., 2001; Ali et al.,2001; Gupta et al.,2003;Liao et al., 2003; Martha et al., 2004; Singh et al., 2006). The main factor responsible for reduced growth of plant is probably associated with transport of essential nutrient including Zn, K, Fe, Mg etc. The essential metal, such as Zn, plays a significant and unique role in stabilizing protein. Zn also plays a role in the biosynthesis of growth hormone viz. Auxin. Thus deficiency of Zn in alluvial soil might be a reason of suppressed growth.

Zinc as one of the essential micronutrients in plants which is necessary for plant growth and development. However, excessive Zn in plants can profoundly affect normal ionic homeostatic systems by interfering with the uptake, transport, osmosis and regulation of essential ions and results in the disruption of metabolic processes such as transpiration, photosynthesis and enzyme activities related to metabolism (Rout and Das, 2003).

Growth inhibition is a general phenomenon associated with most of heavy metals, while the tolerance limits for heavy metal toxicity are specific for each species and even variety of cultural plants (Broadley et al., 2007). Being an essential micronutrient, zinc may promote the growth of *Jatropha* seedlings, when present at lower concentrations, but if present at high levels, zinc inhibited growth by interfering with normal cellular metabolic events and inducing visible injuries and physiological disorder, as are reported by (La'Verne, 2010) and other workers (Ali et al., 1999; Kaya et al., 2000). The first visible damage due to excessive zinc was on root growth due to reduction in cell division (Prasad et al., 1999).

In the present study the decrease in area, plant growth and stem diameter were observed in high concentration of Zn, the decrease in growth and stem diameter was observed. Thus our results suggested that Jatropha seedlings showed a negative response to higher Zn toxicity, possibly through the enhancement of ROS production, which in turn led to the oxidative damage to plant cells and blocked the growth. In all the four soils taken viz. alluvial, mountain, desert and red, maximum reduction of shoot length was recorded in mountain soil. On the basis of the soil analysis these results may be inferred due to high values of pH. However mountain and alluvial soil showed restricted growth. The decreasing order of growth of *Jatropha curcus* in different soil was - Desert > Red > Alluvial > Mountain.

On the basis of earlier studies it may be interfered that desert soil having maximum $CaCO_3$ results in producing best growth. A general trend of reduction in shoot length was in response to the high concentration of Zn in soil. Mountain soil having maximum concentration of Zn results in minimum growth as recorded in earlier researches.

Indexed, Abstracted and Cited in Indexed Copernicus International and 20 other databases of National and International repute

The results also depict that concentration of Cu plays a direct role in growth of *Jatropha curcus.* Mountain soil has less concentration of Cu which resulted in less growth whereas desert soil having maximum concentration of Cu results in maximum growth of this plant.

ACKNOWLEDGEMENTS

First author is thankful to Prof. (Dr.) P.K. Tandon and Prof. (Dr.) Vibhuti Rai for their valuable guidance and important suggestions in writing this paper. Authors are also thankful to the Head, Department of Botany, Lucknow University, Lucknow for providing necessary laboratory facilities for this work.

REFERENCES

Ali, G., Srivastava, P. S. and Iqbal, M. (1999). Morphogenic and biochemical responses of *Bacopa monniera* cultures to zinc toxicity. *Plant Sci*., **139**:1-7.

Ali, A. M. A., and Spiegel, J. V. (2001) . "Acoustic- phonetic features for the automatic classification of fricatives." *Acoust. Soc. Amer.*, **109,** p.p 2217-2235.

Broadley, M. R., White, P. J., Hommond, J. P., Zelko, I. and Lux, A.(2007).) Zinc in plant. *New Phytol*., 173: 677-702 .

Dixit, Vivek, Pandey, Vivek and Radhey, S. (2001).) Differential anti- oxidative response to cadmium in roots and leaves of pea (*Pisum sativum* L. Cv. Azad). *Journal of Experimental Botany,* **52** (358), 1101-1109.

Gilluly, Waters, J., Clement, A., Woodford and Oswald, A. (1975). *Principles of geology (4th ed.).*San Francisco, California: W.H. Freeman. ISBN 978-0716702696.

Gupta, S. S., Ton, V. K., Beudry, V. and Rulli, S.(2003). Antifungal activity of amiodarone is mediated by disruption of calcium homeostasis. *J.Biol Chem* 278(31):28831-9.

Jackson, M. L. (1973). Soil chemical analysis. Pentice hall of India, Pvt. Ltd., New Delhi.

Kaya, C., Higgs, D. And Burton, A. (2000). Plant growth, phosphorus nutrition and acid phosphatase enzyme activity in three tomato cultures grown hydroponically at different zinc concentration. *J. Plant Nutr.,* **23**: 569-579.

Lindsay, W. L. and Narvell, W.A.(1978). Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Sci. Soc. American J.,* 42: 421-428.

Liao, B. H., Liu, H. Y., Lu, S. Q., Wang, K. F., **Probst, A. and Probst, J. L. (**2003).) Combined toxic effects of Cadmium and acid rain on Vicia faba L.Bull. *Env. Cont. Toxicol*. **71**, 998-1004.

La'Verne, S. (2010). Impact Analysis of Soils on the Growth Performance and Physiology of Jatropha .Ph.D. Thesis, Lucknow University, Lucknow.

Marta, A., Filipe, L., Montana, P., Cristina, M., Joaquen, C., Hernandez, Jose L. and Bonedito. (2004).) Interaction between toxic (As, Cd, Hg, Pb) and nutritional essential elements (Ca, Co, Cr, Cu, Fe, Mn, Mo, Ni, Se, Zn) in the tissue of Cattle NW Spain. *Biometals,* **17**, 389-397.

Prasad, K. V. S. K., Saradhi, P. P. and Sharmila, P. (1999). Concerted action of antioxidant enzymes and curtailed growth under zinc toxicity in *Brassica Juncea*.*Environ. Exp, Bot*., **42**: 1-10.

Rout, G. R., and Das, P. (2003). Effect of metal toxicity on plant growth and metabolism. *I. Zinc. Agron*. **23**:3-11

Singh, A. K., Mishra, P. and Tandon, P. K. (2006). Phytotoxicity of Cr in paddy (*Oryza sativa*) plants.*Journal of Environmental Biology* 27 (2) 283-285.

Corresponding author: Dr. Sapna La'Verne, Department of Botany, University of Lucknow, Lucknow, 226007, U.P., India

Email: sapna.laverne@rediffmail.com

Indexed, Abstracted and Cited in Indexed Copernicus International and 20 other databases of National and International repute