Toxicity of Thallium to Plant

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Abstract:

In the present work,the toxicity of thallium to plant was investigated by means of the critical level (TC) and lethal concentration (LC) of thallium in ***Lolium perenne***. The concentrations were found to effect on growth of plant as following :

Sample	TC (mg/kg)	LC (mg/kg)
Roots	0.35	0.75
Shoots	0.0004	0.0008

The results of analytical laboratory indicate that the thallium ion accumulates in roots to prevent it´s arrival to shoots inorder to decrease toxicity . It was observed that the concentration of thallium in roots equal to 1000 multiple by the it´s concentration in shoots .

Introduction:

Thallium in the environment can reach toxic levels in living organism by accumulation, i.e. by building up over period of time [1]. Although traces of certain heavy metals are essential as key components of enzyme systems, other heavy metals, however, may be compete for these site and cause deformation in and inhibit enzyme system [2]. Enzyme have active groups such as amino, and sulphydryl types which have great affinity for the more electronegative metals. The greater electronegativity of the inhibitor metals, as well as the more stable metal chelate so formed, then the from particular stable bonds with soft donor [4]. There are five factors which influence the toxicity of trace metals such as form of metal [5], presence of the metals or poisons [6], physical factors [7] and factors influencing uptake of metal ions by living cell [8].

In plant systems, the toxicity of metal ions and the rate of uptake by plants depends upon their solubility in solution [9].

Table (1) Classification of acceptor and donor electrons (R = alkyl or aryl)

Hard acid	Border line	Soft acid
H^{+}, Na^{+}, K^{+}, Be^{+2}, Mg^{+2}, Ca^{+2}, Mn^{+2}, Al^{+3}, Cr^{+3}, Co^{+3}, Fe^{+3}, As^{+3}	Fe^{+2}, Co^{+2}, Ni^{+2}, Cu^{+2}, Zn^{+2}, Pb^{+2}	Ag^{+}, Cu^{+}, Ti^{+}, Hg^{+2}, RHg^{+}

In general, the toxicity of thallium on living organism originate from:

i) Effect on transport mechanisms [10].
ii) Reduction of mitosis [11].
iii) Oxidation of TI (I) to TI (III) which inhibits the AT-pase of amine – strong granales, thus causing alteration in the catecholamine metabolism [12].
iv) Thallium (I) is able to substitute monovalent cations particulary potassium in enzyme reactions [13]. Thallium is isomorphic with potassium, but has approximately 10 times higher affinity than potassium for the enzymes. The increased affinity may cause toxic effect [14].

It has been shown that the effect upon yield of a potentially harmful element depends on its concentration in plant tissue [15]. This has been established for several metals in plant [16]. The yield curve reduces to a straight line when the concentration plotted in logarithmic from one line horizontal yield plateau and the other a sloping regression line which meet at the upper critical level (Fig . 1 and 2).

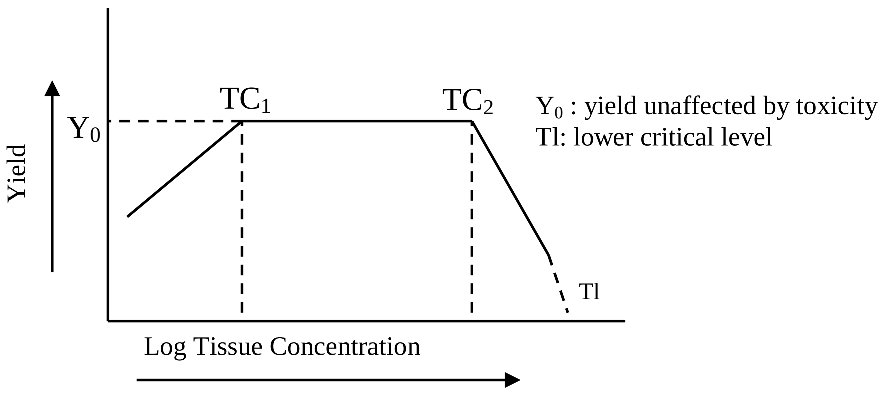
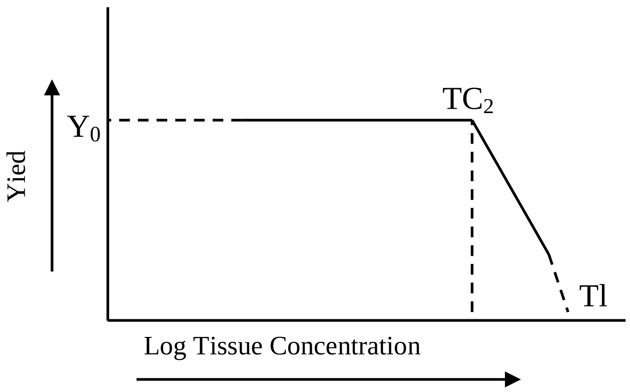


Fig. 1 Yield curve for essential elements



TC_2 : upper critical level
Tl : lethal concentration

Fig.2 Yield curve for non-essential elements

Experimental:

Lolium Perenne which is a relatively hard species of grass was chosen for studying the critical level and lethal concentration of thallium plants. It is very quick grown and hence ideal for this type of study. *Lolium* seeds were germinated in acid wash silver sand placed in a polyethylene potting tray which had rinsed with distilled water to eliminate any chance of metal contamination of the seeding. After ten days of development in the sand, the germinated seedlings were removed from the sand and their roots washed with distilled water. Five seedlings were taken and small strips of sponge wrapped around them at the base of the shoot labeled and left to grow in nutrient solution for one week. Then the roots of plants were cut and the fresh weights of each bunch (Five seedlings) were recorded. The experiment was repeated, thallium nitrate $TINO_3$ was added to the nutrient at different concentration (0, 0.001, 0.005, 0.01, 0.1, 0.5, 1.0, 1.5 and 1.6 µg/ml) and the plants returned to grow for three weeks at room temperature [17].
Every five days a fresh nutrient solution containing thallium was prepared and the old solution discarded. After the end of the third week, the seedlings were removed from the nutrient solution containing thallium was prepared and the old solution discarded the fresh weight and root length
Were recorded. The root and shoot of individual bunches were placed in beakers and left overnight at 50 C^o. Next day the dry weight of each sample was recorded [18].

Results:

Determination of thallium contents of the acid digested samples [19] was carried out using the Varian Atomic Absorption Spectrophotometry(AAS 775) with Graphite Furnace (GTA-95) at the instrumental, parameters and condition listed at Table -2-.
An attempt was made to determine the upper critical level and lethal concentration of thallium in roots and shoots of ***Lolium perenne***. The results obtain are given in Tables -3- and -4-. The yield curves are shown in Figures (3) and (4).

Table (2) Determination of thallium by flame atomic absorption with graphite furnace (AAS-775 with GTA-95)

Step	Temperature (^oC)	Time (sec)	N2 flow L/min	Read
1	75	5.0	3.0	
2	90	6.0	3.0	
3	120	10.0	3.0	
4	200	2.0	3.0	
5	250	5.0	3.0	
6	2200	1.0	0.0	*
7	2200	2.0	0.0	*
8	2200	1.0	3.0	

Wave length = 277 nm
Spectra bandwidth = 0.5 nm
Lamp current = 3.5 ma
Background correction = ON
Sample injection = 20 µl
* = Read signal

Table (3) Thallium concentration in roots and shoots of *Lolium perenne* species

Concentration of thallium (mg/cm^3) in nutrient solution	Dry weight of root (mg)	Concentration of thallium (mg/kg) in root tissue	Log_{10} concentration of thallium in root tissue	Dry weight of shoot (mg)	Concentration of thallium (mg/kg) in shoot tissue	Log_{10} concentration of thallium in shoot tissue
0.00	34.7	N.D	/	279	N.D	/
0.001	34.6	2	0.30	278.8	0.083	-0.6
0.005	34.5	2.92	0.46	278.1	0.125	- 0.90
0.01	34.4	9.0	0.95	277.2	1.00	0.00
0.1	32.55	13.6	1.13	261	1.25	0.10
0.5	23.95	22	1.34	189	1.99	0.30
1.0	13.2	430	2.63	90	32	1.50
1.5	2,4	921	2.96	8	105	2.02
1.6	0.3	1859	3.26	5	244	2.38

N.D (Not Detected)

Table (4) Critical and Lethal Concentrations of Thallium in Roots and Shoots of *Lolium perenne* Species

Concentrations and statistical information	Roots	Shoots
Y_o (mg)	34.7	297
T_c (mg/kg)	0.35	0.75
T_L (mg/kg)	0.0004	0.0008
Correlation Coefficient of Regression line	-0.987	- 0.936
Regression Equation	Y = 34.7 – 21.5X	Y = 279 – 180X
Standard deviation of Y about regression line with (n-2) degrees of freedom	1 – 757	72.31
r-squared = 96.7 per cent,	98.4	81.5
Adjusted for d-f,	98.0	76.8
SS* due to regression	748.65	92,012
MS = SS/df	748.65	92,012
SS due to residual	12.34	20,012
SS due to total	761.08	112,928

SS* = Sum of Square, MS = Mean Square

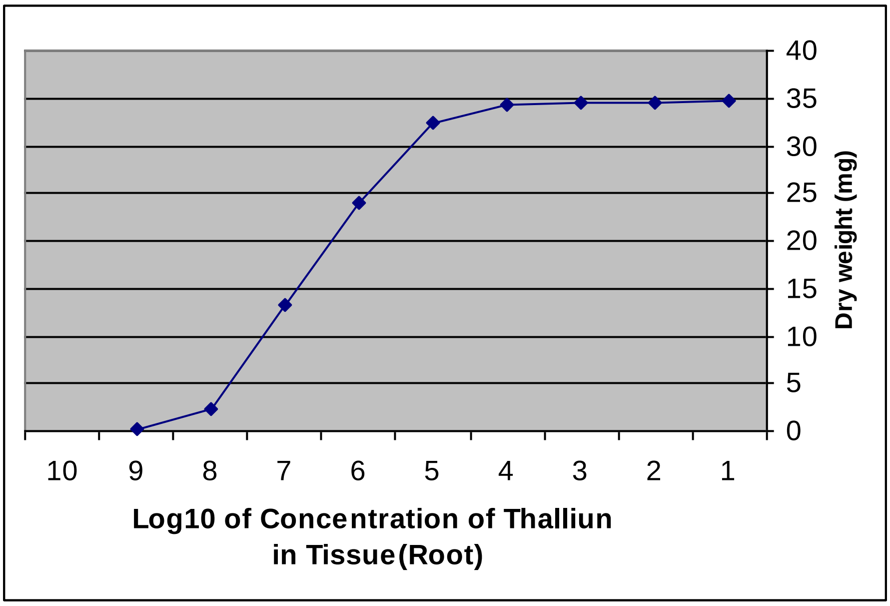


Fig. 3 Yield curve of root yield plotted against log tissue concentration in supplementary experiment to determine thallium upper critical level

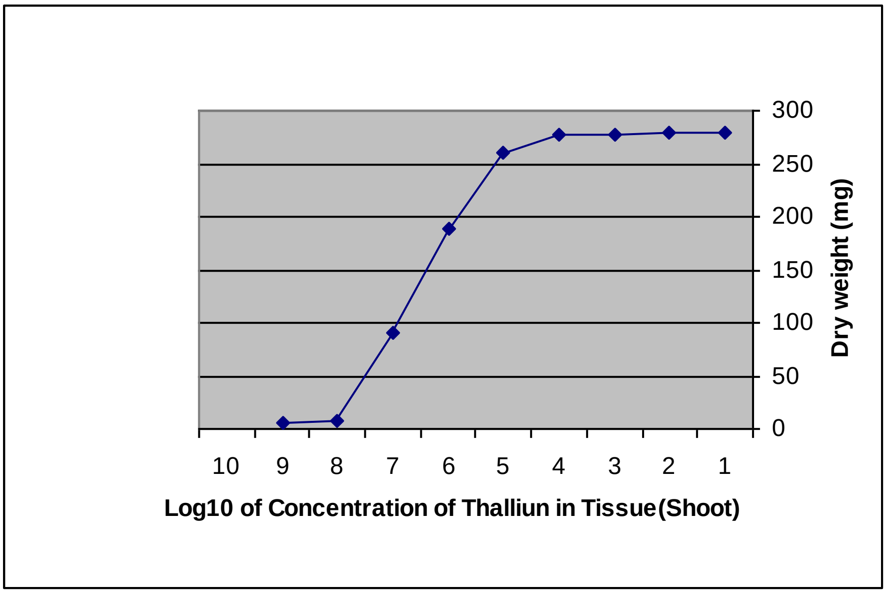


Fig. (4) Yielded curve of shoot yield plotted against log tissue concentration in supplementary experiment to determine thallium upper critical level

Discussion:

To date, it is not known wether the thallium (III) is taken by plants as the trivalent metal or if it is reduced to thallium (I) on the surface of the root. Thallium (I) may be taken up by the plant in the same mechanism of uptake of potassium due to similar ionic radii and valency.

The critical and lethal concentration of thallium in ***Lolium perenne*** roots were found to be approximately 0.35 and 0.004 mg/kg and in shoots 0.75 and 0.0008 mg/kg respectively. In fact, these results may not be accurate and it may be that the critical level of thallium is less than the Figures quoted above. Figure (3) and (4) illustrate that the yields of the plants were affected by all the concentration of thallium which were fed to them, therefore it was difficult to determine the unaffected yield (Y_o), the control experiment was assumed to give $Y_{o.}$ Perhaps when very low concentration (<0.001 mg/ cm^3) of thallium are fed to such plants they might produce an unaffected yield. The results in this work indicate the accumulation of thallium in roots of plants, these results do not agree with other worker [19], who reported that accumulation of thallium in a green alga .Thallium (I) accumulated in roots of barley[20], these results agree with the results obtain in present work.

Thallium and its compounds are highly toxic because it is absorbed through skin and mucosa membrane therefore it accumulates in central nervous system. The effects of thallium on rates are behavior disorders, hair loss and histological tertian of the liver, kidneys and stomach membrane [21]. Thallium is also toxic to plants and inhibits chlorophyll formation, thallium uptake via roots shows discoloration in the leaf which results from degradation of chlorophyll, beginning at the base of leaf vein, progressing along the vein, reaching the tip and spreading over the whole leaf blade until it is totally covered by intercostals chloroses[22], these results againe agree with the results obtained in this work.

Many studies found that thallium in environment toxic to biotia at low concentration therefore it restricted using in industry, agriculture and drinking water [23-25]

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سمية الثاليوم للنباتات

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الملخص

في هذا البحث تمت دراسة سمية الثاليوم للنباتات باستخدام التراكيز الحرجة والقاتلة لجذور وسيقان (***Lolium perenne***) ولقد وجدت التراكيز المؤثرة على نمو النباتات ما يلي :

النموذج	التركيز الحرج (ملغم/كلغم)	التركيز القاتل (ملغم/كلغم)
الجذور	٠,٣٥	٠,٧٥
السيقان	٠,٠٠٠٤	٠,٠٠٠٨

لقد بينت نتائج التحليل المختبري بأن جذور النباتات تجمع ايون الثاليوم وتمنع وصوله الى السيقان وذلك لتقليل سميته ويلاحظ أن تراكيز الثاليوم في الجذور مساويا الى١٠٠٠ مضروباً في تراكيز الثاليوم في السيقان