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MECHANICS AND KINETICS OF LEAD UPTAKE BY EXCISED BARLEY ROOTS

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ABSTRACT

Technique of excised barley roots (genotype Giza 2000) was adopted for experiments carried out with the purpose of evaluating the mechanics and kinetics of root absorption for lead element. In addition, interaction has been evaluated between the mentioned heavy metal and certain essential element, (i.e., potassium). Kinetics studies were performed through evaluation of both Vmax and Km parameters along with their responses to environmental factors including both concentration of the concerned ion in the absorption media and the time interval of absorption. The experimental media of the excised barley roots involved both the concerned lead source, Pb $(NO_3)_2$, with concentrations variable between 2 and 500 mg L^{-1} Pb; series involved the same above mentioned Pb concentrations accompanied with either 50 or 100 mg L^{-1}K in the form of KCl were also involved, absorption periods being successively variable between 5 min. and 3 h.

Obtained results representing the uptake of the studied element revealed positive responses for Pb presence, Pb uptake by the studied excised barley roots being generally increased with increasing its concentration in the growth media. This is true at all studied absorption periods; however, lead uptake was, in general, slightly responded as time progressed.

Indicated results showed multiphase pattern of absorption within the studied range of Pb concentrations; two mechanisms and a start for the third were encountered with responses being somewhat dependent on the time interval of absorption. Kinetics studies revealed that both Vmax and Km were responded to absorption time interval within both shown mechanisms. Values of Vmax decreased up to 30 min. for the first mechanism, but increased then decreased for the second mechanism as time goes on. The general depressive effect found with values of the indicated Vmax was also encountered with those of Km, both being frequently favored with presence of K in spite of the general pattern of consistency.

As far as interactions are concerned, presence of potassium seemed to be effective particularly at high Pb concentrations. Application of potassium was found to be generally favorable for the Pb uptake, particularly with 100 mg L^{-1}rate possibly due to synergetic effect of K. The obtained absorption pattern was relatively affected with K-Pb interactions. For both studied mechanisms, the Vmax values of Pb absorption, generally opposite to those of Km of the second mechanism, gradually decreased with time interval possibly due to the increases in toxic effect of lead with time progress.

As far as the responses to absorption period variable between 5 min. and 3 h., relatively slight effects were observed.

According to the above mentioned presentation, recommendations may be introduced as to selecting the suitable potassium fertilization design, including time of fertilization that goes along with values of available Pb in environment.

Key words: Lead, Excised roots, Ion uptake, Uptake mechanics, Uptake kinetics, Barley.

INTRODUCTION

Chemical pollutants especially Pb have effective role in destruction of biosphere and is hazardous as a contaminant in soils; subsequently plants, animals and human. Lead is a contaminant added with soil fertilizers, pesticides and as a resultant of precipitation for output particles derived from combustion of gasoline in vehicles; such gasoline contains about 2-8 gm Pb $gall^{-1}$. Toppi and Gabbrielli (1999) reported that heavy metals, such as lead, are important environmental pollutants whose presence in the atmosphere, soil, and water even in trace concentrations can cause serious problems to all organisms; heavy metal bioaccumulation in food chain can be highly dangerous. Piechalal *et al.* (2002) found that the largest amount of lead, up to 75 mg Pb g^{-1} dry weight, was accumulated in roots of *P. vuglaris;* the highest rate of Pb ions uptake from the media took place during the first 10 h of incubation with lead but after 96 h of incubation, lead content in the media decreased by half. Thus, it was suggested that *P. vuglaris* can be used in rhizofiltration. Recently, Kadukova and Kalogerakis (2007) pointed out that the roots were the main accumulation site of Pb in all plants under the studied treatments irrespective of ion concentration in soil. Alekseeva *et al.* (2007) added that energy expenditure for response reactions and adaptation was dependent on the permeability of the plasma membrane of the root cells. As far as uptake behavior is concerned, EL-Leboudi *et al.* (2000) reported that mechanics and kinetics may be studied through evaluation of both Vmax and Km parameters along with their responses to environmental factors including both concentration of the concerned ion in the absorption media and time interval allowed for such absorption. Later on, Weis and Weis (2004) pointed out the importance of both active and passive circulation of elements; through their action as "nutrient pumps"; active uptake of element may promote immobilization in plant tissue.

Abd-Elmoniem (1991) showed that at low concentration of $FeSO_4$, values of Vmax were variable during the studied absorption time interval. At high concentration of $FeSO_4$, on the other hand, values of Vmax were again variable during the studied absorption time interval. Abd-Elwahed (1997) added that at low concentrations of both $FeSO_4$ and Fe EDDHA forms, values of Vmax were variable for the investigated absorption time intervals. Correspondent values obtained at high concentrations of both concerned iron sources were again variable for the indicated absorption time intervals.

Marschner (1995) suggested that the Km reflects the affinity of the carrier site for the ion, just as in enzymatic reactions where it indicates the affinity of the enzyme for the substrate. The plasma membrane was proposed to be an effective barrier against the diffusion of solutes either from the apoplasm into cytoplasm (influx) or from the cytoplasm into the apoplasm and the external solution (efflux). The plasma membrane was also considered to be the principal site component for active transport in either direction, the other main barrier to diffusion being the tonoplast (vacuolar membrane). Recently, Meyers *et al.* (2008) reported that lead uptake was restricted largely to root tissue. Uptake enhancement using genetic engineering technique would benefit investigation of plasma membrane transport mechanisms; a membrane transport protein may therefore be involved. In contrast, endocytosis of Pb into a subset of vacuoles was observed, resulting in the formation of dense Pb aggregates.

The current work was planned to investigate lead uptake mechanics and dynamics by excised barley roots and responses to affecting factors including each of concentration in the growth media as well as absorption period; interactions with potassium were also evaluated.

MATERIALS AND METHODS

Technique of excised barely roots described by Epstein and Hagen (1952) and later adopted by several investigators such as EL-Leboudi *et al.* (2000) and Wang (2003) was adopted, to evaluate both mechanics and kinetics parameters of ion uptake by the indicated excised barely roots.

A series of experiments using growth media including the use of lead nitrate $Pb(NO_3)_2$ solution were prepared to have concentrations of 0,2.5,10,20,50,100 and 500 mg L^{-1} Pb, successive absorption periods of 0,5,15,30,60 and 180 min. being used.

Second and third series of experiments involved the same mentioned Pb concentrations accompanied with either 50 or 100 mg L^{-1} K in the form of KCl, absorption periods being again the same previously mentioned.

Aliquots were finally taken out, representing each time interval to be analyzed for Pb using atomic absorption spectrophotometer, (Page *et al.* 1982). Following the end of time interval, uptake of Pb by the excised roots was evaluated as the differences between the content of aliquots taken before and after sampling.

Both Vmax and Km parameters were evaluated as expression for uptake kinetics; such parameters are derived from the dynamic equation of uptake (Epstein and Hagen 1952).

$$v = V(M) / Km + (M)$$

Where v is the uptake at a concentration (M).
Vmax is maximal velocity and Km is Michaelis constant.

RESULTS AND DISCUSSION

Uptake of lead by excised barley roots (Giza 2000) was studied through evaluation for certain parameters thought to express responses to affecting factors including each of concentration in the growth media as well as absorption period and interactions with potassium. Indicated parameters were Vmax (the maximum absorption velocity) and Km (Michaelis constant).

1. Effect of lead concentration in the absorption media.

Figure (1) represents the responses of lead uptake, arbitrary representing velocity as the consumed time interval is constant, by excised barely roots to its concentration in the absorption media at successive time intervals, interactions with K being also shown. Such pattern shows distinct responses; uptake appeared to be favored, at all studied absorption periods as concentration of Pb in the growth media increased, with more effect being generally encountered towards relatively higher levels. Obtained data agree with those of Skripnichereko and Zolotoryave (1980) who reported that when Pb was present in soluble forms in nutrient solutions, plant roots were able to take up great amounts of this metal, the rate increased with increasing either concentration in solution or absorption period. Kabate-Pendias and Pendias (1984) added that Pb was absorbed mainly by root hairs and stored to a considerable degree in cell walls of plant. More recently, De Varennes *et al.* (1996) found that addition of Pb to soil resulted in increased uptake and translocation by A*lyssum pinodasile* plants. At the highest level of Pb (500 mg Pb Kg^{-1} soil); the plants absorbed 55 times more Pb than control plants, such responses being explained to be based on presence of carriers.

Indicated trend agrees with results of Lehoczky *et al.* (2002) who reported that as available Pb increased in the soil, Pb concentration increased in plant roots; responses to relatively high concentrations appeared to be a resultant of several mechanisms. In fact, Epstein (1966) previously suggested two mechanisms to occur; these two mechanisms being considered to be either to operate in parallel across the same membrane or in series as to have the first mechanism passing through one membrane and subsequently through a second membrane by another mechanism.

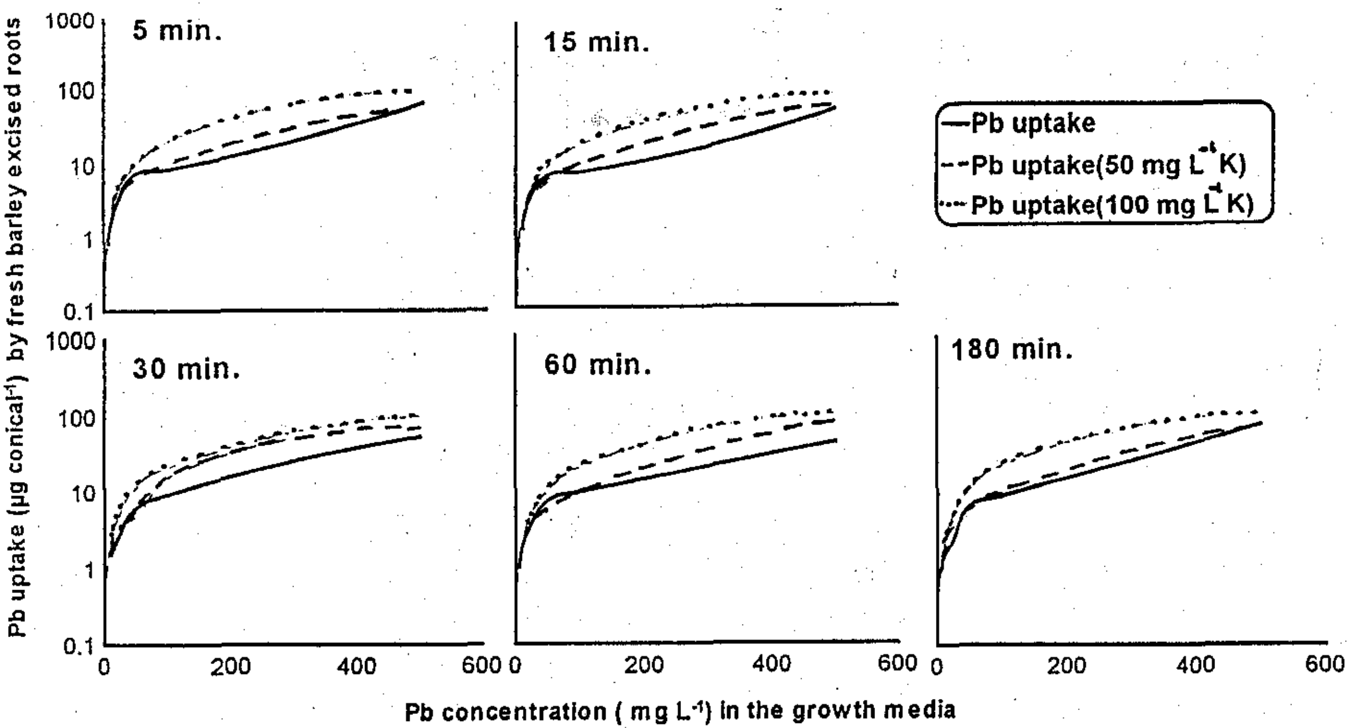

Fig.(1): Responses of Pb uptake, by the studied excised barley roots, to its concentration in the growth med under different conditions of absorption periods at various K additions .

Kadukova and Kalogerakis (2007) pointed out that the roots were the main accumulation site of Pb in all plants under the studied treatments irrespective of ion concentration in soil. Alekseeva *et a.l.* (2007) added that energy expenditure for response reactions and adaptation was dependent on the permeability of the plasma membrane of the root cells.

Figure (1) also shows that potassium was effective; the effect was dependent on both Pb concentration in the growth media and applied level of potassium, absorption being higher at high levels of lead and the higher rate of 100 mg L^{-1} potassium. Several investigations have been reported to discuss the interactions between lead and other elements, one of which is potassium. Kabate-Pendias and Pendias (1992) suggested that the geochemical characteristics of Pb^{+2} somewhat resemble certain group of elements; Pb has the ability to replace K, Ba, Sr and even Ca, both within different soil minerals and their sorption sites.

It may be worth to mention that, responses of lead uptake followed a pattern not greatly affected with absorption period; this is true whether K was absent or applied at either of the two used concentrations. In spite of that, Epstein *et al.* (1963) previously proposed a multiplicity of carrier sites in the transport of many ionic species to which roots and other tissues are exposed. Selectively of absorption from the inorganic substrate was clear with selective transport being interpreted in terms of binding of the ions to ion-specific or ion group- specific sites of carriers. Competition among ions, on equal or unequal terms, and other kinds of interactions were interpreted in terms of differential affinities of carrier sites for different ions. More recently, Marschner (1995) added that potassium was the most abundant cation in the cytoplasm; K^+ and its accompanying anions represented a major contribution to the osmotic potential of cells and tissues of different plant species. Potassium and other monovalent cations may activate enzymes by inducing conformational changes in the enzyme protein. Another function of K^+ was the activation of membrane-bound protein-pumping ATPases; this activation not only facilitates the transport of K^+ from the external solution across the plasma membrane into the root cells, but also makes potassium the most important mineral element in cell extension and osmoregulation.

Several investigations have been frequently interested in evaluating both mechanics and kinetics parameters for different ions. For lead, well known metal mechanisms are both passive and active transport systems across cell wall and membranes, respectively. Cataldo *et al.* (1979) suggested that uptake kinetics are complicated by an inability to quantitative that portion of the root activity involved in transport and resolving the active uptake into the symplast from physical sorption processes in the apoplast. This may go along with results of Epstein and James (1954) who previously reported two mechanisms representing the establishment of exchange equilibrium between the solution and root, which acts as exchanger, and active absorption tissues through metabolic process. Kinetic studies were repeatedly performed through evaluation of both Vmax and Km parameters along with their responses to environmental factors including both concentration of the concerned ion in the absorption media and the time interval of absorption.

a. Mechanics.

Figure (1) may be misleading as to be not able to show the different mechanisms of lead absorption due to the large scale adopted for the semi-log relationship, particularly at low lead concentration range of 0-10 mg L^{-1} Pb. Accordingly, figure (2) was designed to show multiphase pattern of absorption within the studied range of 2-500 mg L^{-1} taking in particular considerations the ranges of 2-10 mg L^{-1}, 10-100 mg L^{-1} and 100-500 mg L^{-1} , respectively, possibly representing three mechanisms; the indicated figure also shows that the mentioned responses were somewhat dependent on the time interval of absorption.

The obtained pattern was relatively affected with K-Pb interactions. During the 1st mechanism, which represented the low concentration range; time progress seemed to give more chances for K to interact with Pb as to have favorable effect on Pb absorption, during the absorption by excised roots even at the high rate of 100 mg L^{-1} K. Longer time intervals of 180 min. seemed to be, however, less effective in the indicated Pb responses possibly due to relative less chances for Pb to be absorbed as time goes on. In other words, interactions between both elements during the first mechanism appeared to be in favor of Pb; such pattern seemed to be relatively changed during the 2nd mechanism and the start of the 3rd one, whose

Pb concentration in the growth media was relatively high, competition being relatively in favor of K uptake on expenses of Pb. The mentioned figure also shows that the 1st mechanism of Pb absorption was almost consistently more responded, as far as K-Pb interactions are concerned compared to the 2nd and the start of the 3rd mechanisms, to K application particularly at the early studied time intervals (up to 60 min.). Of course, such pattern of response may be, again, attributed to the more chances for interactions to be in favor of Pb particularly with the high rate of K application, possibly a resultant of K role imposed on plant metabolic activities. Higher concentrations range during the 2nd and stared 3rd mechanisms, compared to the lower concentration range for the 1st mechanisms, seemed to decrease the efficiency of K role due to the expected toxicity of Pb under such conditions. This may reflect the presence of Pb active uptake during the first mechanism beside that of passive nature, appeared to be obvious during the later mechanisms; such two patterns of uptake appeared to be more interacting during the 180 min. time interval.

Epstein and James (1954) reported that mechanism of active transport involving carriers is analogous to the mechanism of catalysis mediated by enzymes. In each case, the substance acted upon (the ion or substrate, respectively) combines with the agent (carrier or enzyme) to form an intermediate labile complex which subsequently breaks down, and the process in question (transport or catalysis) taken place. Later on, Page and Dainty (1964) investigated the uptake of Mn by excised oat roots from dilute manganese chloride solutions; the time-course of uptake has been analyzed into fast and slow phases. Epstein (1966) added that absorption of nutrient mineral ions by plant was, therefore, a primary process by which essential atoms are abstracted from the inorganic environment, and thus is as important as photosynthesis and nitrogen fixation in the element economy of biosphere. The processes of inorganic ion transport in plant cells and through whole plants were considered therefore to be of great interest to biologists. The author added that there was a difference in the affinity of the two mechanisms for potassium: the first mechanism, located at the plasma lemma, had a high affinity for the ion; the second mechanism, residing in the tonoplast, represented no appreciable contribution to potassium transport as it has a low affinity for potassium.

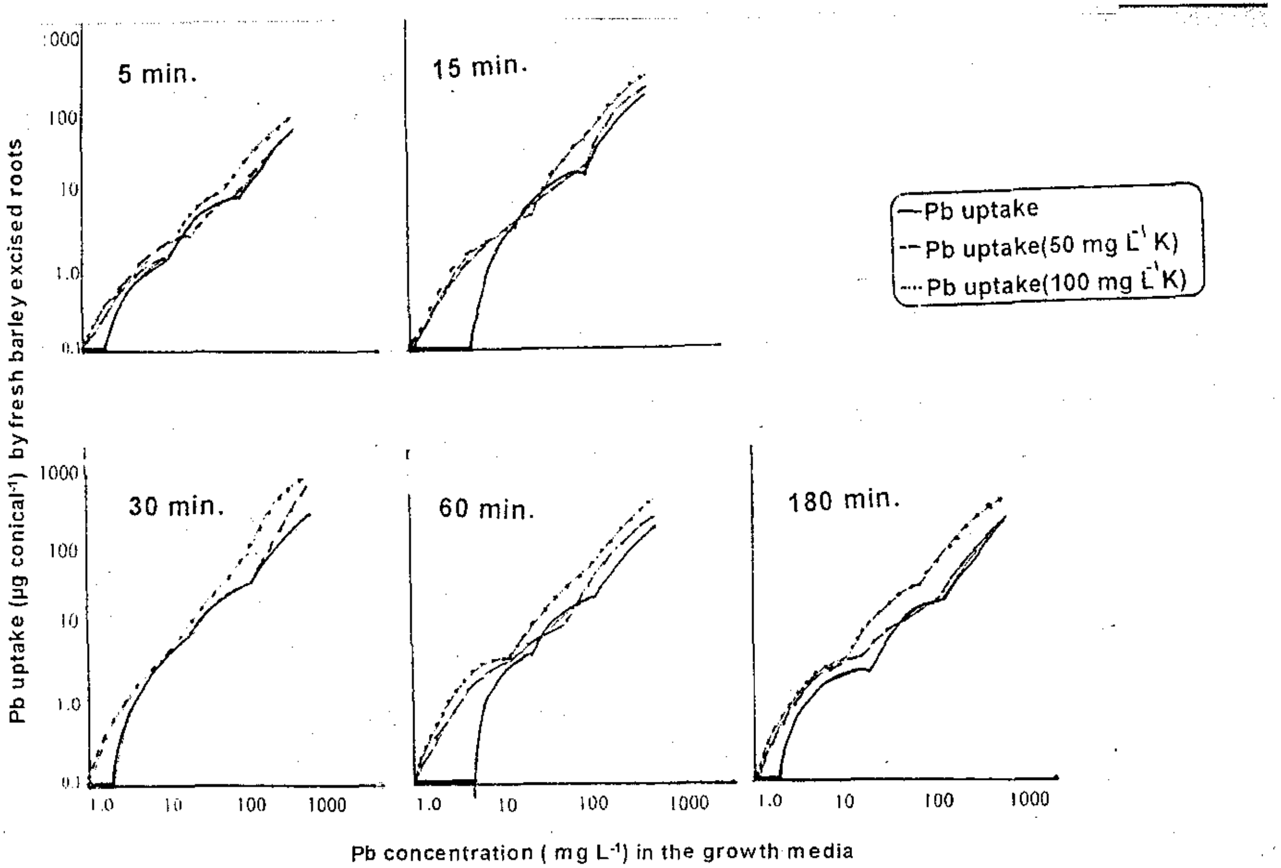

Fig. (2): Mechanisms of Pb uptake, by the stuided excised barley roots, under different conditions of absorption periods at various K additions.

Cataldo *et al.* (1979) showed that the uptake of Ni^{2+} by intact soybean plants, as well as shoots alone exhibited discontinuous transition. Although sets of data exhibited three phases with similar transition points, there were apparent differences in their saturation kinetics, the rate of accumulation of Ni^{2+} by the studied plants being dependent on its concentration in soil solution. Zhang and Taylor (1989) suggested that uptake of aluminum by excised roots of two Al tolerant cultivars and two Al sensitive cultivars of wheat was biphasic, with a rapid phase of uptake in the first 30 minutes followed by a linear phase of uptake up to 180 minutes. The authors added that precipitation of Al phosphate compounds or formation of insoluble polynuclear Al species could account for immobilization of Al in the apoplasm during the linear phase of uptake. Abd-Elmoniem (1991) studied the response of iron uptake from $FeSO_4$ salt by excised barley roots for two genotypes; he found that two distinct phases appeared to exist at two tested concentrations ranges: the first mechanism being reported to be operating at plasmalemma and the second mechanism at the tonoplast. Abd-Elwahed (1997) also showed that the responses of iron uptake by excised barley roots had two distinct phases appeared to exist at the two tested concentration ranges. More recently, Maser *et al.*(2001) suggested that heavy metal accumulation responses were different from those of metal tolerance, both being dependent on certain cell proteins variable in the concerned sub-cellular compartments. Clemens (2001) added that tolerance mechanisms were greatly connected to the pathways of uptake, partitioning and accumulation of toxic metals; efflux activities may lead to accumulation in certain tissues, basal tolerance thus reducing the availability of absorbed toxic metal ions for interaction with molecules in the cell.

Greger (2004) mentioned that Pb was toxic to plants. However, *C. odarate* plants had certain detoxification mechanisms within their plant tissues, which allow plants to accumulate high amounts of the indicated element. Hawari and Mulligan (2006) added that ion exchange accounted for almost 50% of the total uptake mechanism of lead; thirty percent of the total uptake mechanism was attributed to a precipitation mechanism, the remaining 20% being due to complexation.

b. Kinetics.

Kinetics of metal uptake may provide additional information on nutrition characteristics of plants with different tolerance to heavy metals; the experimental data of lead uptake kinetics by the studied excised roots of barley are shown in Table (1).

Results indicate distinct differences for the kinetic phenomenon of Pb element as far as velocity, represented by uptake during a defined time interval, was taken in consideration, such differences being, as expected, dependent on the concentration of Pb in the growth media. For both studied mechanisms, the Vmax values of Pb absorption gradually decreased with time interval possibly due to the increases in toxic effect of lead with time progress.

As far as the mechanisms were concerned and as expected, results reveal the superiority in Vmax values of the second mechanism compared to the first one, differences being dependent on the concerned time interval. Relatively lower values of Vmax at relatively longer time intervals may suggest a short time required for uptake to reach its maximum velocity. This may agree with results of Van Assche and Cliisters (1990) who reported that exposure of plants to Pb may cause hazardous effects such as inhibition and inactivation of enzymatic activities. Abd-Elmoniem (1991) point out, however, that at low concentration of $FeSO_4$, values of Vmax were variable between 0.54 and 55.5 mg g^{-1} fresh roots for an absorption time interval variable between 5 min. and 6 h. At high concentration of $FeSO_4$, on the other hand, values of Vmax were variable between 0.87 and 71.4 mg g^{-1} fresh roots for an absorption time interval again variable between 5 min. and 6 h. Later on, Abd-Elwahed (1997) added that at low concentration of both $FeSO_4$ and Fe EDDHA forms, values of Vmax were variable between 0.71- 20.77 mg g^{-1} and 0.63-20.7 mg g^{-1} fresh roots respectively, for the absorption time intervals variable between 7.5 min. and 6 h. Correspondent values obtained at high concentrations of both concerned iron sources were variable between 1.33-48.5 and 1.26-45.2 mg g^{-1} fresh roots respectively, for the indicated absorption time intervals. It seems that kind of element is of great importance in defining kinetics behavior; toxicity of Pb appeared to be greatly affecting.

Table (1). Kinetic parameters for the lead uptake by the studied excised barley roots at the different absorption periods.

Time (min.)	Pb only		Pb+(50 mg L^{-1} K)		Pb+(100 mg L^{-1} K)	
	Vmax (µg g^{-1} f.w. $min.^{-1}$)	Km (mg L^{-1})	Vmax (µg g^{-1} f.w. $min.^{-1}$)	Km (mg L^{-1})	Vmax (µg g^{-1} f.w. $min.^{-1}$)	Km (mg L^{-1})
First mechanism						
5	150.00	4400.0	190.00	4400.0	180.00	4400.0
15	50.000	3200.0	10.000	4600.0	10.000	4000.0
30	30.000	2100.0	30.000	4000.0	40.000	4000.0
60	-	-	-	-	-	-
180	-	-	-	-	-	-
Second mechanism						
5	900.00	26000	1050.0	38000	1000.0	23000
15	290.00	24000	350.00	32000	700.00	50000
30	160.00	38000	90.000	14000	360.00	40000
60	80.000	31000	50.000	15000	90.000	23000
180	230.00	32000	30.000	38000	60.000	50000

Results also show that K was generally not greatly effective on the indicated trend of responses of Vmax to the studied time duration for both investigated mechanisms, even for the first mechanism, the values were generally decreased with time interval. This was true in spite of the positive favorable effects obtained with the first mechanism at the 30 min. time interval possibly due to the promotive influence expected to be found with potassium presence on the metabolic activities reflected on more chances for absorption of Pb; such suggestion may be confirmed by results representing the absolute values of Vmax which were frequently increased with K presence. In fact and as previously mentioned, Marschner (1995) found that potassium is the most abundant cation in the cytoplasm; K^+ and its accompanying anions make a major contribution to the osmotic potential of cells and tissue of glycophytic plant species.

As is expected, values of Km reported in Table (1) generally decreased as the studied time progressed towards the 15-30 min., this was generally true for the two observed mechanisms, in spite of the dependency of responses on the concerned mechanism and the relatively higher values encountered with later absorption intervals of the second mechanism.

Of course, relatively low values of the studied Km parameter at relatively longer time intervals of the first mechanism, opposite to those of later intervals of the second mechanism, are not unexpected suggesting relatively more efficiency for Pb absorption in spite of relatively low values for Vmax. Page and Dainty (1964) reported that the uptake in a given time rate, similar to an enzyme reaction, expresses velocity of absorption and would therefore be dependent on the external concentration of the ion and the dissociation constant, Km, of the ion carrier complex (Michaelis constant). Cataldo *et al.* (1979) found that Km and Ki constants for Ni^{2+} competed with Cu were 6.1 and 9.2 μM for the two studied ions, respectively. Kochian (1991) added that cationic solutes were likely to be driven largely by the negative membrane potential across the plasma membrane, which is generated in part by metabolically dependent processes, such as proton extrusion, via the plasma membrane H- ATPase. Marschner (1995) suggested that Km value represents the affinity of the carrier site for the ion; the plasma membrane was thought to be an effective barrier against the diffusion of the solutes and also considered, along with tonoplast, to be the principal site components for active transport. More recently, Charissa *et al.* (2004) reported that the Michaelis constant, Km, may define the influx rate which appeared to be related to affinity between the element and its carrier.

Epstein and Hagen (1952) and Epstein (1953) showed that the rate of absorption of alkali cations and monovalent anions could be described by rate equations originally worked out in connection with studies of the rates of enzyme reactions, although the variables and parameters have different meanings. The implication was that active ion transport, like enzymatic catalysis, involves intermediate complex formation between the ions and active agents (carriers). Later on, Clarkson (1988) pointed out that kinetics of metal absorption by plants have often been found to exhibit two distinct phases, a rapid initial uptake phase followed by a slower steady and linear uptake phase.

Lin (1979) suggested that active K^+ influx and H^+ efflux were mediated by an active H^+/K^+ exchange ATPases mechanism, which could be separated from the Pi uptake component. According to the proposed exchange mechanism, it should also be possible to use Pi transport site-specific chemical modifier (s) to differentiate the two components. More recently, Sneller *et al.* (1999) reported that when all free metal ions were cheleated, synthesis of metabolites was terminated. The lower amount of free metals in the cells could allow metal -sensitive enzymes to function and the plant to survive. The capacity for chelation was, however, finite and as metal concentration continued to increase, toxic effects become manifested. Axelsen and Plamgren (2001) added that passage into the vascular tissue of roots required transport of metal ions and/or metal legend complexes across a cell membrane. Good candidates for such an activity were certain enzymes of ATPases referred to as heavy metal transporting p-type ATPases (HMA_S). Later on, Nies (2003) mentioned that proteins of bacteria mediated the efflux of metal from the cells and were essential components of metal tolerance mechanisms, p-type ATPases being the key players for affixing metal ions which was the major tolerance mechanism in bacteria.

Results previously presented in table (1) also show that K was generally effective on the indicated responses of Km to the studied time duration for both investigated mechanisms, positive favorable effects being generally obtained at certain studied time intervals, particularly the late ones, possibly due to the promotive influence expected to be found with potassium presence on the metabolic activities reflected on more chances for absorption of Pb. In fact, Marschner (1995) pointed out that potassium and other univalent cations activate enzymes by inducing conformational changes in the enzyme protein. Another function of K^+ was proposed to be the activation of membrane-bound protein-pumping ATPase. This activation not only facilitates the transport of K^+ from the external solution across the plasma membrane into the root cells but, as previously mentioned, also makes potassium the most important mineral element in cell extension and osmoregulation.

2. Effect of lead absorption period.

To complete the picture, it was thought to express the previously mentioned relationships in different pattern representing the relationship between the Pb uptake by excised barley roots and the used time interval (Figure 3).The indicated figure shows that Pb uptake by excised barley roots was slightly responded positively to the time interval allowed for absorption; this was true for all ion concentrations in the growth media. In fact, Lerda (1992), Bandyopadhyay (1997), Patra (1999) and Bhowmik (2000) showed that, in general, effects on uptake behavior were more pronounced at higher concentration and longer duration exposures, lower concentrations may be stimulating for metabolic processes and enzymes involved. In spite of that, at relatively long time intervals, metabolic creation of the concerned ion carriers along with their turn – over mechanics seemed to be relatively inhibited by Pb present in the growth media particularly at high ion concentrations. EL-Leboudi *et al.* (2000) pointed out that behavior of P uptake allowed an almost linear relationship within different studied time intervals possibly indicating that uptake was mainly an active process. Relationship to ion concentration in the growth media was, however, hyperbolical with two distinct phases: one operating at low concentration range and the other at higher concentration range. The authors added that the dual mechanism with responses more pronounced at high applied element concentration, which seemed to be reflected on activation of hydrogen pump at plasma membrane as well as promotion for metabolic activity, synthesis and turn-over of the concerned carrier being of importance.

With regard to potassium interactions, Figure (3) again shows a general slight positive effect on the absorption of lead by the studied excised barley roots. The effect was, as previously mentioned, more observed at relatively high Pb concentration, especially when K was applied at high concentration of 100 mg L^{-1}, responses to absorption period being almost nil. Kabate-Pendias and Pendias (1992) found that when Pb was present in soluble form in nutrient solutions, plant roots were able to take up great amounts of this metal, the rate of uptake increased with increasing concentration in the solutions.

From the obtained uptake data, positive responses for Pb presence in the growth media appeared to be encountered, Pb uptake by the studied excised barley roots being generally increased with increasing its concentration in the growth media. The obtained pattern was also true at all studied absorption periods; lead uptake was slightly responded as time progressed.

As far as interactions are concerned, presence of potassium seemed to be effective, effect being dependent on the concentration of applied K, Pb concentration in the growth media, mechanism of Pb uptake and absorption time interval.

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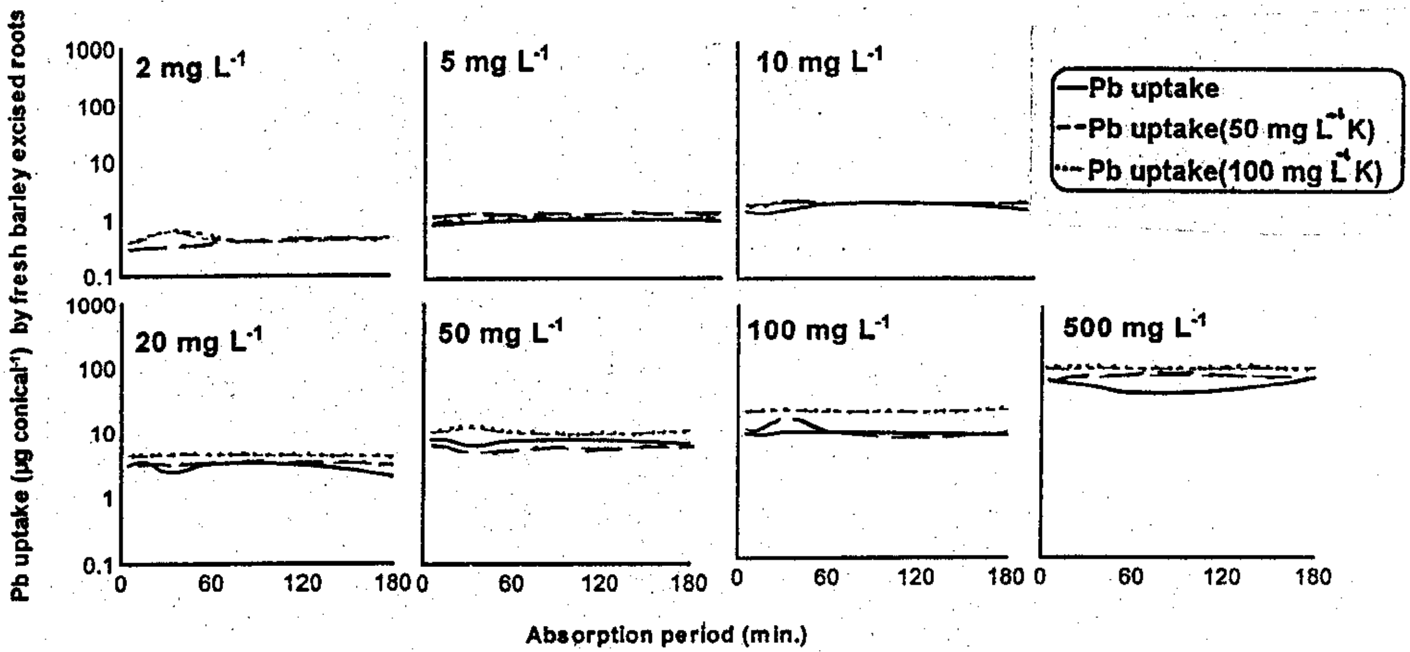

Fig.(3): Lead uptake, by the studied excised barley root, from different concentrations of Pb in the growth media as influenced by different absorption periods at various K additions.

According to the above mentioned presentation, recommendations may be introduced as to selecting the suitable potassium fertilization design, including time of fertilization that goes along with values of available Pb in environment.

REFERENCES

Abd- Elmoniem, E. M. 1991. Kinetics of ion transport in plant. Ph. D. Thesis, Fac. Agric. , Ain Shams Univ.

Abd-Elwahed, M. S. 1997. A study on uptake dynamics of some nutritional elements by plant roots. M. Sc. Thesis, Fac. Agric. ,Ain Shams Univ.

Alekseeva, V.Ya. ,A. N. Tsentsevitsky, N. L. Loseva, L. K. Gordon and G. G. Rakhimova. 2007. Energy expenditure induced by changes in the ion homeostasis of wheat root cells. Thermohimica Acta. 458: 97-100.

Axelsen, K. and M. Plamgren. 2001. Inventory of the super family of p-type ion pumps in *Arabidopsis*. Plant Physiol. 126:696-706.

Bandyopadhyay, B. 1997. Studies on the structure and behavior of some genera of the family Cataceae and the effects of arsenicals on plant in vivo. Ph. D. Thesis, Calculta Univ. , Calculta.

Bhowmik, N. 2000. Cytotoxic effects of lead compounds on plant systems. Ph. D. Thesis, Calculta Univ. , Calculta.

Cataldo, D. A. , T. R. Garland and R. E. Wildung. 1979. Nickel uptake kinetics using intact soybean seedling. Plant Physiol. 73: 844-848.

Charissa, Y. P., W.H. Jianwei, J. B. Michael, V.K. Leon and P. E. Mark. 2004. Mechanisms of arsenic hyperaccumulation in *Pteris* species: root As influx and translocation. Planta. 219: 1080-1088.

Clarkson, D. T. 1988. The uptake and translocation of manganese uptake by plant roots. In "Manganese in Soil and Plant", Graham, R. D. , 101-111.

Clemens, S. 2001. Molecular mechanisms of plant metal homeostasis and tolerance. Planta. 212: 475-486.

De Varennes, A. , M.O. Torres, J. F. Coutunho, M..M. G.S Rocha And M.M. P. M. Neto. 1996. Effect of heavy metals on the growth and minerals composition of a nickel hyperaccumulators. J. Plant Nutr.19: 669-676.

Lin, W. 1979. Potassium and phosphate uptake in corn roots. Plant Physiol. 63: 952-955.

Marschner, H. 1995. "Mineral nutrition of higher plants" (2nd Ed.). Academic Press, New York.

Maser, P., S. Thomin.e,J. Ward, K. Hirschi, H. Sze,I. Talke, A. Amtmann, F. Maatthuis, D. Sanders, J. Harper, J. Tchieu, M.Gribskov, M. Persans, D. Salt, S.Kim and M.Guerinot. 2001. Phylogenetic relationships within cation transporter families of *Arabidopsis*. Plant Physiol.126:1646-1667.

Meyers, D. E. R. ,G.J. Auchterlonie, R. I. Webb and B. Wood. 2008. Uptake and localisation of lead in the root system of *Brassica juncea*. Environ.Pollution. 153: 323-332.

Nies, D. H. 2003. Efflux-mediated heavy metals resistance in prokaryotes, FEMS Microbiol. Rev. 27: 313-339.

Page, E. R. and J. Dainty. 1964. Manganese uptake by excised oat roots. J. Exp. Bot.15: 428-443.

Page, A. L. ,R. H. Miller and D. R. Keeney. 1982. "Methods of soil Analysis. (Part 2)- Chemical and Microbiological Properties", 2nd Ed; Amer. Soc. Agrono., Madison, Wisconsim, U.S.A.

Patra, M. 1999. Cytotoxic effects of mercurial on plant systems in vivo. Ph. D. Thesis, Calculta Univ. , Calculta.

Piechalal, A. B. Tomaszewska, D. Baralkiewicz and A. Malecka. 2002. Accumulation and detoxification of lead ions in legumes. Phytochem. 60: 153-162.

Skripnichereko, J.J. and B. N. Zolotoryava. 1980. Supply of lead to plants with increasing concentration of pollutants in nutritive medium. Agrokimiya. 9-110.

Sneller, F. , E. Noordover, W. Ten Bookum, H. Schat, J. Bedaux and J. Verkeij.1999. Quantitative relationship between phytochelation accumulation and growth inhibition during prolonged exposure to cadmium in *Silene vulgaris*. Ecotoxicol. 8: 167-175.

Toppi, L. S. and R. Gabbrielli. 1999. Review: Response to cadmium in high plants. Environ. Exp. Bot. 41: 105-130.

Van Assche, F. and H. Cliisters. 1990. Effect of metals on enzyme activity in plants. Plant Cell and Environ.13: 195-206.

Wang, J. J. 2003. Kinetics of manganese uptake by excised roots of sensitive and tolerant- tobacco genotypes. J. Plant Nutr. 26: 1439-1450.

Weis, J. S. and P. Weis. 2004. Metal uptake, transport and release by wetland plants: implications for phytoremediation and restoration. Environ. International. 30: 685-700.

Zhang, G. and J. Taylor. 1989. Kinetics of aluminum uptake by excised roots of aluminum-tolerant and aluminum-sensitive cultivars of *Triticum aestivum* L. Bull Environ. Contam. Toxicol. 91: 1094-1099.

ميكانيكية وديناميكية امتصاص الرصاص بواسطة جذور نبات الشعير

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تم إجراء عدة تجارب تتضمن تقدير امتصاص نباتات الشعير صنف جيزة2000 لدراسة ميكانيكية وديناميكية امتصاص الرصاص حيث تم استخدام أسلوب الجذور المقطوعة. تضمنت الدراسة سلسله من التجارب من أجل تقدير امتصاص الرصاص المضاف في صورة نترات رصاص حيث تم تقييم ميكانيكية هذا الامتصاص وديناميكيته خلال تقييم كل من ثابت السرعة القصوى للامتصاص وثابت ميكانيل وتأثير بعض العوامل البيئية مثل تركيز العنصر تحت الدراسة في وسط الامتصاص و فترات الامتصاص و التداخل مع بعض العناصر الضرورية الكبرى متمثلة في البوتاسيوم.

أحتوي وسط الامتصاص لجذور الشعير المقطوعة في السلسلة الأولي علي مجموعة تركيزات تتراوح ما بين صفر- 500 ملليجرام لتر$^{-1}$ للرصاص علاوة علي عنصر البوتاسيوم بمجموعه من التركيزات تتراوح من صفر-100 ملليجرام لتر$^{-1}$ مع استخدام فترات امتصاص تتراوح من 5 دقائق آلي 3 ساعات.

وتشير النتائج المتحصل عليها إلى ما يلي:

زيادة امتصاص عنصر الرصاص بزيادة التركيز في بيئة الامتصاص وذلك مع أي من فترات الامتصاص المستخدمة. وتظهر ميكانيكيات الامتصاص المختلفة ظهور ميكانيكيتين وبداية ظهور الثالثة بحيث كانت الميكانيكية الأولي في مدي تركيزات منخفضة والأخرى في مدي من التركيزات المتوسطة وبداية ظهور الثالثة في التركيزات العالية جدا.

إما عن سلوك كل من ثابت السرعة القصوى للامتصاص وثابت ميكانيل فكان متشابها خلال مدي التركيزات المستخدمة للعنصر تحت الدر اسه وذلك بمرور الوقت في كل من الميكانيكيتين الأولى و الثانية. انخفضت قيم ثابت السرعة القصوى للامتصاص بمرور الوقت حتى 30 دقيقه في الميكانيكية الأولى بما يعنى حدوث سميه واضحة للجذور نتيجة وجود الرصاص في بيئة الامتصاص أما عن الميكانيكية الثانية فأن القيم المطلقة زادت ولكنها تقل بمرور الوقت ويقترح أن القيمة الكبيرة في الوقت القليل يعنى الوصول للسرعة القصوى بسهوله في الوقت القصير. أما بالنسبة لتأثير التداخل مع البوتاسيوم كأحد العناصر الضرورية الكبرى المتداخلة مع الرصاص فأن الاتجاه العام لا يختلف كثيرا بوجود البوتاسيوم حيث قلت القيم أيضا بمرور الوقت ولكن القيم المطلقة اختلفت بحيث كانت أفضل من عدم وجود البوتاسيوم وذلك يعنى أن البوتاسيوم له تأثير على بعض العمليات الحيوية والذي ينعكس على امتصاص الرصاص .

وبالنسبه لثابت ميكانيل فانه أيضا ينخفض بصفة عامة بمرور الوقت حتى 30 دقيقه في الميكانيكية الأولى و180 دقيقه في الميكانيكية الثانية بحيث كانت الأستجابه أكبر في الميكانيكية الثانية آي أن القيم أكبر من الميكانيكية الأولى، وبصفة عامة كانت القيم الكبيرة في الأوقات القصيرة سواء في الميكانيكية الأولى أو الثانية مما يعنى كفاءة امتصاص عاليه. أما عن إضافة البوتاسيوم فانه أيضا يعمل على تحسين القيم المطلقة آي له أثر استجابه واضح خلال فترات الامتصاص وذلك يؤكد ما سبق أن ذكرناه أن البوتاسيوم له تأثير على بعض العمليات الحيوية والذي ينعكس بدوره على امتصاص الرصاص. أخيرا، بالنسبة لفترة الامتصاص والتي تتراوح من 5 دقائق الى 3 ساعات فكان لها تأثير بسيط على امتصاص الرصاص.

مما سبق، فان التوصيات اللازمة تتضمن اتباع نظام للتسميد البوتاسي يتلاءم مع مستوى الرصاص الميسر في البيئة وكذلك إجراء التسميد المذكور في الوقت المناسب.