Interaction Effect of Silicon and Lead on Growth and Development on *PisumSativum* Plants

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Received: June 25, 2017 Accepted: October 24, 2017 Online Published: December 1, 2017

doi: 10.23918/eajse.v3i2p258

Abstract: This study was conducted in the greenhouse of Biology Department in the College of Science-University of Salahaddin- Erbil. In this study the interaction effects of exogenous Silicon (Si) and Pb on peas plant were researched. This experiment consisted of combination treatments of foliar spray with different Silicon(Si) concentrations at doses (0,100, 200, 300ppm) and soil irrigation by two lead (Pb) concentrations (0, 100 mg.Kg^{-1} soil). The following growth parameters were observed; plant height, number of leaves, number of branches, dry weight of shoot system, water content, and yield characteristics including number of pods per plant, number of seeds per pod, dry weight of 100 seeds and chlorophyll content. The results elucidate that Si significantly decreases the negative effect of Pb on plant height, dry weight of 100 seeds, chlorophyll b and total chlorophyll content.

Keywords: Lead, Silicon, *PisumSativum*, Toxicity And Chlorophyll Content

1. Introduction

Pissumsattivum is the botanical name of garden pea; it is an annual, herbaceous plant, bearing compound leaves with tendrils, the pods containing (4-10) seeds .pod $^{-1}$.the green plant may reach 1m in length with white flowers (Hassan, 2006). It belongs to leguminous family, which is regarded as the second most important family after graminae, because the pulses, which are rich in protein belong to it. Besides, their roots contain nodules, which are responsible for nitrogen fixation in the soil. It's origin from Central Asia, Mediterranean (Burine, 2006). Peas and other legumes crops are more important to soil and have economic side because they break up disease and pest cycles, improve soil microbe diversity and activity, improve soil aggregation, conserve soil water, and provide economic diversity. It is a main source of carbohydrate, sugars, amino acids, and protein (25%), vitamins A and C, calcium and phosphorus, apart from having a small quantity of iron. (Van Blommestein, 1979).

Lead is one of the trace elements, which consider as a heavy metal and very dangerous pollutant to environment. The main source of Pb in environment by human activity releasing from motor vehicles, stationary fuel, road dust composition, industries and traffic roads (Burzynski, 1987). Soils contaminated with Pb decreases crop productivity thereby posing a serious problem for agriculture (Johnson & Eaton, 1980). Although Pb is not an essential nutrient for plants, majority of lead is easily taken up by plants from the soil and accumulated in root while only a small fraction was translocated upward to the shoots (Patra *et al.*, 2004). Pb affects several metabolic activities in different cell compartments. The effect of Pb depends on doses, type of soil, soil properties and plant species. Effct of Pb toxicity leads to decreases percent of germination, length and dry weight of root and shoots, disturbed mineral nutrition, reduction in cell division (Abdul, 2010).

Silicon is not considered as an essential element for higher plants (Ma & Yamaji, 2006). Si exerts a number of beneficial effects on growth and yield of several plant species, which include improvement of leaf exposure to light, resistance to lodging, decreased susceptibility to pathogens and root parasites, and amelioration of a biotic stresses (Wang & Ihang, 2003). Si depositions in the epidermal layer of the leaves are thought to be responsible for the reduction of mutual leaf shading by keeping leaves more erect, while in the roots they can increase cell wall elasticity during root cell elongation (Kaya, 2006). Si is studied to have beneficial effects on the growth, development and yield of plants through protection against biotic and a biotic stresses. Si is recommended to be used for enhancing the tolerance of plants to a biotic stresses, including heavy metals toxicity (Ahmad *et al.*, 2012). However, the possible effects of Si are; in alleviating Pb toxicity in cotton plants which effect on chlorophyll contents, photosynthesis, growth, Pb uptake and accumulation, soluble protein and the activities of major antioxidant enzymes. Si also protects the plant tissues from membrane oxidative damage under Pb stress, thus mitigating Pb toxicity and improving the growth of cotton plants (Bharwana *et al.*, 2013).

2. Materials and Methods

This study was conducted in the glasshouse of Department of Biology, College of Science, University of Salahaddin-Erbil, during December 30 , 2014 to February 15, 2015, to investigate the interaction effects of Silicon (Si) and Lead (Pb) on growth and development of Peas *(Pisumsativum).* We have 24 plastic pots each pot with a diameter of 24 cm in length and 21 cm in depth used. Each pot filled with 7kg of dried sandy loam soil of Askikalak area, the soil sieved through 2mm pore size sieves. From each pot, three seeds were sown and then thinned to one plant later. This experiment consisted of combination treatments of foliar spray with different Si concentrations at doses (0, 100, 200, 300ppm) and soil irrigation by two Pb concentrations (0, 50, 100 $mg.Kg^{-1}$ soil). This experiment consisted of 8treatments with three replications. Fertilizers at the rate of $10kg.donm^{-1}$ which included urea containing %45 N, super phosphate P_2O_5 containing 45% P, added to the pots as solutions (Muhummed, 2004). The following measurements taken for each pot; plant height $(cm).plant^{-1}$, number of $leaves.plant^{-1}$, number of $branches.plant^{-1}$, shoot dry $weight.plant^{-1}$, water content $(g.plant^{-1})$ of shoot system estimated as follows: fresh weight, shoot system dried at 110°C for 1 hrs, and then dried at 70°C for 24 hrs, in an oven. After cooled at room temperature, dry weight of shoot obtained for half an hour (He *et al*., 2005).

Water content =F.wt.-D.wt.

F.wt. =fresh weight

D.wt. =dry weight

Chlorophyll content in leaves $(mg.g^{-1})$ was estimated according by taking 0.5g of fresh leaves left in 10 ml of absolute ethanol for 24 hrs. In dark condition, this process was repeated three times to complete extraction of chlorophyll. The end volume reached 30 ml were spectrophotometrically estimates on two wave length 649and 665 nm as follows (Wintermans & Demote, 1967):

µg chlorophyll a/ml solution = (13.70) (A665nm)-(5.76) (A 649nm)

µg chlorophyll b/ml solution = (25.80) (A649nm)-(7.60) (A 665nm)

Total chlorophyll =chlorophyll a + chlorophyll b

A=absorbance

Nm =nanometer

3. Experimental Design

The data of this study was designed according to Factorial Completely Randomized Designs (Factorial C.R.D) with three replications and eight treatments. Duncan Multiple Range Test was used for the comparison of treatment means at 5% for green house parameters and 1% levels for laboratory parameters (Al-Rawi & Khalafulla, 1980). The statistical analysis was done by using Statistical Package for Social Sciences (SPSS version 16 software). For drawing graph, Excel 2007 software was used.

4. Results and Discussion

4.1 Vegetative Growth Parameters

Data presented in Table (1) shows that Si decreases the negative effect of Pb vegetative growth parameters, which Si significantly ($p \leq 0.05$) increased plant height at (100, 300ppm) as compared with Pb_0Si_0, Si decreases the negative effect of Pb on plant height at $Pb_{100}Si_{300}$ as compared with $Pb_{100}Si_0$. According to results shown in Figure (1), the interaction effects of Si and Pb on water content of shoot system significantly ($p \leq 0.05$) increased dry weight of shoot system by Pb_0Si_{200}, Pb_0Si_{300} as compared with $Pb_0Si_{0,}$ and also increased significantly at $Pb_{100}Si_{100,}$ $Pb_{100}Si_{200}$, $Pb_{100}Si_{300}$as compared with $Pb_{100}Si_0$, and there were significant differences between treatments, these result partially agreed with those obtained by (Savin *et al.*, 2014), the decrease in plant growth might be due to accumulation of certain nutrient, reduction in photosynthesis and chlorophyll'a'. increases amount of toxic element usually caused reduction in plant growth (Ahmad & Sahid, 2012). Results showed that lead caused significant decrease in peas growth, shoot dry weight by enhancing Pb uptake and accumulation. While, silicon protects peas plants against lead stress by lowering uptake and accumulation of lead. It can be notices that silicon addition in lead contaminated soils can help to lowering Pb contamination.

4.2 Yield Characteristics

Table (2) shows that Si decreases the negative effect of Pb on yield characteristics, which Si significantly ($p \leq 0.05$) increased dry weight of 100 seeds at Pb_0Si_{200} as compared to Pb_0Si_{300}, and also Si decrease the negative effect of Pb at $Pb_{100}Si_{100}$, $Pb_{100}Si_{200}$ as compared to $Pb_{100}Si_{0,}$ these results partially agreed with those mentioned by (Gholami & Falah, 2013) that Si caused to increase yield components found, using silicon in corn plant leads to increase production in this plant.

4.3 Chemical Components

Table (3) shows that Si decreases the negative effect of Pb on photosynthetic pigments, which Si significantly ($p \leq 0.05$) increased chlorophyll **b** $Pb_0Si_{100,}$ Pb_0Si_{200}, Pb_0Si_{300} and also total chlorophyll at Pb_0Si_{300} as compared with Pb_0Si_0, Si decrease the negative effect of Pb on chlorophyll **b** at $Pb_{100}Si_{100}$, $Pb_{100}Si_{200}$, $Pb_{100}Si_{300}$ and also total chlorophyll at $Pb_{100}Si_{100}$ $Pb_{100}Si_{200}$ $Pb_{100}Si_{300}$ as compared with $Pb_{100}Si_0$. Si increase in chlorophyll contents which led to increased photosynthesis and consequently yield components which important to increase production, then those chlorophyll contents of peas plants were increased by silicon addition under non-Pb stress condition, proving beneficial effects of Si on peas growth (Ahmad *et al.*, 2012).

Table 1: Interaction effects of Si and Pb on vegetative growth characteristics after 30 days from application

Interaction treatments		**vegetative growth characteristics**		
Pb mg.Kg^{-1}	**Si ppm**	**Plant height(cm)**	**Number of leaves**	**Number of branches**
0	**0**	**24 ab**	**37 a**	**8.1 a**
	100	**27.66 b**	**41.2 a**	**10.33 a**
	200	**18.66 a**	**31.66 a**	**7.2 a**
	300	**28.2 b**	**40 a**	**9.5 a**
100	**0**	**23.5 ab**	**37.5 a**	**7.8 a**
	100	**24.66 ab**	**33.55 a**	**6.66 a**
	200	**22.33 ab**	**32.66 a**	**7.6 a**
	300	**27.33 b**	**41.33 a**	**8.33 a**

*Data presented as mean, the same letters mean not significant differences while the different letters mean significant differences $p \leq 0.05$

Table 2: Interaction effects of Si and Pb on yield characteristics

Interaction treatments		**Yield characteristics**		
Pb mg.Kg^{-1}	**Si ppm**	**Number of pods.plant^{-1}**	**Number of seeds.pod^{-1}**	**Dry weight of 100 seeds(g)**
0	**0**	**2.66 a**	**2.7 a**	**24.5 ab**
	100	**3.33 a**	**3.34 a**	**17.98 a**
	200	**4.66 a**	**3.8 a**	**27.46 b**
	300	**4.33 a**	**3.5 a**	**21.53 ab**
100	**0**	**3.2 a**	**3.7 a**	**23.41 ab**
	100	**3.1 a**	**4.2 a**	**26.21 b**
	200	**3.66 a**	**3.8 a**	**25.32 b**
	300	**3.33 a**	**3.53 a**	**24.67 ab**

*Data presented as mean, the same letters mean not significant differences while the different letters mean significant differences p≤0.05

Table 3: Interaction effects of Si and Pb on chlorophyll content of leaves ($mg.g^{-1}$fresh weight)

Interaction treatments		Photosynthetic pigments ($mg.g^{-1}$fresh weight)		
Pb $mg.Kg^{-1}$	**Si ppm**	**Chlorophyll a**	**Chlorophyll b**	**Total chlorophyll**
0	0	1.02^{a}	0.66^{ab}	1.68^{ab}
	100	0.99^{a}	0.86^{b}	1.85^{ab}
	200	0.83^{a}	0.8^{b}	1.64^{ab}
	300	1.03^{a}	1.01^{b}	2.05^{b}
100	0	1.05^{a}	0.41^{a}	1.47^{a}
	100	0.89^{a}	0.98^{b}	1.87^{ab}
	200	0.77^{a}	0.96^{b}	1.77^{ab}
	300	0.81^{a}	0.88^{b}	1.7^{ab}

*Data presented as mean, the same letters mean not significant differences while the different letters mean significant differences p≤0.01

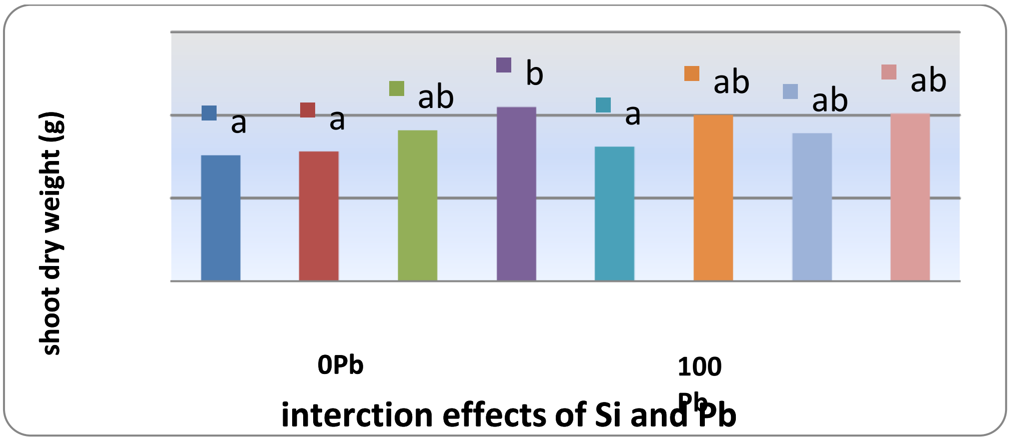

Figure1: Interaction effects of Si and Pb on dry weight of shoot system

*Data presented as mean, the same letters mean not significant differences while the different letters mean significant differences p≤0.05

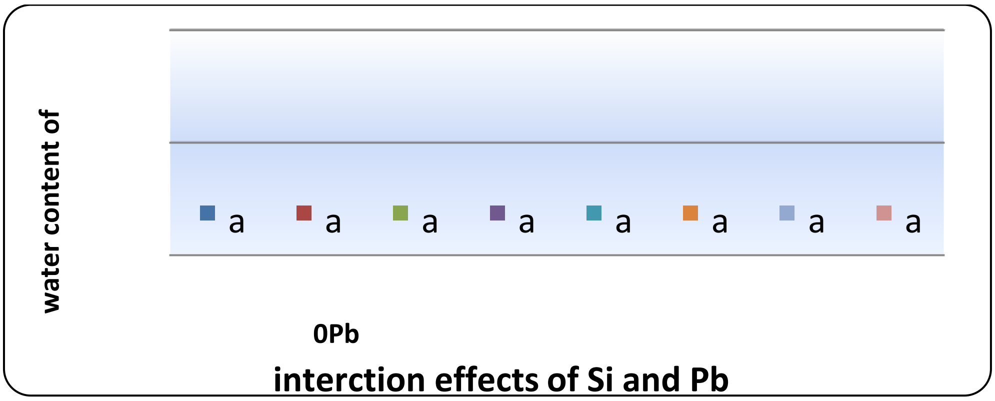

Figure 2: Interaction effects of Si and Pb on water content of shoot system

*Data presented as mean, the same letters mean not significant differences while the different letters mean significant differences p≤0.01

5. Conclusion

The negative effects of Pbtoxicity are on growth, yield characteristics, and chemical components alleviated by foliar application of Si. The results indicated that Si significantly decreased negative effects of Pb on plant height, dry weight of 100 seeds, and chemical contents.

6. Recommendations

1. Conducting more studies regarding Silicon to increase the growth and product characteristics of peas and other crops, especially legumes.
2. More studies are suggested for alleviating negative effects of heavy metals by positive effects of Si.

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