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Role of Fruit peels in mitigating of Lead stress in Broad bean plant

by:

Solin T. Mahmood   *Dlzheen T. Hussain*

Supervised by:

Halala R. Qader

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Abstract

Fruit peels can potentially reduce heavy metal stress in plants, but their effectiveness depends on several factors such as (type of peel, concentration of the metal in the soil, plant properties, and soil properties). Fruit peels are rich in organic materials like cellulose, lignin, and pectin, which can bind to heavy metal ions through a process called adsorption. Studies have shown that peels from banana can effectively adsorb various heavy metals like lead. Fruit peels can use as pre-treatment and using with other remediation techniques, such as phytoremediation, could be more effective. In our study the banana peels not completely eliminate heavy metal or guarantee plant safety, but they reduce the bioavailability and some harmful effect on plant morphology. Plants that treated with banana peel are stronger and have resistance under lead stress than plants that treated with orange peel, due to banana peel contain more antioxidant and rapidly decomposed in soil than orange peel. Lead exposure in plants hinder chlorophyll production, damage chloroplast and rate of photosynthesis but by improving overall plant health and stress tolerance, fruit peels help maintain a better photosynthetic rate under lead stress. Also this process is sustainable, low-cost approach to mitigating heavy metal stress in plants, eco-friendly tool, and reduced food waste.

Keywords: fruit peel, lead, broad bean, heavy metal stress

1. Introduction

Most plants need a certain amount of these top three macronutrients: nitrogen, phosphorus, and potassium. Some plants are more needful of nitrogen, while others are more needful of phosphorus, and still others need a higher level of potassium. Fruit peels contain the most incredible nutrients in the world. There are many health benefits of both orange and banana peels that are unknown (Nossier, 2021), to make the environment free from pollutants. Fruit peels are very rich in macro and micronutrients that are indispensable for plant growth (Dayarathna and Karunarathna, 2021). From orange, a large amount of peel is produced annually. It is primarily a waste, but it is a good source for molasses, pectin, and limonene (Wedamulla *et al*., 2022). Banana peels; it contains also manganese which helps in the photosynthesis process; and sodium, which helps in the movement of water between cells; especially some potassium-loving plants need. and magnesium and sulfur, both of which are helpful in the formation of chlorophyll, also contain calcium, which helps plants to take up more nitrogen (Nossier, 2021). Fruit peel waste accumulates in considerable quantities daily, at domestic and industrial levels. Most frequently, people remove fruit skin and throw away as a waste. It is a vital issue, especially at the industrial level that needs to be appropriately managed (Dayarathna and Karunarathna, 2021).

Broad bean, (*Vicia faba*), is a species of legume (family *Fabaceae*) widely cultivated for its edible seeds. Presently, faba beans are major crop in many countries including China, Ethiopia and Egypt, and are widely grown for human food throughout the Mediterranean region and in parts of Latin America (Singh *et al*., 2013). The climate where common bean originated is sub-tropical to temperate, with defined wet and dry seasons, and bean prefers regions with moderate rainfall, rather than dry regions or areas with excessive rain (Assegid, 2022). Hot, dry weather is injurious to the crop, so early planting is important. Faba bean is excellent crops for cropping systems because its unique ability to fix atmospheric N2 symbiotically which is heavy depends on the sufficient populations of effective rhizobia. It can accumulate N both from soil and the atmosphere (Singh *et al*., 2013). Beneficial attributes of fava bean as a cover crop include: biomass production, high biological nitrogen fixation, upright growth habit, a strong tap root that reduces soil erosion, may suppress weeds, a good pollinator plant, increased populations of beneficial insects, and easy termination and decomposition of residue (Etemadi *et al*., 2018).

Metal uptake is highly a complex process involving metal transfer from soil sap to inside cells of roots (Tangahu *et al.*, 2011). Soil solution then can move between cells and. Once metal ions are taken up by roots, they are either stored by roots or transported to the shoot (Jan and Parray, 2016). Heavy metals such as mercury, cadmium, lead, chromium, and arsenic are considered to pose a significant threat to untargeted living entities due to their toxicity character, even at low concentrations (Di *et al.,* 2023). Some of the heavy metal phytotoxic manifestations include the disturbance of nutrient uptake and translocation, photosynthetic reduction decrease in photosynthetic pigments, inhibition of electron transport, decrease in CO2 fixation, chloroplast disorganization, photo oxidative damage, the generation of reactive oxygen species (ROS), the inhibition of anti-oxidative enzymes, cellular redox imbalance, DNA damage, and protein oxidation (Akhtar *et al*., 2021). Lead is one of the ubiquitously distributed most abundant toxic elements in the soil. It exerts adverse effect on morphology, growth and photosynthetic processes of plants (Yadav, 2010). *Vicia faba* plants have a higher resistance to lead and a faster initiation of the detoxication system than other legumes when cultivated (Kohli *et al*., 2020). Plants exposed to lead ions showed a considerable decrease in the total chlorophyll and those photosynthetic efficiency (Souahi, 2021). High concentrations of lead inhibits chlorophyll synthesis by impaired uptake of other essential ions by plants like Mg and Fe, or due to increased chlorophyllase activity (Dalyan *et al*., 2020). It has been shown that plants exposed to lead ions showed a decline in the photosynthetic rate as a result of distorted chloroplast and restrained synthesis of chlorophyll, as well as deficiency of CO as a result of stomatal closure (Giannakoula *et al.*, 2021).

The main sources of heavy metal pollution include man-made and natural sources. One of the main problems with heavy metals is that they are not metabolized in the body. In fact, heavy metals are not excreted after entering the body, but have been deposited in tissues such as fat, muscles, bones and joints, which causes various diseases and complications in the body. Heavy metals also replace other salts and minerals needed by the body. For example, in case of zinc deficiency in food, cadmium replaces it. In general, neurological disorders (Parkinson's, Alzheimer's, depression, schizophrenia), various cancers, nutritional deficiencies, hormonal imbalance, obesity, abortion, respiratory and cardiovascular disorders, weakened immune system, premature gene destruction, dermatitis, memory loss, anorexia, arthritis, hair loss, osteoporosis and in acute cases death are the results of the effects of heavy metals entering the human body (Budovich, 2021).

Therefore, the purpose of this study was to explore the feasibility of using fruit peel waste for lead stress removal from broad bean plant (*Vicia faba*), due to heavy metal released in the environment has been increasing continuously as a result of industrial activities and technological developments and poses a threat to human health.

2. Materials and methods

2.1 Study area

The study was conducted in the glasshouse of Biology department, College of Science, University of Salahaddin-Erbil, during 10th October 2023 to 16th March 2024. Pot experiment consisted of combination treatments of fruit peels (banana and orange peel) with different concentrations at doses (0, 5, 10 g.pot-1) and method of application (powder of fruit peels banana and orange peels), 12 treatments with two replications, include 24 plastic pots each pot with a diameter of 24 cm in length and 21 cm in depth filled with 7kg of dried sandy loam soil of Askikalak area, the soil sieved through 2mm pore size sieves. In each pot, three seeds were sown and then thinned to one plant later. Soil irrigation on 5th November 2023 by two lead concentrations (0, 10 ml). The following measurements were taken for each pot; plant high (cm). plant^{-1}, number of branches. plant^{-1}, number of leaves. Plant^{-1}, water content, chlorophyll content, stomatal slide.

2.2 Collection and processing of fruit peels

Fruit peels like banana and orange peels collected, these fruit peels washed with tap water, cut to small pieces then dried at sunlight for (14-20) days in late summer after that make these peels as powder by using blender then sieved and stored at room temperature (Dayarathna and Karunarathna, 2021). Fruit peels (banana and orange) as powder methods differently applied to soil in each pot on 10th October 2023.

Figure 1: orange & banana powder

2.3 Water content

After measuring fresh weight, shoots were dried at 110°C for 1 hrs., and then dried at 70°C for 24 hrs., in an oven. After being 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

2.4 Chlorophyll content (mg. g^{-1}fresh weight)

Chlorophyll content in leaves (µg. g -1) estimated on 24th November 2023 by taking 0.5g of fresh leaves, left in 10 ml of absolute ethanol for 72 hrs., in dark condition. This process repeated three times to complete extraction of chlorophyll, the end volume reached 30 ml were spectrophotometric ally estimates on two wave length 649nm and 665nm as follows: (Waterman Demote, 1965).

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

µg Carotenoid/ml solution= (1000 A470 - 2.13 C a - 97.64*C b) /209
A=absorbance
Nm =nanometer

2.5 Preparation of stomatal slide

Prepared depending on nail polish and strip off methods. From fresh leaves, the samples were fixed by nail polish then a girdle was made on the upper surface of the leaf by using lancet, then the wounded epidermis was removed gently using narrow tong, and then washed and stained with safranin and washed again (Al-Khazraji and Aziz, 1990).

2.6. Statistical Analysis

The data were statistically analyzed according to Factorial Completely Randomized Designs (Factorial C.R.D) with three replications and twelve 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. The statistical analysis was carried out by using SPSS program (version 27). For drawing graphs, Excel 2015 software was used.

3. Result and discussion

3.1 Growth characteristics

Table (1) showed that interaction effect of fruit peel and lead significantly ($p \leq 0.05$) increased plant height at (pb_0 banana $peel_{10}$) after 15 days from application, and at (pb_0 orange $peel_5$) after 15 days from application, and at (pb_0 orange $peel_5$) after 45 days from application, although at (pb_{10} banana $peel_{10}$) after 15 days from application, and at (pb_{10} banana $peel_{10}$) after 45 days from application. Also at (pb_{10} orange $peel_5$) after 45 days from application as compared with control. Their interaction significantly ($p \leq 0.05$) increased number of branches at (pb_0 banana $peel_{10}$) after 30 days from application although at (pb_0 orange $peel_{10}$) after 45 days from application. (table 2). These results agreed with those obtained by (Mercy and Jenifer, 2014), which fruit peels as a natural fertilizer increased plant growth. (Jariwala and Syed, 2017) mentioned that fruit peels as a natural fertilizer fulfills as a requirements of micronutrients. Fruit peels contain sugar, protein, nutritional components especially potassium which necessary for plant growth (El-Bassiouny, *et al.,* 2016).

3.2 Photosynthetic pigments

According to results presented in table (4) Interaction effects of fruit peel and Pb significantly ($p \leq 0.01$) increased photosynthetic pigments at (pb_0 banana $peel_{10}$) Chlorophyll b from application, and (pb_0 banana $peel_5$) Total Chlorophyll from application, and (pb_0 banana $peel_{10}$) Total Chlorophyll from application, and (pb_0 banana $peel_5$) Carotenoid from application, and (pb_0 banana $peel_{10}$) Carotenoid from application, and (pb_0 orange $peel_{10}$) Chlorophyll b from application, and (pb_0 orange $peel_{10}$) Total Chlorophyll from application, and (pb_{10} banana $peel_5$) Chlorophyll b from application, and (pb_{10} banana $peel_5$) Total Chlorophyll from application, and (pb_{10} orange $peel_5$) Total Chlorophyll from application. Increasing in chlorophyll a, b, and total chlorophyll increased photosynthetic process which increasing yield of plants and increase production. Carotenoids play as a free radical which increased chlorophyll of such plants (Bakry *et al.,* 2012). Banana peels contain nutrient like phosphorus, magnesium, and calcium, especially potassium, which is absorbed and transported to the plant at a high rate. Effective means, and it has the first role in activating respiratory enzymes, producing adenosine triphosphate (ATP), regulating the rate of photosynthesis, absorbing carbon dioxide, and maintaining the balance of electric charge (Howeidi *et al*., 2023). Fruit peels increased nutrients in plants especially N, P which is used in biosynthesis of chlorophyll content.

3.3 Stomata number in leaves

In table (5) Interaction effects of fruit peel and Pb on number of stomata in leaves of broad bean plant significantly ($p \leq 0.01$) increased total number of stomata at (pb_{10} banana $peel_0$), number of closed stomata at (pb_{10} banana $peel_0$), and number of open stomata at (pb_{10} banana $peel_0$). Although at (pb_{10} banana $peel_5$) number of total stomata and at (pb_{10} banana $peel_5$) number of open stomata. At (pb_{10} orange $peel_0$) number of open stomata, and at (pb_{10} orange $peel_0$) number of closed stomata. At (pb_{10} orange $peel_5$) number of open stomata. As well as at (pb_{10} orange $peel_{10}$) total number of stomata and at (pb_{10} orange $peel_{10}$) number of open stomata. Banana peels are a good source of potassium, a vital nutrient for plants. Potassium plays a role in regulating guard cells, which control the opening and closing of stomata. Improved potassium availability could potentially influence stomata functioning indirectly (Sardans and Peñuelas, 2021).

Table 1: Interaction effects of fruit peel and Pb on plant height at different stages of growth

Interaction treatments			Plant height (cm) after (days) from application		
Pb mg.Kg^{-1}	Fruit peels (gm)		15 days	30 days	45 days
0	Banana peel	0	32.00 bc	36.66 bc	40.33 bc
		5	27.50 bc	33.50 c	35.50 c
		10	36.5 a	42.00 abc	44.00 ab
	Orange peel	0	39.5 a	47.5 a	49.5 a
		5	34.00 bc	38.50 abc	39.00 bc
		10	37.00 a	40.50 abc	44.5 ab
10	Banana peel	0	27.00 c	36.50 abc	39.00 bc
		5	27.5 bc	40.00 abc	41.5 abc
		10	35.5 a	46.00 a	49.00 a
	Orange peel	0	40.5 a	45.5 a	47.50 a
		5	36.00 a	40.00 abc	39.50 bc
		10	41.00 a	43.50 ab	45.00 ab

***Means within the same column, with the same letters are not significantly different from each other according to Duncan's multiple ranges test at 5% level**

Table 2: Interaction effects of fruit peel and Pb on number of branches at different stages of growth

Interaction treatments			Number of branches .plant^{-1}		
Pb mg.Kg^{-1}	Fruit peels (gm)		15 days	30 days	45 days
0	Banana peel	0	9.50 ab	13.50 a	16.00 d
		5	10.00 bc	12.50 ab	15.00 d
		10	9.00 abc	11.50 b	13.66 d
	Orange peel	0	9.50 ab	13.50 a	42.00 ab
		5	10.00 a	13.00 ab	34.00 bc
		10	9.50 ab	13.00 a	32.50 c
10	Banana peel	0	8.50 bc	10.00 ab	11.50 d
		5	8.00 c	11.00 b	16.00 d
		10	9.50 ab	13.00 ab	16.50 d
	Orange peel	0	9.50 ab	11.00 b	48.50 a
		5	9.00 abc	11.00 b	42.00 ab
		10	9.10 abc	11.00 b	43.50 a

***Means within the same column, with the same letters are not significantly different from each other according to Duncan's multiple ranges test at 5% level.**

Table 3: Interaction effects of fruit peel and Pb on number of leaves at different stages of growth

Interaction treatments			Number of leaves.plant^{-1}		
Pb mg.Kg^{-1}	Fruit peels (gm)		15 days	30 days	45 days
0	Banana peel	0	25.00 abc	44.50 ab	45.50 abc
		5	32.50 a	49.50 a	60.50 ab
		10	22.50 bc	40.00 abc	64.50 a
	Orange peel	0	25.00 abc	42.00 abc	45.50 abcd
		5	22.50 abc	34.00 abc	64.50 a
		10	19.50 abc	32.50 bc	54.00 abc
10	Banana peel	0	30.00 bc	48.50 ab	57.00 ab
		5	2.00 bc	32.00 bc	36.00 abc
		10	27.00 abc	40.50 abc	49.50 abcd
	Orange peel	0	17.00 c	45.50 ab	56.50 ab
		5	26.00 abc	42.00 abc	53.50 abc
		10	24.50 abc	43.50 ab	49.50 abcd

***Means within the same column, with the same letters are not significantly different from each other according to Duncan's multiple ranges test at 5% level.**

Table 4: Interaction effects of fruit peel and Pb on photosynthetic pigments

Interaction treatments			Photosynthetic pigments			
Pb mg.Kg^{-1}	Fruit peels (gm)		Chlorophyll a	Chlorophyll b	Total chlorophyll	Carotenoid
0	Banana peel	0	0.47 bc	0.85 b	1.33 f	0.29 d
		5	0.46 bc	1.15 a	1.63 ab	0.84 ab
		10	0.56 bcd	0.93 b	1.49 c	0.74 abc
	Orange peel	0	0.55 bcd	0.80 b	1.36 def	0.52 bcd
		5	0.48 cd	0.85 b	1.34 f	0.70 abc
		10	0.45 d	1.08 a	1.54 bc	0.47 bcd
10	Banana peel	0	0.63 a	0.81 b	1.45 cde	0.64 abcd
		5	0.58 ba	1.09 a	1.67 a	0.79 abc
		10	0.63 a	0.83 b	1.46 c	0.95 a
	Orange peel	0	0.56 abc	0.86 b	1.34 f	0.70 abc
		5	0.47 bc	0.88 b	1.45 cd	0.82 abc
		10	0.52 bcd	0.83 b	1.35 ef	0.45 cd

***Means within the same column, with the same letters are not significantly different from each other according to Duncan's multiple ranges test at 1% level.**

Table 5: Interaction effects of fruit peel and Pb on number of stomata in leaves of broad bean plant

Interaction treatments			Number of tomata		
Pb mg.Kg^{-1}	Fruit peels (gm)		Total number	Open stomata	Closed stomata
0	Banana peel	0	7.33 d	4.66 bcd	2.66 c
		5	7.66 cd	4.33 bcd	3.33 c
		10	10.33 abcd	5.00 bc	5.33 bc
	Orange peel	0	11.00 ab	6.66 ab	4.33 bc
		5	9.00 bc	5.66 bc	3.33 c
		10	13.00 a	6.33 abc	7.00 ab
10	Banana peel	0	10.66 abc	0.66 e	10.00 a
		5	12.33 a	8.66 a	3.66 bc
		10	10.33 abcd	5.66 bc	4.66 bc
	Orange peel	0	11.00 ab	2.00 de	9.00 a
		5	10.33 abcd	5.00 bc	5.33 bc
		10	7.66 cd	3.33 cde	4.33 bc

***Means within the same column, with the same letters are not significantly different from each other according to Duncan's multiple ranges test at 1% level.**

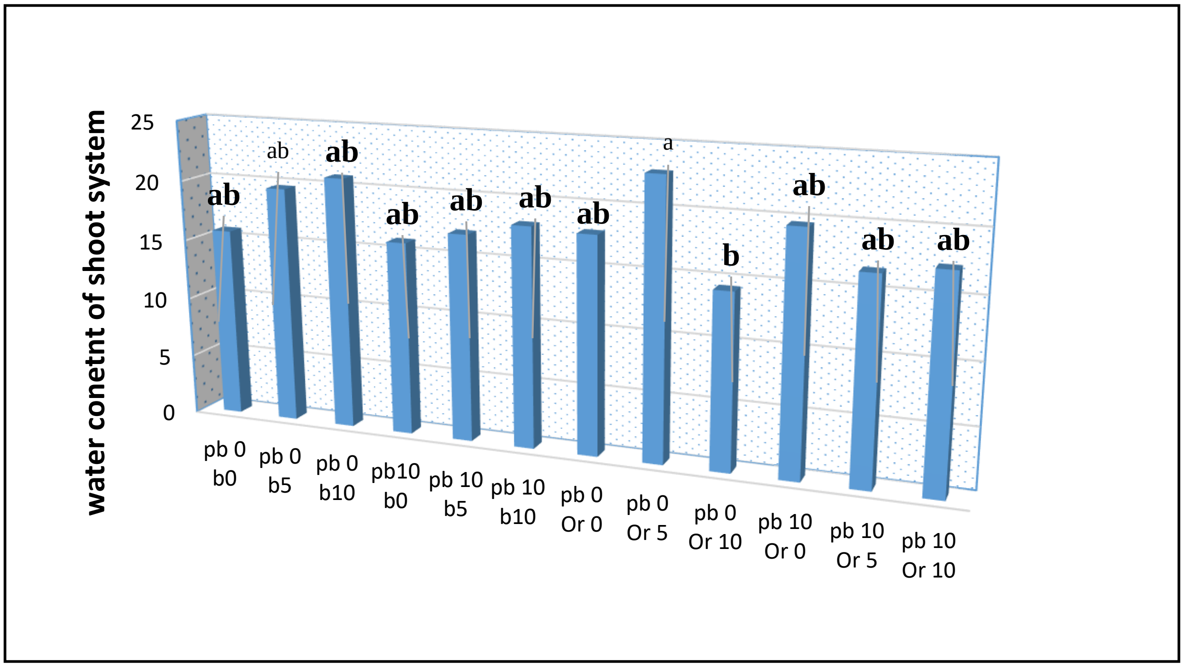

Figure 2: Interaction effects of fruit peel and Pb on water content of shoot system

***Means within the same column, with the same letters are not significantly different from each other according to Duncan's multiple ranges test at 1% level.**

4. Conclusion

This study demonstrated that fruit peels can be beneficial for plants under lead stress. Our result showed that banana peels are more effective than orange peel for broad been plant under lead stress, Plants treated with banana peel exhibited positive effects observed in experiment. However, the process was slower compared to the control group. A few of broad bean that treated with orange peels have positive response to lead stress but required longer time than banana peels. However, banana peels as a potential mitigating factor, offering some level of protection compared to orange peel, emphasize that it doesn't completely eliminate the harm caused by lead.

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