Effect of Phosphorus Fertilizers on The Cadmium Content in Soil and Growth of some Vegetables

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ABSTRACT

Two field experiment (2005/2006 and 2006/2007) were carried out in sandy soil at Abu.El-Atta village, west Nubaria Region to test the rates of cadmium content in soil and eaten parts of some vegetables as affected by four levels of phosphorus fertilizer.

The tested variables were four levels of phosphorus fertilizer rates (0, 100, 200, and 300 Kg P_2O_5, / Feddan). The vegetables used were tomato, lettuce and radish to represent eaten parts such as fruits, leaves and roots, respectively. The obtained results revealed that:

There were significant differences between the rates of phosphorus fertilizer rates and the content of Cd in plant tissues for tomato, lettuce and radish. Notably, Increasing the rate of phosphorus fertilizer increased the Cd content in plant tissue.

The Cd concentration in tomato Juice was 0.12 mg Kg^{-1} at the rate of 300 kg phosphorous fertilizer treatment.

In lettuce, Cd concentration was 0.24 mg Kg^{-1} at the rate of 300 kg phosphorus fertilizer treatment in the whole plant.

4) In radish, Cd was 0.54 mg Kg^{-1} with the treatment of 300 kg phosphorus fertilizer in the whole plant.

In conclusion, application of phosphorus fertilizer, which is used as source of phosphorus at high level could affect the agriculture environment.

The vegetative growth parameters for the three crops (lettuce, tomato and radish) were measured and statistically analyzed for each parameter. The main results were as follows: (1) lettuce: Generally; there was significant increase with all studied parameters till 200 kg phosphorus fertilizer. (2) tomato; Generally, there was significant increase with all studied parameters till 200 kg phosphorus fertilizer, while the yield parameter had significant increase till 300 kg phosphorus fertilizer and (3)radish; Generally, there was significant increase for all studied parameter till 200 kg phosphorus fertilizer The root length parameter was not significant and the fresh yield significant at 200 kg phosphorus fertilizer.

NTRODUCTION

Phosphorus fertilizers are important for supplying grown plants with phosphorus element, but on the other side, the high doses could contaminate the soil and plants with heavy metals like Cd. There is some indirect evidence of possible heavy metal build-up in some agricultural soils related to long term and high doses application of inorganic phosphorus fertilizers (Ewa *et al.*, 1999 and Lee *et al.*, 1997). Tadrova and Dombalov (1995) reported that long-term fertilization with high levels of phosphorus fertilizers increased the concentration of Cd, Cr, Ni, Pb and Zn in soils. The same trend was found by He and Singh (1993); Lee *et al.* (1997) and Jeng and Singh (1999). Barcelo and Pochenrieder (1990) demonstrated, that Cd is considered as one of the most dangerous heavy metals for its high mobility and showed toxic affects in small concentrations on sensitive plants. This heavy metal poses considerable threats to public health, because it can easily transferred to edible portions of vegetables (Zarcinas *et al.*, 1996 and Lehoczky *et al.*, 1996).

Tomato (*Lycopersicon esculentum* L.) is the most widely grown vegetable in the world recognized as a reach source of vitamins and minerals. The inadequate P nutrition reduced tomato yield especially in areas of the field with heavy soil texture (Pettygrove *et al.*, 1999). In a field study at Ambo University (Ethiopia), (Tesfaye Balemi, 2008) reported that using the rates of 110 kg N + 120kg P_2O_5 per hectare, resulted in significantly higher marketable tomato fruit than using 80 kg N + 90 kg P_2O_5 per hectare. Also, Radish (*Raphanus sativus* L.) is grown in large areas and used as salad in Egypt. The eaten part of Radish is the root. In greenhouse experiment Camilia (2006) found that super phosphate application increased P, K and Fe amounts in the tissues of radish roots. Likewise, Lettuce (*Lacluca sativa* L.) is grown in large areas of the newly reclaimed lands of Egypt for salad consumption in the local market and export to Europe. The eaten portion of the plant is leaves.

The objective of this study are to study the effect of using high rates of phosphorus fertilizers on cadmium contamination to soil and vegetable crops in sandy soils.

MATERIALS AND METHODS

The vegetable crops used to evaluate the effect of different rates of phosphorus fertilizers during 2005/2006 and 2006/2007 seasons were as follows:

1. Tomato (c.v. Super super strain B), grown in low tunnels and represents the fruit vegetables.
2. Lettuce (c.v. Romany), represents vegetable leafy crop and,
3. Radish (c.v. Balady), represents vegetable rooty crop.

The soil chemical and physical analyses are presented in Table 1.

Table 1: The physical and chemical analysis of the soil at the experimental site.

A) The chemical analysis of soil samples.

Depth Cm.	E.C dSm^{-1}	pH	Soluble cations and anions meq./l							
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
0 – 30	0.35	9.13	1.23	0.54	1.56	0.17	0	1.10	1.73	0.67
30-60	0..30	9.38	1.25	0.49	1.61	0.15	0	1.07	1.74	0.69

B) The physical soil properties.

Depth (cm)	Bulk density g/cm^3	PWP %	FC %
0 - 15	1.65	6.80	15.61
15 - 30	1.67	6.78	15.39
30 - 45	170	5.99	11.01
45 - 60	1.74	5.97	10.99

C) Soil Texture and its fractions.

Depth cm.	Sand %	Silt %	Clay %	Texture Class
0:30	90.9	2.6	6.5	Sandy
30:60	91.0	1.8	7.2	Sandy

Phosphorus fertilizer was applied in the form of triple Super Phosphate (45-47% P_2O_5) with four fertilization treatments at 0, 100, 200 and 300 kg/feddan. Fertilizer treatments have been repeated on the same plots. There was one crop for each experiment. The Cd content in triple super phosphate was determined and its value was 2.9 ppm. The four fertilization treatments were arranged in a randomized complete block design with three replicates. The total number of plots/crop was 12. The experimental unit was 10 rows, each 10 meters long. Tomato was planted on ridges 1.5 m wide and spacing between plants was 0.5 m. Radish was planted in rows 0.7m wide and on the two sides of the row. Lettuce was planted in rows 0.5 m wide and on the two sides of the row with spacing 0.3 m between plants, with average number of plants 60000/feddan approximately.

According to the most suitable sowing dates, tomato was planted on the 20th of November and the 25th of November for 2005/006 season and 2006/007 season, respectively. Radish and lettuce were grown on the 1st and 7th of October in the 2005/006 and 2006/007 seasons, respectively. All other agricultural practices were applied as recommended for commercial production of the three crops.

At harvest, five plants were taken at random samples from each plot. Vegetative parts (leaves, stems, roots and fruits) were cut, washed with tap water and rinsed with deionized water and dried at 70 °C in a drying oven to a constant weight and ground using a gate mill for chemical analysis.

Soil and plant analysis:

Plant samples (leaves, stems, roots and fruits) were digested in a mixture of concentrated HNO_3 and $HCLO_4$ (4:1by volume). However, P and Cd in the digestion solution were determined with ICP-AES (Chen *et al.*, 2004). A certified standard reference material (SRM 1515, apple leaves) of the National Institute of Standards and Technology, USA, was used in the digestion and analysis as part of the QA/QC protocol (Quality Assurance/Quality Control according to EPA protocol). Reagent blank and analytical duplicates were also used where appropriate to ensure accuracy and precision of the analysis.

Soil samples were digested, at first, with 65% and 72% $HCLO_4$ (Walsh, 1971). Then, with 40%HF for total Cd. The plant available metal concentrations in soil were determined after extraction with 0.005M DTPA (Lindsay and Norvell, 1978).

All plant and soil materials digested and/or extracted were analyzed for Cd, using inductively coupled plasma spectrometry (ICP-MS). The data reported in this paper were the mean of four replicates of the analysis.

Vegetables growth parameters:

Lettuce:

A random sample of 5 plants was taken from each plot after one month from transplanting to record the plant height from soil surface to the top of the plant in cm, Average plant weight (g); average leaves fresh weight (g), stem length (cm), and numbers of leaves was estimated. At harvest time the total fresh yield was determined in t/feddan.

Tomato:

Five random plants from each plot were chosen to collect data about number of leaves at flowering stage, plant height (cm), average number of branches per plant, number of fruits/plant. At harvest, the average fresh fruit yield/feddan was determined.

Radish:

Random sample of five plants were collected from each plot for crop data as, plant length (cm), root diameter cm, root length (cm), dry matter content of roots and total fresh yield (t/feddan) at harvest. Five samples were taken randomly to measure dry mater in roots. Fresh weight of the roots was measured and then the roots were dried in an oven at 70C till the weight is constant, and the dry matter % was calculated.

Data were subjected to the statistical analysis of variance and when the F ratio was significant, the least significant difference (LSD) test was applied using SPSS statistical package version 9.0 for windows 98 to compare treatments means.

RESULTS AND DISCUSSION

Cadmium concentration in tomato plant:

The average results of this research (2005/006 and 2006/007) revealed that Cd content of tomato plants increased with increasing phosphorus fertilizer rate as compared with untreated (control) as shown in Table 2. These results are in agreement with those observed from earlier results on rice, sweet corn, and tomato (Reddy and Patrick, 1977 and Mahler *et al.*, 1980). Also, results in Table 2, showed that the distribution of Cd was not homogeneous. A higher proportion remains in the roots than that transferred to the shoots. This finding is in agreement with those reported by Petterson (1976), who indicated similar results for cucumber, wheat, oat and tomato. Results, also, demonstrated that the concentrations of Cd were highest in roots and decreased in the other parts of plant.

Table 2: Effect of Phosphorus fertilizer rates on Cd in tomato plant.

Phosphorus fertilizer treatment (kg /feddan)	Cd (mg kg^{-1})			
	fruits		Roots +shoots	Whole plant
	Juice	Flesh		
0	0.080	0.009	0.212	0.100
100	0.090	0.010	0.228	0.109
200	0.100	0.015	0.228	0.114
300	0.120	0.020	0.387	0.176
$LSD_{0.05}$	0.032	0.004	0.057	0.029

*Feddan =4200 m^2

Results in Table 2 demonstrate that the root system of tomato seems to act as the first barrier to C in the soil. In spite of the different mobility of metals in plants, the root sys em accumulates them to a significantly higher extent than do the above ground organs and as a result, it is one of the targets of their toxic effect. Ernst *et al.*, 1992, drew similar results. There are significant differences in the Cd concentration in different parts of the plants. However, the variatio of Cd concentration as a function of the rate of application of phosphorus fertilizer did show a clear cut. Generally, Cd concentration in various plants parts was higher at 300 kg phosphorus fertilizer/fed treatment while, other concentrations were not significant. The Cd concentration was in the following order flesh < Juice < root + shoots. The concentrations of Cd ranged between 0.009 and 0.020 mg kg^{-1} , 0.08 and 0.120 mg kg^{-1} and 0.212 and 0.387 mg kg^{-1} in tomato flesh, juice, and roots + shoots, respectively. These results illustrated that vegetative parts especially the roots restricted the transportation of the ion to tomato fruits and reduced the accumulation in the tomato fruits. In other words, Cd was preferentially accumulated in roots and shoots with low transport to fruits. Results revealed that the concentration of Cd in different tissues of tomato plants increased with increasing phosphorus fertilizer rates. In general, the pronounced concentration of Cd in vegetative parts of tomato may be due to the presence of Cd in phosphorus fertilizer, which increases with increasing application rate. In addition, increasing phosphorus fertilizer application increased soil DTPA extractable Cd. This could be responsible for increasing the uptake of Cd by tomato plants, and the accumulation in the vegetative parts, indicated the existence of a reduced translocation of this metal from the vegetative to the reproductive organs. These results are in agreement with those of Pezzarossa *et al.* (1993). ACMS (2003) reported that Health Authorities have set an upper limit for cadmium in root, tuber and leafy vegetables, that is called the "Maximum permitted concentration (MPC)" and is set at 0.1 mg kg^{-1} of fresh weight.

Cadmium concentration in lettuce plant

Results presented in Table 3 indicated that Cd concentrations in leaves and roots of lettuce plant after harvest varied between a minimum value of 0.07 mg kg^{-1} and a maximum value of 0.3 mg kg^{-1} in direct response to application of different levels of phosphorus fertilizer. The results indicated generally, that Cd concentrations in both leaves and roots increased with the increase of phosphorus fertilizer level. Significant differences were found between treatments but no significant difference in Cd content in leaves were observed between treatments 100 and 200 kg /fed. Also, in the roots no significance differences were found between 0 and 100 kg/fed and between 200 and 300 kg /fed treatments. In the whole plant, the Cd content was not significantly different between the 200 and the 300 kg /fed treatments. The Cd concentration in leaves ranged between 0.07 at zero treatment and 0.13 mg kg-1 at 300 kg/fed, whereas in roots, it varied between 0.16 and 0.37 mg kg-1. This can be attributed to the enrichment in Cd in the soil from phosphorus fertilizer which consequently increased Cd concentration in plant tissues. These results are in agreement with the finding of Moral *et al.* (1994) and Pezzarossa *et al.* (1993). The results of Table 3 also showed that phosphorus fertilization increased Cd accumulation in the roots more than its accumulation in the leaves. The results also indicated that lettuce roots observed Cd from the soil and transport it to the shoots to different degrees, but most of the absorbed Cd remains in the root or redistributed to the root from the shoots. This suggestion is confirmed by the study of Cataldo *et al.*, (1983) who reported that normally Cd ions are mainly retained in the roots, and only small amounts are transported to the shoots. Greger and Lindberg (1986) reported a 4 – 10 times increase in the Cd content of sugar beet, *Beta vulgaris L.*, roots when Cd concentration was raised from 5 – 10 mM. They also found that, the Cd content of the shoots was only 10 – 20% of that of the roots. A similar behavior was observed when weeds were grown in clay soil and irrigated with different concentration (5, 10, 20 mg/kg) of Cd (Ewais, 1997). The author further revealed that most of the Cd was accumulated in roots (81%) and only 19% were transported to the shoots. In this respect, lettuce plant may be considered as 'Cd shoot excluders' with Cd accumulating at higher concentrations in roots than in shoots. This behaviour is one of several strategies for plants to tolerate Cd (Weigel and

Jager, 1980). This may be due to the hindrance of the transportation of Cd to the leaves.

Table 3: Effect of phosphorus fertilizer treatments on the average (two seasons) of Cd concentration in lettuce cultivar "dark green".

Phosphorus Treatment ($kg\ P_2O_5/fed^*$)	Cd ($mg\ kg^{-1}$)		
	Leaves	Roots	Whole plant
0	0.07	0.16	0.12
100	0.08	0.23	0.17
200	0.11	0.34	0.2 3
300	0.13	0.37	0.24
$LSD_{0.05}$ **	0.02	0.07	0.04

* fed is fedan = $4200 m^2$
** $LSD_{0.05}$. Least significant differences at 0.05 significant levels

Cadmium concentration in radish plant

Table 4 shows the effect of applying phosphorus fertilizer at four different levels (0, 100, 200, and 300 kg/fed) on the Cd concentration in radish plants. The concentration of Cd in the leaves was 0.78 mg kg^{-1} at 0 level of P and reached 1.04 mg kg^{-1} at 300 kg/fed. . Statistical analysis revealed significant increases in Cd concentration of leaves with increasing levels of phosphorus treatments with respect to control. However, when the phosphorus fertilizer level increased from 200 to 300 kg/fed, the increase in Cd concentration in leaves was not significant. No significant variations were observed in Cd concentration in the roots between tested treatments. The Cd concentrations ranged between 0.51 mg kg^{-1} and 0.54 mg kg^{-1} at 200 kg/fed and 300 kg/fed, respectively. The results showed that the leaves accumulated more Cd than roots under all levels of P. This tendency towards increasing Cd concentration in leaves may be attributed to active transport. These findings are in agreement with the study of Pezzarossa *et al.* (1993). They reported that the application of Cd bearing phosphate fertilizer increased the Cd level in soils and plants. The obtained results also are in agreement with the findings of Moral *et al.* (1994) and Webber (2003), who reported that Cd accumulation in plant materials varies with crop type and plant part and Cd has the ability to be transported to aerial parts. Also, Petterson (1976) claimed that there were significant differences between plant species in their response to different Cd concentration.

Another view was postulated by Schierup and Larsen (1981), who reported that differences in the ability of plants to accumulate heavy metals is related to differences in their root morphology. The investigators suggested that a plant with numerous roots would accumulate more metals than one with few thick roots.

Table 4: Effect of phosphorus fertilizer treatments on the Cd concentration in radish cultivar "Baldy"

Phosphorus Treatment (kg/fed*)	Cd (mg kg^{-1})	
	leaves	Roots
0	0.78	0.51
100	0.90	0.52
200	1.01	0.52
300	1.04	0.54
$LSD_{0.05}$**	0.04	0.03

* 1fed is = $4200m^2$.
** $LSD_{0.05}$: Least significant differences at 0.05 significant levels

In conclusion, the results of the present investigation showed that most of the Cd absorbed is mainly accumulated in the roots of tomato and lettuce plant, while it translocated freely to the leaves in case of radish. Comparing Cd concentration in the three plants at different levels of phosphorus fertilizer revealed that the radish plant accumulated more Cd than both lettuce and tomato plants. Radish plants accumulated Cd from 4.3 to 7.8 times more than tomato plants, while in lettuce plants the range was from 3.23 to 5.6 times. Our results are in close agreement with those reported by Webber (2003), who reported that broad-leaved vegetables accumulate more cadmium than most other plants.

Cadmium and phosphorus concentrations in the soil

Table 5 shows the average content of Cd and P in soils of the three crops and the two growing seasons. The ranges of available Cd in the soil were 0.40-0.5, 0.40-0.45 and0.38-0.44 mg kg^{-1} in soils of tomato radish and lettuce, respectively. The same trend was observed for available P in the soil with increasing phosphorus fertilizers rates. Available P varied from 5.31 to 17.2, 5.3 to 9.7 and 5.3-7.3 mg kg^{-1} in the soils of tomato, radish and the lettuce respectively. The variation of Cd and P in the soils might be due to the amounts of phosphorus fertilizer added to the soil.

Significant positive correlation coefficients (0.975, 0.921 and 0.898) were found between available P and Cd in the three experiments, which could be due to the presence of this heavy metal in the phosphorus fertilizer as contaminant (Nicholson and Jones, 1994). Also a positive and significant correlation coefficient (0.737) was found between the concentration of Cd in plants and the available P of all experimental soils. It could be concluded that excess P helps in the accumulation of Cd in both soil and vegetative parts of tomato, lettuce and radish. Similarly, Pezzarossa *et al.* (1993) observed that Cd concentration in edible parts of plants was dependent on P_2O_5 application.

There are other criteria to evaluate soil contamination by heavy metals such as background concentrations which represent natural elemental concentration in soils without human influence (Chen *et al.*, 1999). The baseline background concentration of Cd in this study is 0.40 and the treated soils of the three crops slightly surpass the background level of cadmium. However, soil contamination may be considered when concentration of an element in soils is two or three times greater than the mean background levels (Logan and Miller, 1983) and none of the treatments reached that level.

Table 5: Effect of phosphorus treatments on the concentration of available and Cd in sandy soils after harvesting tomato, lettuce and radish plants.

Phosphorus Treatment (kg P_2O_5/fed)	Available element (mg kg^{-1}) in soil		Correlation coefficient between P and Cd
	P	Cd	
	tomato plant experiment		
0	5.31	0.40	
100	13.2	0.40	
200	14.7	0.45	
300	17.2	0.51	0.975*
	radish plant experiment		
0	5.3	0.40	
100	7.8	0.41	
200	8.5	0.43	
300	9.7	0.45	0.921*
	lettuce plant experiment		
0	5.3	0.38	
100	6.3	0.39	
200	6.5	0.42	
300	7.3	0.44	0.898*

Correlation coefficient between Cd of leaves and available P in soil is 0.737*

The concentration of Cd in soils of the experimental site increased slightly due to the application of phosphorus fertilizers, but the concentration did not reach contamination levels in the three experiments. An intensive increase of phosphate fertilizer application will lead to the accumulation of available Cd in the soil that in turn affects the Cd content in plants. The results showed that significant correlations between available P and Cd both in soil and plant tissue. The ability of plant to accumulate Cd may depend on crop type and plant part. To avoid the side effects or toxicity of Cd on animals and humans, we recommend using fertilizers low in cadmium and avoiding overuse of phosphorus fertilizers.

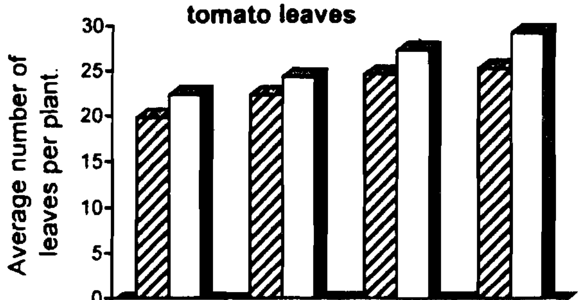
Growth parameters:

The following figures show that total yield and its component (growth parameters) increased with increasing the phosphorus fertilizer rates significantly to the level of 200 kg and the increase after that is not significantly. These figures were similar for all studied vegetable crops.

1) Tomato:

The total fruit yield, number of flowers, number of leaves, stem length, fresh weight of leaves and the total yield increased significantly with increasing the rate of phosphorus fertilizer 200 kg treatment and after that the increase was not significant. But, there was a significant difference between phosphorus fertilizer rates 200 and 300 kg and the total fruit yield of tomato in the two growing seasons. These results are in agreement with those observed by Tesfay Balemt, (2008).

Effect of P fertilizer rates on average number of tomato leaves

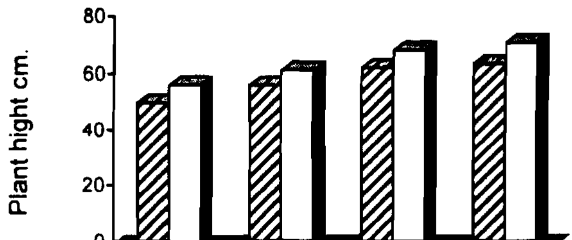


	Control	100	200	300
2005/006	19.83	22.3	24.67	25.33
2006/007	22.33	24.33	27.33	29.33

P fertilizer rates

LSD $_{0.05}$ = 1.44 (2005/006) LSD $_{0.05}$ = 1.96 (2006/007)

Effect of P fertilizer rates on Tomato average plant hight cm.

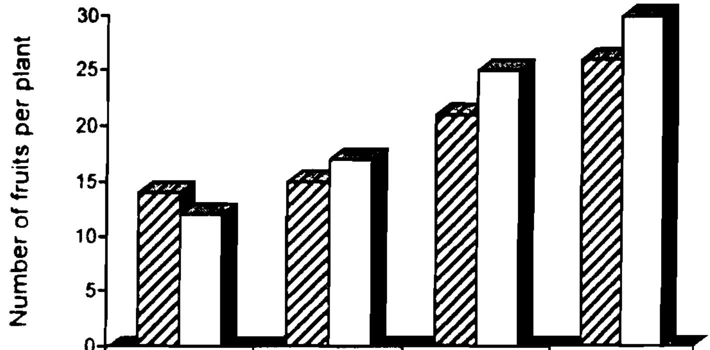


	Control	100	200	300
2005/006	49.7	55.8	62	63.3
2006/007	56	61	68	70.7

P fertilizer rates.

LSD $_{0.05}$ =3.46 (2005/006) LSD $_{0.05}$ = 4.58 (2006/007)

Effect of P fertilizer rates on average number of fruits/ plant for tomato

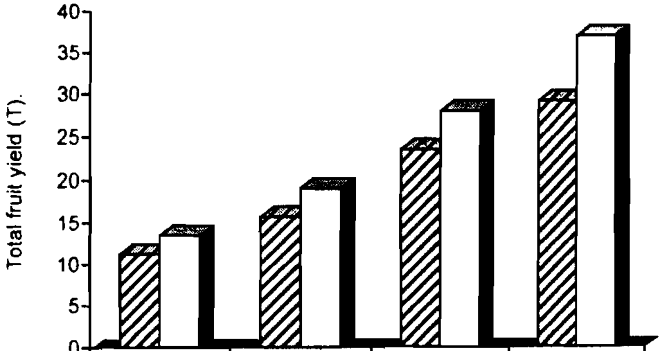


	Control	100	200	300
2005/006	14	15	21	26
2006/007	12	17	25	30

P fertilizers rates

LSD $_{0.05}$ = 2.82 (2005/006) LSD $_{0.05}$ = 3.77 (2006/007)

Effect of P fertilizer or average tomato total fruit yield (t/feddan).



	Control	100	200	300
2005/006	11.2	15.68	23.52	29.13
2006/007	13.44	19.04	28	36.96

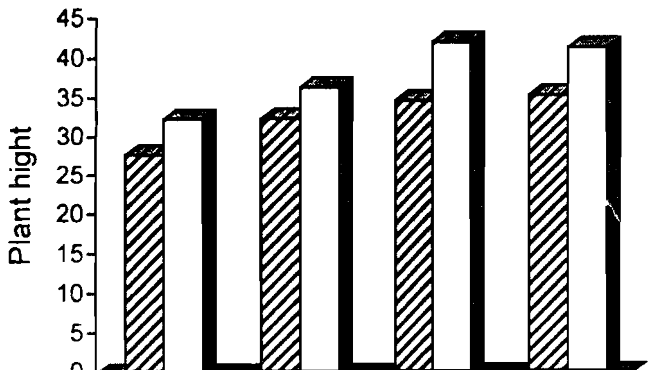
P fertilizer rates.

LSD $_{0.05}$ = 3.16 (2005/006) LSD $_{0.05}$ = 4.20 (2006/007)

2) Lettuce:

The growth parameters as plant height, number of leaves, stem length, fresh weight of leaves and total yield increased significantly with increasing the rate of phosphate fertilizer till 200 unit of P2O5 and after that the increase was not significant. Similar results were observed by Deenik *et al.*,(2007). There is no significant difference between 100 and 200 kg and the plant height in the 2005/006 season. Also, There are no significant differences between the three rates of phosphorus fertilizers and stem length in the first season.

Effect of p fertilizer rates on lettuce average plant hight (cm).

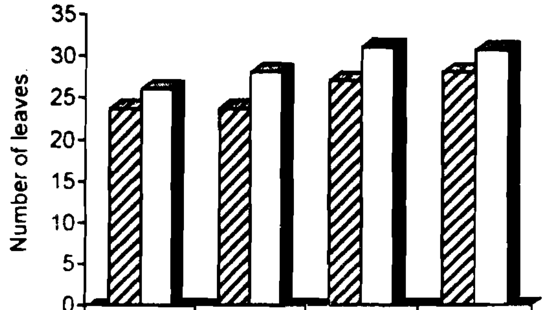


	Control	100	200	300
2005/006	27.66	32.33	34.66	35.33
2006/007	32.33	36.33	42	41.33

Phosphate fertilizer rates.

LSD $_{0.05}$ = 2.55 (2005/006) LSD $_{0.05}$ = 3.52 (2006/007)

Effect of P fertilizer rates on average Number of leaves for lettuce

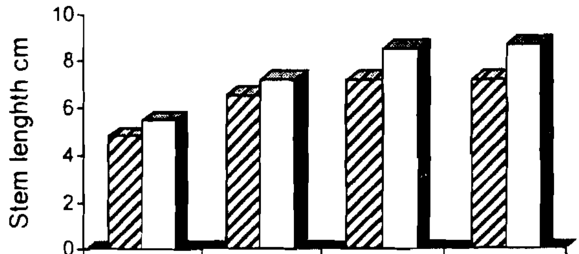


	Control	100	200	300
2005/006	23.66	23.66	27	28
2006/007	26	28	31	30.66

Phosphate fertilizer rates.

$LSD_{0.05}$ = 1.80 (2005/006) $LSD_{0.05}$ = 1.72 (2006/007)

Effect of p fertilizer rates on lettuce average stem lenghth (cm)

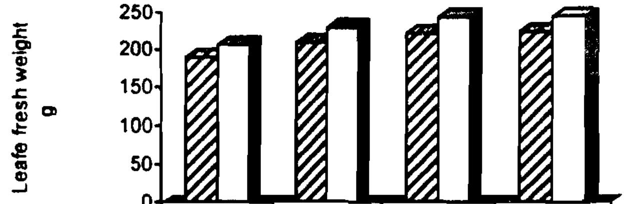


	Control	100	200	300
2005/006	4.83	6.5	7.17	7.17
2006/007	5.5	7.16	8.5	8.66

Phosphate fertilizer rates

$LSD_{0.05}$ = 0.941 (2005/007) $LSD_{0.05}$ = 1.3 (2006/007)

Effect of p fertilizer rates on average total lettuce fresh weight of leaves per plant (g)

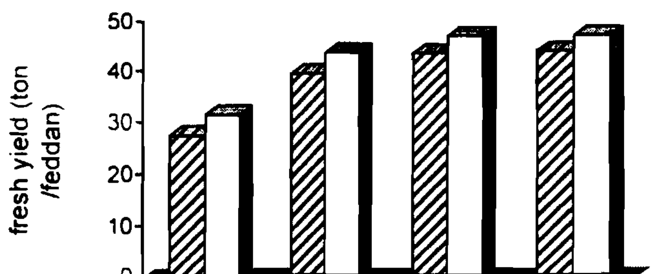


	Control	100	200	300
2005/006	189.3	208.6	221.3	224
2006/007	206	229	243.3	245

Phosphate fertilizer rates

$LSD_{0.05}$ = 12.34 (2005/006) $LSD_{0.05}$ = 14.10 (2006/007)

Effect of p fertilizer rates on average lettuce yield (t/fedan).



	control	100	200	300
2005/006	27.4	39 4	43.4	44
2006/007	31.4	43.6	47	47.13

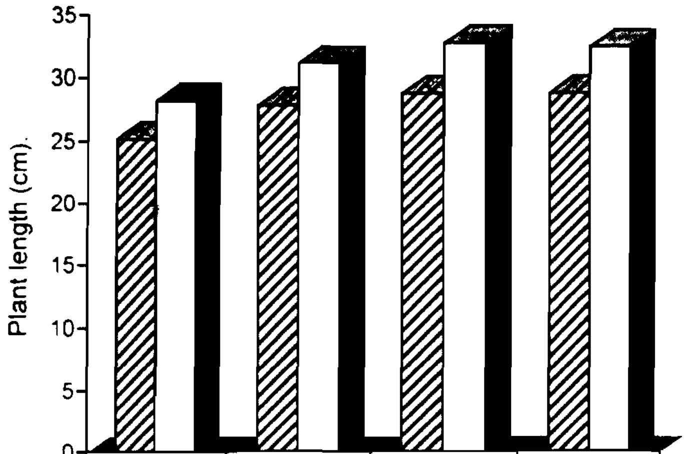
Phosphate fertilizer rates.

$LSD_{0.05}$ = 3.85 (2005/006) $LSD_{0.05}$ = 3.3 (2006/007)

3) Radish

Total root yield and its component (plant height, root length & diameter, and dry matter of leaves and roots) increased with increasing the rate phosphate fertilizer and these observations were similar to what was reported by Wojciech Tyksinski, *et al.*, (2006).

Effect of P fertilizers rates on average length of radish (cm)

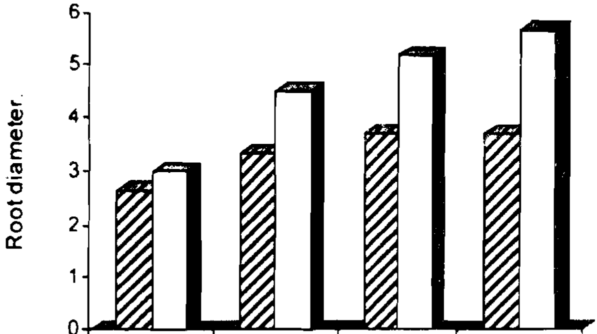


	control	100	200	300
2005/006	25.17	27.83	28.83	28.83
2006/00	28.17	31.17	32.83	32.5

Phosphorus fertilizer rates

LSD $_{0.05}$ = 1.58 (2005/006) LSd $_{0.05}$ = 2.58 (2006/007)

Effect of P fertilizers on average radish root diameter (cm)

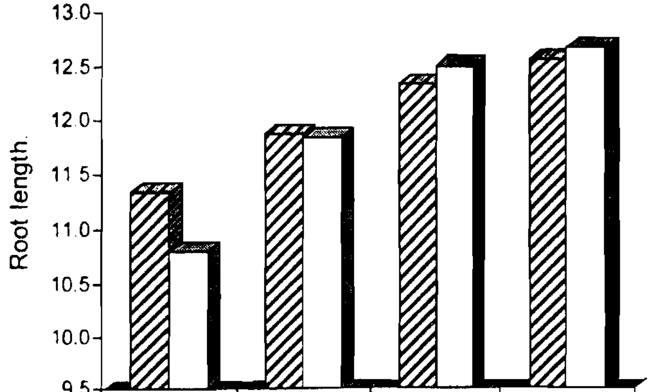


	Control	100	200	300
2005/006	2.66	3.33	3.7	3.7
2006/007	3	4.5	5.17	5.66

Phosphate fertilizers rate

LSD $_{0.05}$ = 0.486 (2005/006) LSD $_{0.05}$ = 1.02 (2006/007)

Effect of P fertilizer on average radish root length (cm)

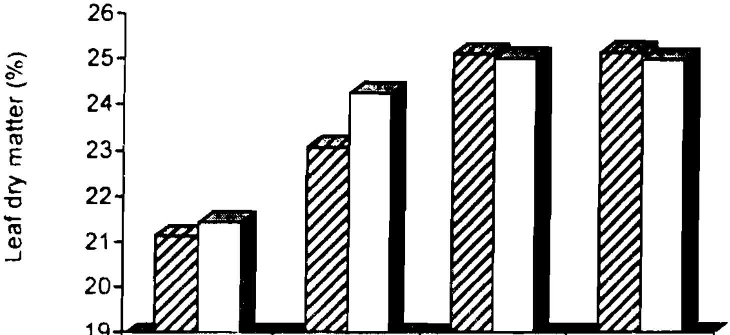


	Control	100	200	300
2005/006	11.33	11.87	12.33	12.57
2006/007	10.8	11.83	12.5	12.67

P fertilizers rates

LSD $_{0.05}$ = 0.403 (2005/006) LSD $_{0.05}$ = 0.666 (2006/007)

Effect of P fertilizer rates on average radish leaf dry matter (g).

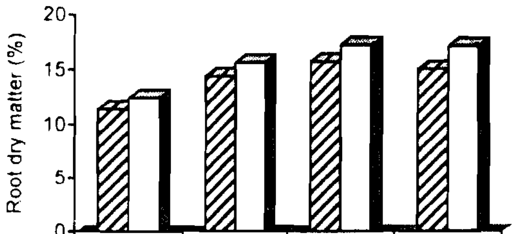


	Control	100	200	300
2005/006	21.13	23.07	25.1	25.13
2006/007	21.43	24.23	25	24.97

P fertilizer rates

$LSD_{0.05}$ = 1.19 (2005/006) $LSD_{0.05}$ = 1.00 (2006/007)

Effect of P fertilizer rates on average radish root dry matter (g).

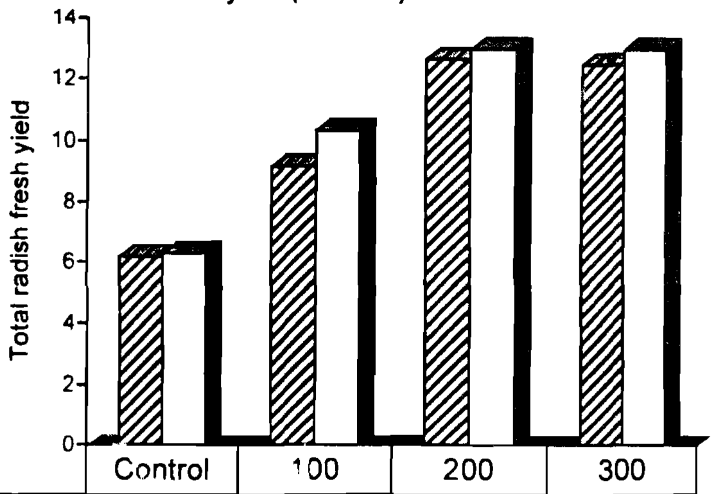


	Control	100	200	300
2005/006	11.4	14.4	15.7	15.03
2006/007	12.4	15.6	17.2	17.07

P fertilizer rates

$LSD_{0.05}$ = 1.41 (2005/006) $LSD_{0.05}$ = 1.40 (2006/007)

Effect of P fertilizer rates on average radish total fresh yield (t/feddan)



	Control	100	200	300
2005/06	6.17	9.17	12.67	12.5
2006/007	6.3	10.33	13	13

P fertilizer rates

LSD $_{0.05}$ = 1.25 (2005/006) LSD $_{0.05}$ = 1.39 (2006/007)

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الملخص العربى

تأثير مستويات التسميد الفوسفاتى على محتوى الأرض وبعض محاصيل الخضر من عنصر الكادميوم

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١ ، ٣ معهد بحوث البساتين ، ٢ معهد بحوث الأراضي والمياه والبيئة

تم إجراء تجربتان حقليتان خلال موسمي ٢٠٠٥ و ٢٠٠٦ بالأراضى الرملية بقرية عبد العظيم أبو العطا شرق الطريق الصحراوى الإسكندرية- القاهرة. وكانت المعاملات كالتالى:

١. أربع مستويات من التسميد الفوسفاتى هى (صفر – ١٠٠ – ٢٠٠ – ٣٠٠) كجم فو٢ أ٥ فى صورة تربل سوبر فوسفات الكالسيوم.

٢. ثلاث محاصيل من الخضر هى (الطماطم – الخس – الفجل) وجاءت النتائج كما يلى:

- هناك فروقاً معنويه بين مستويات التسميد الفوسفاتى ومحتوى أنسجة النباتات النامية (الطماطم – الخس – الفجل) من الكادميوم .
- وجد أن الكادميوم فى عصير الطماطم كان ٠,١ ميجا جرام/كجم ثمار طماطم عند مستوى ٣٠٠ كجم من فو٢ أ٥ فى صورة تربل سوبر فوسفات الكالسيوم.
- فى محصول الخس كان تركيز الكادميوم ٠,٢ ميجا جرام/كيلوجرام من الخس عند مستوى ٣٠٠ كجم فو٢ أ٥ فى صورة تربل سوبر فوسفات الكالسيوم.
- فى محصول الفجل كان تركيز الكادميوم ٠,٦ ميجا جرام/كيلوجرام من الخس عند مستوى ٣٠٠ كجم فو٢ أ٥ فى صورة تربل سوبر فوسفات الكالسيوم

بالنسبة للقياسات الخضرية فى النباتات وجد الآتى:

أولاً: محصول الخس:

وجد أن صفة إرتفاع النبات هناك زيادة معنويه مع مستويات التسميد الفوسفاتى حتى مستوى ١٠٠ وحدة فو٢أ ٥ وبعدها زيادة عير معنوية فى موسم ٢٠٠٥ بينما كانت الزيادة المعنوية حتى ٢٠٠ وحدة فو٢أ٥ فى الموسم الثانى. وبالنسبة لصفة عدد الأوراق كانت هناك زيادة معنويه حتى مستوى ٢٠٠ وجدة فو٢أ٥ فى موسمى النمو. وبالنسبة لصفة طول الساق كانت هناك زيادة معنوية حتى مستوى ١٠٠ وحدة فو٢أ٥ فى موسمى النمو. وبالنسبة لصفة وزن الأوراق الطازجة للنبات الواحد كانت هناك زيادة معنوية حتى ١٠٠ وحدة فو٢أ٥ فى موسمى الدراسة. وبالنسبة لصفة المحصول الطازج كانت هناك زيادة معنوية حتى ١٠٠ وحدة فو٢أ٥ فى الموسم الأول وحتى ٢٠٠ وحدة فى الموسم الثانى.

ثانياً : محصول الطماطم:

بالنسبة لصفة عدد الأوراق على النبات الواحد كانت هناك زيادة معنوية حتى مستوى ٢٠٠ وحدة فو٢أ٥ فى موسمى الزراعة. وبالنسبة لصفة إرتفاع النبات كانت هناك زيادة معنوية حتى ٢٠٠ وحدة فو٢أ٥ فى موسمى الدراسة . وبالنسبة لصفة عدد الثمار للنبات الواحد هناك زيادة معنوية مع التسميد الفوسفات فى موسمى الدراسة.

ثالثاً: محصول الفجل :

بالنسبة لصفة إرتفاع النبات كانت هناك زيادة معنوية حتى مستوى ١٠٠ وحدة فو٢أ٥ فى موسمى الدراسة. بالنسبة لصفة طول الجذر لا توجد فروق معنويو فى موسمى الدراسة. بالنسبة لصفة قطر الجذر كانت هناك زيادة معنوية حتى مستوى ١٠٠ فو٢أ٥ خلال موسمى الدراسة. وبالنسبة لصفة المادة الجافة بالأوراق هناك فروق معنوية حتى ٢٠٠ وحدة فو٢أ٥ فى الموسم الأول و حتى ١٠٠ وحدة فى الموسم الثانى. وبالنسبة لصفة المادة الجافة للجذور فى الفجل كانت هناك زيادة معنوية حتى مستوى ٢٠٠ وجدة فو٢أ٥ فى موسمى الدراسة . وبالنسبة لصفة المحصول الطازج للفجل كانت هناك زيادة معنوية حتى مستوى ٢٠٠ وحدة فو٢أ٥ فى موسمى الدراسة.