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Effect of Road Dust on Vegetative Characters and Leaves Heavy Metal Contents of *Zizyphus spina-christi* (L.) Willd, *Syzygium cumini* (L.) Skeels and *Olea europaea* L. Seedlings

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Abstract: The industrial activities of man and the uncontrolled development of large cities, especially in the near past, resulted in contamination of air, water and soil. Burning crops and combustion of fuel contribute a considerable amount of pollutants to air which are widely believed to have detrimental effects on plants. Seedlings of *Zizyphus spina-christi* (L.) Willd, *Syzygium cumini* (L.) Skeels and *Olea europaea* L. (Picual cv.) were exposed to Alexandria desert road dust by dusting and spraying the dust upon them, to study the effect of these treatments on both the vegetative characters (seedling height, number of leaves/ meter, leaf area and specific leaf density) and the chemical constituents (leaves content of Cd, Cr, Cu, Ni, Pb, Zn and total carbohydrates). Results showed negative effects on the seedlings of the three species as, seedling height, number of leaves/ meter and leaf area decreased whereas, leaves content of heavy metals increased significantly with dusting and spraying treatments when compared to the control, demonstrating clearly that dust treatments have direct adverse effects on vegetative characters and chemical constituents of the three species seedlings.

Key words: Road dust · Christ's thorn jujube · Jambul · Olive · Vegetative characters · Heavy metals · Total carbohydrates

INTRODUCTION

Solid matter which is composed of soil, anthropogenic metallic constituents and natural biogenic materials, is called dust [1, 2]. The particles of dust that deposit from the atmosphere and accumulate along roadsides are called road dust particles [2, 3]. Road dust does not remain deposited in place for long. It is easily re-suspended back into the atmosphere [1, 2].

Motor vehicles introduce a number of pollutants on both sides of roads [4]. Rood dust is a natural sink of organic and inorganic contaminants (e.g. nutrients, toxic pollutants, heavy metals and hydrocarbons) [5]. The most common toxic metals released in road dust are cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni) lead (Pb) and zinc (Zn) [2, 6].

With the development of transportation business, metal levels in plants have significantly increased due to more traffic exhaust combustion [6].

To protect lives from toxic metal contaminants, it is important to study the effect of these toxic metals on spread plants. *Zizyphus spina-christi* (L.) Willd commonly known as Christ's thorn jujube, *Syzygium cumini* (L.) Skeels commonly known as jambul and *Olea europaea* L. commonly known as olive tree, are widespread in Egypt, cultivated for the great economic and social importance and the possible benefits derived from utilization of any of their byproducts [7- 10].

There is a lack of information regarding heavy metals in the dust of Alexandria desert road and its effects on plants. This investigation was, therefore, carried out to determine the effects of dusting and spraying desert road dust on vegetative characters and the contents of heavy metals and total carbohydrates in leaves of *Zizyphus spina-christi* (L.) Willd (Christ's thorn jujube), *Syzygium cumini* (L.) Skeels (jambul) and *Olea europaea* L. Picual cv. (olive) seedlings.

MATERIALS AND METHODS

Species and Dust: *Zizyphus spina-christi* (L.) Willd (Christ's thorn jujube), *Syzygium cumini* (L.) Skeels (jambul) and *Olea europaea* L. Picual cv. (olive) seedlings were transplanted in 30 cm pots at Experimental Farm

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Table 1: Metals analyses of Alexandria desert road side dust sediment.

Elements	Cd	Cr	Cu	Ni	Pb	Zn
Conc. (ppm)	0.04	6.50	2.00	0.03	4.50	4.70

DTPA extraction solution

of Faculty of Agriculture, Cairo, University, Giza, Egypt. Seedlings exposure took place during the period of the beginning of March till the end of July in the two successive seasons of 2008 and 2009. The pots were filled with washed sand as a planting media and were watered regularly to keep the planting media moist.

The dust used in the experiment was collected from the beginning of Alexandria desert road at point of car passing side. Heavy metals analyses of Alexandria desert road side dust sediment are presented in Table (1).

Treatments: The seedlings of the three studied species were dusted (with dry dust) once/ week, once/ 2 weeks and once/ 3 weeks and sprayed (with dust mixed with tap water 1: 2 V/V) once/ week and once/ 2 weeks. Untreated seedlings were known as control.

Vegetative Characters: At the end of the experiment in both seasons the following vegetative characters were determined:

- Number of leaves per meter (No. leaves/ m): five shoots were taken from each replicate randomly to determine both the height of each shoot (cm) and the number of leaves/ shoot, from that, average No. leaves/ m was calculated.
- Leaf area (cm^2): ten leaves were collected from seedlings at each replicate randomly to determine the average leaf area, by using portable leaf area meter (model L13000 made in USA).
- Plant height (cm): five seedlings were taken from each replicate randomly to measure plant height in cm.
- Specific leaf density (mg/cm^2): was calculated by following the formula according to Yehia [11].

$$\frac{\text{Total dry weight (10 leaves) (g)}}{\text{Total leaf area (10 leaves) (cm}^2\text{)}} \times 1000$$

Chemical Analyses: In both seasons, twenty leaves were taken from each replicate randomly and oven dried at 70°C for the chemical analyses. Cd, Cr, Cu, Ni, Pb and Zn contents were measured in mg/100g dry weight at FARP element laboratory, Cairo University. Samples were digested using ETHOS 1 Advanced Microwave Digestion System and determined using Thermo Scientific ICP Spectrometer (iCAP 6000 series). Total carbohydrate contents were determined in g/100g dry weight colorimetrically according to Duboies *et al.* [12].

Experimental Design and Data Analyses: The layout of the experiment was a complete randomized design with one factor, when comparing among means of treatments for each species individually and with two factors (the first was the species and the second was the treatments), when comparing among the interaction means of the three species. Each treatment was replicated three times and eight seedlings were used in each replicate .The obtained data was subjected to analysis of variance (ANOVA) according to Snedecor and Cochran [13]. Mstat - C Program [14] was used to calculate least significant differences LSD to compare among means according to Waller and Duncan [15] at $P \leq 0.05$.

RESULTS AND DISCUSSION

Effect of Dusting and Spraying Treatments on Vegetative Characters of Christ's thorn jujube, Jambul and Olive Seedlings: In the first season, leaf area, No. leaves/ m and plant height values of Christ's thorn jujube seedlings were the highest in control (3.97 cm^2, 132.67 and 98.00 cm, respectively), while they were the lowest in dusting 1/ week treatment (1.39 cm^2, 78.84 and 66.00 cm, respectively) compared to other treatments. In contrast, specific leaf density was the lowest in control (0.48 mg/cm^2) and was the highest in dusting 1/week treatment (1.08 mg/cm^2) compared to other treatments. Similar trend was observed in the second season except for specific leaf density, as dusting 1/ 3 weeks treatment was the heights (2.28 mg/cm^2) (Table 2).

In the first season, leaf area, No. leaves/ m and plant height of jambul seedlings were significantly the highest in control (33.36 cm^2, 53.08 and 134.33 cm, respectively), while they were significantly the lowest in dusting 1/week treatment (17.01 cm^2, 28.33 and 107.00 cm, respectively) when compared to other treatments. Similar trend was observed in the second season (Table 3).

In the first season, leaf area, No. leaves/m and plant height of olive seedlings were significantly high in control (3.88 cm^2, 127.10 and 88.00 cm, respectively) compared to other treatments. Specific leaf density was significantly high with dusting 1/week and 1/2 weeks treatments (2.70 and 2.81 mg/cm^2, respectively) compared to other treatments. Similar trend was observed in the second season (Table 4).

Table 2: Effect of dusting and spraying treatments on vegetative characters of Christ's thorn jujube seedlings (2008 and 2009 seasons).

Treatments	Vegetative characters			
	Leaf area (cm^2)	No. leaves/ m	Plant height (cm)	Specific leaf density (mg/cm^2)
		2008 season		
Dusting 1/ week	1.39	78.84	66.00	1.08
Dusting 1/ 2 weeks	1.70	86.60	74.00	0.82
Dusting 1/ 3 weeks	2.34	103.67	90.33	0.73
Spraying 1/ week	2.48	116.00	87.67	0.89
Spraying 1/ 2 weeks	2.60	116.00	92.33	0.74
Control	3.97	132.67	98.00	0.48
LSD at 0.05	0.41	10.17	6.98	0.45
		2009 season		
Dusting 1/ week	1.49	79.22	67.00	0.81
Dusting 1/ 2 weeks	1.88	88.49	74.33	1.54
Dusting 1/ 3 weeks	2.47	106.48	89.03	2.28
Spraying 1/ week	2.05	112.33	85.67	1.44
Spraying 1/ 2 weeks	2.16	111.67	92.00	0.52
Control	3.13	117.33	99.33	0.58
LSD at 0.05	0.40	13.01	6.60	2.19

Table 3: Effect of dusting and spraying treatments on vegetative characters of jambul seedlings (2008 and 2009 seasons).

Treatments	Vegetative characters			
	Leaf area (cm^2)	No. leaves/ m	Plant height (cm)	Specific leaf density (mg/cm^2)
		2008 season		
Dusting 1/ week	17.01	28.33	107.00	2.63
Dusting 1/ 2 weeks	20.00	33.81	123.00	2.30
Dusting 1/ 3 weeks	24.00	42.57	118.00	2.67
Spraying 1/ week	26.33	46.95	111.67	1.37
Spraying 1/ 2 weeks	26.23	38.89	117.00	0.97
Control	33.36	53.08	134.33	2.12
LSD at 0.05	2.61	4.24	3.68	0.22
		2009 season		
Dusting 1/ week	16.83	29.67	105.00	4.80
Dusting 1/ 2 weeks	21.11	34.35	121.33	2.08
Dusting 1/ 3 weeks	24.67	41.39	114.33	1.70
Spraying 1/ week	27.00	45.57	113.00	1.01
Spraying 1/ 2 weeks	29.00	38.31	120.00	1.15
Control	35.10	48.33	133.33	1.96
LSD at 0.05	1.32	5.13	5.39	0.51

Table 4: Effect of dusting and spraying treatments on vegetative characters of olive seedlings (2008 and 2009 seasons).

Treatments	Vegetative characters			
	Leaf area (cm^2)	No. leaves/ m	Plant height (cm)	Specific leaf density (mg/cm^2)
		2008 season		
Dusting 1/ week	2.39	83.83	62.33	2.70
Dusting 1/ 2 weeks	1.84	96.67	66.00	2.81
Dusting 1/ 3 weeks	3.25	113.33	71.00	2.37
Spraying 1/ week	2.15	95.00	68.67	1.65
Spraying 1/ 2 weeks	2.32	115.12	76.33	1.86
Control	3.88	127.10	88.00	2.32
LSD at 0.05	1.08	7.94	3.94	0.32
		2009 season		
Dusting 1/ week	2.20	85.94	61.67	2.91
Dusting 1/ 2 weeks	2.23	102.83	65.00	4.43
Dusting 1/ 3 weeks	3.25	116.00	70.00	1.91
Spraying 1/ week	2.54	101.67	63.67	2.01
Spraying 1/ 2 weeks	2.27	115.43	74.00	1.19
Control	3.89	127.50	83.33	1.88
LSD at 0.05	0.49	7.97	5.63	0.24

Table 5: Effect of dusting and spraying treatments on heavy metals (mg/100g) and total carbohydrates (g/100g) contents in leaves of Christ's thorn jujube seedlings (2008 and 2009 seasons).

	Chemical analyses						
Treatments	Cd	Cr	Cu	Ni	Pb	Zn	Total carbohydrates
				2008 season			
Dusting 1/ week	0.00	6.68	1.05	0.00	6.48	6.86	62.69
Dusting 1/ 2 weeks	0.00	6.02	1.10	0.00	0.54	5.40	62.31
Dusting 1/ 3 weeks	0.04	4.54	0.83	0.00	0.52	6.23	66.04
Spraying 1/ week	0.01	12.06	1.26	0.00	0.36	5.31	66.22
Spraying 1/ 2 weeks	0.01	5.77	1.37	0.00	0.68	4.84	63.92
Control	0.06	4.55	0.79	0.00	0.36	4.01	74.55
LSD at 0.05	0.26	1.90	0.27	N.S	0.12	0.62	6.80
				2009 season			
Dusting 1/ week	0.00	6.72	1.23	0.00	6.77	6.57	62.09
Dusting 1/ 2 weeks	0.01	6.08	0.92	0.00	0.84	6.29	63.93
Dusting 1/ 3 weeks	0.00	4.12	0.83	0.00	0.54	5.23	63.10
Spraying 1/ week	0.12	5.96	1.23	0.00	0.71	5.89	65.45
Spraying 1/ 2 weeks	0.00	6.23	1.37	0.00	0.51	6.08	64.53
Control	0.00	4.03	0.97	0.00	0.33	3.78	75.54
LSD at 0.05	0.26	1.17	0.26	N.S	0.24	1.09	7.93

Table 6: Effect of dusting and spraying treatments on heavy metals (mg/100g) and total carbohydrates (g/100g) contents in leaves of jambul seedlings (2008 and 2009 seasons).

	Chemical analyses						
Treatments	Cd	Cr	Cu	Ni	Pb	Zn	Total carbohydrates
				2008 season			
Dusting 1/ week	0.01	7.28	1.81	0.00	0.61	6.46	61.12
Dusting 1/ 2 weeks	0.01	3.76	1.35	0.00	0.35	5.17	72.98
Dusting 1/ 3 weeks	0.01	3.56	1.16	0.00	0.45	4.61	68.21
Spraying 1/ week	0.00	3.60	0.47	0.00	0.49	3.95	67.80
Spraying 1/ 2 weeks	0.00	3.04	0.76	0.00	0.31	5.26	69.71
Control	0.01	3.18	0.55	0.00	0.39	3.22	78.27
LSD at 0.05	N.S	1.42	0.30	N.S	0.14	1.78	3.37
				2009 season			
Dusting 1/ week	0.01	5.10	1.49	0.00	0.59	5.81	64.42
Dusting 1/ 2 weeks	0.01	2.08	1.37	0.00	0.57	5.04	64.84
Dusting 1/ 3 weeks	0.00	1.55	0.92	0.00	0.28	5.15	62.30
Spraying 1/ week	0.00	3.48	2.52	0.00	0.45	5.42	62.35
Spraying 1/ 2 weeks	0.01	1.81	0.45	0.00	0.28	4.53	68.08
Control	0.00	0.61	0.66	0.00	0.26	0.88	76.60
LSD at 0.05	N.S	1.26	0.62	N.S	0.26	1.78	6.47

Effect of Dusting and Spraying Treatments on Heavy Metals and Total Carbohydrates Contents in Leaves of Christ's thorn jujube, Jambul and Olive Seedlings: In the first season, Pb and Zn contents were significantly high (6.48 and 6.86 mg/ 100 g, respectively) in leaves of Christ's thorn jujube with dusting 1/week treatment compared to other treatments. Chromium (Cr) content with spraying 1/week was significantly high (12.06 mg/100 g) compared to other treatments, while it was significantly low with dusting 1/3 weeks and control (4.54 and 4.55 mg/100 g, respectively) compared to other treatments. Nickel (Ni) and Cd contents recorded 0.0 mg/100 g in all treatments. Total carbohydrates content was significantly the highest in control (74.55 g/100 g) compared to other treatment. In the second season, similar trend was observed, as control recorded the lowest contents of Cr, Cu, Pb and Zn (4.03, 0.97, 0.33 and 3.78 mg/100 g, respectively) and the highest content of total carbohydrates (75.54 g/100 g) compared to other treatments (Table 5).

In the first season, it was observed that Cr, Cu, Pb and Zn contents in leaves of jambul were the

highest with dusting 1/ week treatment (7.28, 1.81, 0.61 and 6.46 mg/ 100g), while these values were the lowest in control (3.18, 0.55, 0.39 and 3.22 mg/ 100 g) compared to other treatments. Total carbohydrates content was significantly the highest in control (78.27 g/100 g) and it was significantly the lowest with dusting 1/week treatment (61.12 g/100 g) compared to other treatments. Similar trend was observed in the second season (Table 6).

In the first season, Cr content was significantly the highest with spraying 1/ week treatment (6.79 mg/100 g) in leaves of olive seedling, while it was the lowest with dusting 1/3 weeks treatment (3.14 mg/ 100 g) compared to other treatments. Cupper (Cu) content recorded 0.96 and 1.16 mg/100 g with dusting and spraying 1/week treatments, respectively and these means were the highest compared to other treatments. Lead (Pb) content was the lowest in control (0.08 mg/ 100 g), while there were no significant differences among dusting 1/2 weeks, spraying 1/2 weeks, dusting 1/week and spraying 1/week treatments (0.40, 0.42, 0.49 and 0.60 mg/100 g, respectively). Total carbohydrate contents were significantly high with spraying 1/2 weeks and control (69.95 and 73.81g/100g, respectively) compared to other treatments. Similar trend was observed in the second season (Table 7).

Effect of Dusting and Spraying Treatments and Seedling Species on Vegetative Characters of Christ's thorn jujube, Jambul and Olive Seedlings: In the first season, leaf area was the highest in control of jambul (33.36 cm^2) compared to other seedling species and different treatments. No. leaves / m was the highest in control of olive and Christ's thorn jujube (127.00 and 132.67) while, it was the lowest with dusting 1/week treatment (28.33) in jambul seedlings. Plant height was the highest in control of jambul (134.08 cm) compared to other treatments, while it was the lowest 62.33, 66.00 and 66.00 cm with dusting 1/week, dusting 1/2 weeks in olive and dusting 1/week in Christ's thorn jujube, respectively. Specific leaf density was significantly lower with treatments of Christ's thorn jujube (Table 8). Similar trend was observed in the second season (Table 9).

Effect of Dusting and Spraying Treatments and Seedling Species on Heavy Metals and Total Carbohydrates Contents in Leaves of Christ's thorn jujube, Jambul and Olive Seedlings: In the first season, Cr content was significantly the highest with spraying 1/ week treatment in Christ's thorn jujube (12.06 mg / 100 g) while, it was low in control of jambul and olive seedlings (3.18 and 4.04 mg/ 100 g). Lead and Zn contents were the highest in Christ's thorn jujube seedlings (6.48 and 6.86 mg/ 100 g) compared to jambul and olive seedlings,

Table 7: Effect of dusting and spraying treatments on heavy metals (mg/100g) and total carbohydrates (g/100g) contents in leaves of olive seedlings (2008 and 2009 seasons).

	Chemical analyses						
Treatments	Cd	Cr	Cu	Ni	Pb	Zn	Total carbohydrates
				2008 season			
Dusting 1/ week	0.00	3.73	0.96	0.00	0.49	3.50	65.87
Dusting 1/ 2 weeks	0.00	3.58	0.22	0.00	0.40	1.26	63.33
Dusting 1/ 3 weeks	0.00	3.14	0.20	0.00	0.23	1.08	65.79
Spraying1/ week	0.00	6.79	1.16	0.00	0.60	3.64	63.84
Spraying 1/ 2 weeks	0.00	4.40	0.29	0.00	0.42	3.39	69.95
Control	0.00	4.04	0.21	0.00	0.08	1.24	73.81
LSD at 0.05	N.S	0.86	0.60	N.S	0.21	1.92	6.35
				2009 season			
Dusting 1/ week	0.10	4.40	1.60	0.00	0.48	3.39	63.15
Dusting 1/ 2 weeks	0.00	3.82	0.54	0.00	0.45	3.19	63.87
Dusting 1/ 3 weeks	0.00	2.95	0.48	0.00	0.25	1.35	71.86
Spraying 1/ week	0.01	6.46	0.74	0.00	0.59	3.59	68.80
Spraying 1/ 2 weeks	0.02	4.96	0.72	0.00	0.66	6.94	72.04
Control	0.00	4.23	0.38	0.00	0.12	2.21	75.41
LSD at 0.05	N.S	2.00	0.41	N.S	0.17	1.01	7.08

Table 8: Effect of dusting and spraying treatments and seedling species on vegetative characters of Christ's thorn jujube, jambul and olive seedlings (2008 season).

	Vegetative characters			
Treatments	Leaf area (cm^2)	No. leaves/ m	Plant height (cm)	Specific leaf density (mg/cm^2)
		Christ's thorn jujube		
Dusting 1/ week	1.39	78.84	66.00	1.08
Dusting 1/ 2 weeks	1.70	86.60	74.00	0.82
Dusting 1/ 3 weeks	2.34	103.67	90.33	0.73
Spraying 1/ week	2.48	116.00	87.67	0.89
Spraying 1/ 2 weeks	2.60	116.00	92.33	0.74
Control	3.97	132.67	98.00	0.48
		Jambul		
Dusting 1/ week	17.01	28.33	107.00	2.63
Dusting 1/ 2 weeks	20.00	33.81	123.00	2.30
Dusting 1/ 3 weeks	24.00	42.57	118.00	2.67
Spraying 1/ week	26.33	46.95	111.67	1.37
Spraying 1/ 2 weeks	26.23	38.89	117.00	0.97
Control	33.36	53.08	134.08	2.12
		Olive		
Dusting 1/ week	2.39	83.83	62.33	2.70
Dusting 1/ 2 weeks	1.84	96.67	66.00	2.81
Dusting 1/ 3 weeks	3.25	113.33	71.00	2.37
Spraying 1/ week	2.15	95.00	68.67	1.65
Spraying 1/ 2 weeks	2.32	115.12	76.33	1.86
Control	3.88	127.00	88.00	2.32
LSD at 0.05	1.63	6.90	4.78	0.66

Table 9: Effect of dusting and spraying treatments and seedling species on vegetative characters of Christ's thorn jujube, jambul and olive seedlings (2009 season).

	Vegetative characters			
Treatments	Leaf area (cm^2)	No. leaves/ m	Plant height (cm)	Specific leaf density (mg/cm^2)
		Christ's thorn jujube		
Dusting 1/ week	1.49	79.22	67.00	0.81
Dusting 1/ 2 weeks	1.88	88.49	74.33	1.54
Dusting 1/ 3 weeks	2.47	106.48	89.03	2.28
Spraying1/ week	2.05	112.33	85.67	1.44
Spraying 1/ 2 weeks	2.16	110.67	92.00	0.52
Control	3.13	107.33	99.33	0.58
		Jambul		
Dusting 1/ week	16.83	29.67	105.00	4.80
Dusting 1/ 2 weeks	21.17	34.35	121.33	2.08
Dusting 1/ 3 weeks	24.67	41.39	114.33	1.70
Spraying 1/ week	27.00	45.57	113.00	1.01
Spraying 1/ 2 weeks	29.00	38.31	120.00	1.15
Control	35.10	48.33	133.33	1.96
		Olive		
Dusting 1/ week	2.20	85.94	61.67	2.91
Dusting 1/ 2 weeks	2.23	102.83	65.00	4.43
Dusting 1/ 3 weeks	3.25	116.00	70.00	1.91
Spraying 1/ week	2.54	101.67	63.67	2.01
Spraying 1/ 2 weeks	2.27	115.43	74.00	1.19
Control	3.89	127.50	83.33	1.88
LSD at 0.05	0.80	8.34	5.44	1.16

Table 10: Effect of dusting and spraying treatments and seedling species on heavy metals (mg/100g) and total carbohydrates (g/100g) contents in leaves of Christ's thorn jujube, jambul and olive seedlings (2008 season).

	Chemical analyses						
Treatments	Cd	Cr	Cu	Ni	Pb	Zn	Total carbohydrates
Christ's thorn jujube							
Dusting 1/ week	0.00	6.68	1.05	0.00	6.48	6.86	62.69
Dusting 1/ 2 weeks	0.00	6.02	1.10	0.00	0.54	5.40	62.31
Dusting 1/ 3 weeks	0.04	4.54	0.83	0.00	0.52	6.23	66.04
Spraying 1/ week	0.01	12.06	1.26	0.00	0.36	5.31	66.22
Spraying 1/ 2 weeks	0.01	5.77	1.37	0.00	0.68	4.84	63.92
Control	0.00	4.55	0.79	0.00	0.36	4.01	74.55
Jambul							
Dusting 1/ week	0.01	7.28	1.81	0.00	0.61	6.46	61.12
Dusting 1/ 2 weeks	0.01	3.76	1.35	0.00	0.35	5.17	72.98
Dusting 1/ 3 weeks	0.01	3.56	1.16	0.00	0.45	4.61	68.21
Spraying 1/ week	0.00	3.60	0.47	0.00	0.49	3.95	67.80
Spraying 1/ 2 weeks	0.00	3.04	0.76	0.00	0.31	5.26	69.71
Control	0.01	3.18	0.55	0.00	0.39	3.22	78.27
Olive							
Dusting 1/ week	0.00	3.73	0.96	0.00	0.49	3.50	65.87
Dusting 1/ 2 weeks	0.00	3.58	0.22	0.00	0.40	1.26	63.33
Dusting 1/ 3 weeks	0.00	3.14	0.20	0.00	0.23	1.08	65.79
Spraying 1/ week	0.00	6.79	1.16	0.00	0.60	3.64	63.84
Spraying 1/ 2 weeks	0.00	4.40	0.29	0.00	0.42	3.39	69.55
Control	0.00	4.04	0.21	0.00	0.08	1.24	73.81
LSD at 0.05	0.05	1.25	0.37	N.S	0.17	1.38	5.03

Table 11: Effect of dusting and spraying treatments and seedling species on heavy metals (mg/100g) and total carbohydrates (g/100g) contents in leaves of Christ's thorn jujube, jambul and olive seedlings (2009 season).

	Chemical analyses						
Treatments	Cd	Cr	Cu	Ni	Pb	Zn	Total carbohydrates
Christ's thorn jujube							
Dusting 1/ week	0.00	6.72	1.23	0.00	6.77	6.57	62.09
Dusting 1/ 2 weeks	0.01	6.08	0.92	0.00	0.84	6.29	63.93
Dusting 1/ 3 weeks	0.00	4.12	0.83	0.00	0.54	5.23	63.10
Spraying 1/ week	0.12	5.96	1.23	0.00	0.71	5.89	65.45
Spraying 1/ 2 weeks	0.00	6.23	1.37	0.00	0.51	6.08	64.53
Control	0.00	4.03	0.97	0.00	0.33	3.78	75.54
Jambul							
Dusting 1/ week	0.01	5.10	1.49	0.00	0.59	5.81	64.42
Dusting 1/ 2 weeks	0.01	2.08	1.37	0.00	0.57	5.04	64.84
Dusting 1/ 3 weeks	0.00	1.55	0.92	0.00	0.28	5.15	62.30
Spraying 1/ week	0.00	3.48	2.52	0.00	0.45	5.42	62.35
Spraying 1/ 2 weeks	0.01	1.81	0.45	0.00	0.28	4.53	68.08
Control	0.00	0.61	0.66	0.00	0.26	0.88	76.60
Olive							
Dusting 1/ week	0.10	4.40	1.60	0.00	0.48	3.39	63.15
Dusting 1/ 2 weeks	0.00	3.82	0.54	0.00	0.45	3.19	63.87
Dusting 1/ 3 weeks	0.00	2.95	0.48	0.00	0.25	1.35	71.86
Spraying 1/ week	0.01	6.46	0.74	0.00	0.59	3.59	68.80
Spraying 1/ 2 weeks	0.02	4.96	0.72	0.00	0.66	6.94	72.04
Control	0.00	4.23	0.38	0.00	0.12	2.21	75.41
LSD at 0.05	0.05	1.37	0.49	N.S	0.21	1.23	6.28

while they were low in control of olive seedlings (0.08 and 1.24 mg/ 100 g, respectively). Total carbohydrates were significantly high in control of olive, Christ's thorn jujube and jambul seedlings (73.81, 74.55 and 78.27 g/ 100 g respectively), while it was the lowest in dusting 1/week treatment of jambul, Christ's thorn jujube and olive (61.12, 62.69 and 65.87g / 100 g, respectively) (Table 10). In the second season, similar trend was observed (Table 11).

From the data recorded in this study it is clear that, vegetative characters (leaf area, No. leaves/ m and plant height) were high in control compared to other treatments. No differences in specific leaf density were recorded among treatments. Generally, dusting treatments negatively affected the vegetative characters and chemical constituents more than spraying treatments.

Lead, Zn, Cu and Cr contents were highly increased in seedlings by dusting 1/week treatment when compared to other treatments. Cadmium and Ni contents in all treatments were (zero mg/100 g). Total carbohydrate contents were decreased by all treatments when compared to the control. Similar trend was observed in the second season. These results are almost in similar trend in the three studied species (Christ's thorn jujube, jambul and olive).

Regarding the effect of different dust treatments on vegetative characters, a remarkable decrease was observed. This may be due to the considerable portion of the dust entering seedling leaves [16]. The deposition of dust particles, containing heavy metals, into the leaf surface is affected by a number of factors including: particle size and mass, wind velocity, leaf orientation, size and moisture level. The deposited particles may be retained on the plant foliage. The degree of retention and in turn the entry of dust particles is influenced by the weather conditions, nature of pollutant and particle size [17]. These results agree with the findings of Unger and Fuller [18] and Vlamis *et al.* [19] who reported that, high levels of heavy metals may inhibit crop production. El-Siginy and Attala [20] found that, air pollution decreased vegetative and dry weight of apple, pear, peach and plum seedlings. Verma and Singh [17] indicated a significant correlation between changes in different foliar parameters and the status of ambient air quality. Also, Honour *et al.* [4] on urban native herbaceous plant species reported an inhibition of growth in response to pollutant exposure.

Concerning the effect of different dust treatments on heavy metals and total carbohydrates contents, it is clear from the data that there was a remarkable increase in heavy metals and a decrease of total carbohydrates contents. This may be due to the persistence of heavy metals in the air which in turn are transported to the plants [21], as higher plants act as biomonitors of aerial heavy metal contamination because of their bioaccumulative properties [17]. These results agree with those obtained by Ihenyen [22] who reported a high Pb, Cu and Cr concentrations in sediments along high density motor ways, while less metals were found along medium and light density motorways. El-Siginy and Attala [20] found that, air pollution increased heavy metals contents (Zn, Cd, Cr, Pb and Ni) in leaves of apple, pear, peach and plum seedlings. Also, Hegazi *et al.* [23] examined oil and flesh of olive fruits Picual cv. at El-Sadat, El-Saff and El-Salheia districts in Egypt and found that heavy metals contents (Pb, Cd and Ni) varied according to the location and the date of fruit harvesting.

With respect to the effect of dust treatments on different seedling species, the results showed different response of the three studied species. This may be due to the degree of foliage dust retention capacity which is influenced by plant species and foliage surface characteristics [17]. These findings are in line with Ligocki *et al.* [24] who found that, there were varietal differences in respect to heavy metals contents in plant leaves. Madejon *et al.* [25] on wild olive and holm oak trees reported that, oak leaves were higher in trace elements than the olive leaves and there were differences in the concentration of trace elements between leaves and fruits among tree species compared with the control. Also, Ukpebor *et al.* [26] indicated that there were varietal differences between *Delonix regia* and *Causuarina equisetifolia* in heavy metals accumulation in leaves and bark.

CONCLUSION

Significant responses were observed in both the vegetative characters and chemical constituents of Christ's thorn jujube, jambul and olive seedlings affected by Alexandria desert road side dust sediment. The degree of such response depends upon plant resistance toward dust particles. However and despite of these responses, plants were thriving well. Therefore, it is recommended that these plant species may be used as mitigators of pollutants along road sides and around contaminated areas as they can take up and store toxic metals from the dusted environment.

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