Effect of Adding Compost or Loam to The Sandy Soil on Helping *(Murraya paniculata* L.) Jack Plants to Overcome the Toxicity of Some Heavy Metals

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ABSTRACT

Two pot experiments were conducted in the open field at the Experimental Farm of Hort. Res. Inst., Giza, Egypt during 2008 and 2009 seasons to detect the role of application of either compost or loam to sandy soil at the rate of 20% (by volume) in reducing the deleterious effects of lead (Pb), cadmium (Cd) and nickel (Ni) combinations at concentrations of 00.00 ppm for each metal (as a control) (T_1), 500 ppm Pb + 50 ppm Cd + 25 ppm Ni as treatment number two (T_2), and 3-and 5-fold of these concentrations for treatments numbers three (T_3) and (T_4), respectively on the growth and chemical composition of one-year-old *(Murraya paniculata* L.) Jack plants grown in 20-cm-diameter black polyethylene bags filled with 2.5 kg of each of the soil mixtures mentioned above.

The obtained results indicated that survival (%) and vegetative and root growth were progressively decreased in the two seasons with increasing heavy metals concentration, while were improved in response to addition of either compost on loam with the superiority of compost treatment, which gave the highest means in both seasons. Root length, however was significantly reduced in response to either heavy metals treatments or compost. A gradual decrement in the percent of pollution resistance index (PRI %) was also noticed with elevating heavy metals level, but application of either compost or loam greatly improved this parameter. Chlorophyll a, b and carotenoids content in the leaves were cumulatively decreased as the rates of heavy metals were increased, while the contents of Pb, Cd and Ni in the leaves and roots were augmentatively increased. Supporting the sand with either compost or loam markedly decreased the content of Pb, Cd and Ni in the leaves and roots. The mastership in all previous measurements was due to compost treatment.

So, it could be recommended to supply a polluted sandy soil with 20% of compost (by volume) to minimize the harmful effects of heavy metals and improve growth and quality of (*Murraya paniculata* L.) Jack transplants grown in such type of soil.

Key words: compost, loam, toxicity, Murraya paniculata

INTRODUCTION

Many ornamental shrubs are widely used for landscaping and gardening due to their attractive shape, regular form and fragrant flowers. Among these shrubs may be (*Murraya paniculata* L.) Jack (formerly *M. exotica* L.) orange jasmine, satinwood, cosmetic barks shrub or Chinese box. Fam Rutaceae. It is a shrubs or small tree up to 10-12 ft.; leaves odd-pinnate, leaflets 3-9 ovate, rhombic ovate to obovate, glossy; flowers white and fragrant; cultivated widely in tropics as ornamental, blooms several times a year (Bailey, 1976).

However, heavy metals pollution, as an ever growing crisis in different parts of the world, is still the most serious problem that needs a quick solvent, which may involve planting some ornamentals, which are considered not food chain crops, to reduce metals toxicity and protecting the environment from hazards of these metals. In this connection, Shahin *et al.,* (2002) found that *Salvia splendens* plants are more tolerant to Pd, Cd and Hg toxicity than *Vinca rosea* plants, although high concentrations of such metals reduced top and root growth, delayed flowering and depressed floret diameter and stalk length. Chlorophylls a and b content in the leaves of both plants was also decreased, while carotenoids content in as well as Pb, Cd and Hg content in the leaves and roots were greatly increased.

On the same line, were those results attained by Bush *et al.,* (2003) on *Betula nigra* and *Ulmus parvifolia,* Laypheng *et al.,* (2004) on *Bougainvillea spectabilis, Ixora coccinea* and *Heleconia sp.,* (Shahin and El-Malt 2006) on sant, oak and Shahin *et al.,* (2007) on *Matthiola incana* and *Dimorphothica ecklonis. Also,* (Abdalla and Mahmoud 2008) stated that *Acalypha wilkesiana* plants are better than *Asclepias curassavica, Tabernaemontana divarigata* and *Dodonaea viscosa* ones for landscaping contaminated soils with Pb, Cd and Ni metals, as it gave higher percentages of survival and pollution resistance index.

On the other hand, growing plants in the polluted sandy soil subject them to higher stress of toxic pollutants, but this could be minimized by the addition of either loam or organic matter which chelates such pollutants and make them unavailable for plants. Moreover, compost improves soil structure, porosity, water holding and soil fertility (Erhart and Hartl, 2006). In this regard, (Patra and Bhowmike2006) mentioned that metal sequestration by organic compounds is one of the major mechanisms for metal tolerance in plants. Obertello *et al.*, (2006) indicated that there are low molecular weight cystein-rich proteins named metallothioneins widespread throughout some plant species and are able to sequester heavy metals such as Cu, Zn and Cd. They also have an important function in heavy metal metabolism and detoxification and in the management of various forms of cellular stress. (Arvanitoyannis and Kassaveti 2007) reported that composted olive oil waste can find applications (1) as an amendement in agriculture because of its high N and P content, (2) as a biofertilizer, by mixing compost with sphagnum or commercial substance and used for ornamental plants growth and (3) as a biofertilizer for toxic metals removal. (El-Tayeb and Mahmoud 2008) revealed that *Thevetia thevetioides* transplants can tolerate toxicity of Pb, Cd and Ni combination, even at high concentrations when grown in sand amended with 25% of either loam or compost.

The current work was done to examine the role of amending sandy soil with either compost or loam for reducing the deleterious effects of some heavy metals on growth and performance of Murraya transplants.

MATERIALS AND METHODS

Two pot experiments were carried out in open field at the Experimental Farm of Hort. Res. Inst., Giza, Egypt during 2008 and 2009 seasons to study the possibility of reducing the harmful effects of some heavy metals combinations on growth and chemical composition of orange jasmine ornamental shrub by application of either compost or loam to the sandy soil.

Hence, one-year-old plants of orange jasmine (*Murraya paniculata* (L.) Jack) at a height of 20 cm with 3 branches carrying about 18-20 leaves were planted on April, 1st in both seasons in 20-cm-diameter black polyethylene bags (one plant / bag) filled with 2.5 kg of one of the following media: 1- pure sand (S) , 2- sand + 20% compost (S+C) and 3- sand + 20% loam (S+L). The physical and chemical properties of the used sand and loam in the two seasons are shown in Table (a), while the analysis of the used compost showed the following contents: 0.03% carbon, 35.03 % organic matter, C/N ratio of 10.66%, 1.91% N, 0.54% P, 1.40% K, 020% Ca, 0.18 % Mg, 2456 ppm Fe and 2356 ppm Mn.

Thawing salts (acetates) of lead (Pb), cadmium (Cd) and nickel (Ni) produced by Aldrich Chemical Co. Inc., 1001 West Saint Paul Avenue, Wisconsin 53233, USA, were thoroughly mixed in combinations with the used medium before filling bags at the concentrations of 00.00 ppm for each metal as a control (T_1), 500 ppm Pb + 50 ppm Cd + 25 ppm Ni for treatment (T_2), and 3-and 5- fold of these concentrations for treatments (T_3) and (T_4); respectively. In addition, each heavy metals combination was combined with the three studied media to form twelve interaction treatments. The bags were irrigated immediately after planting with 250 ml tap water/bag, but thereafter the irrigation was done once every 3 days with only 200 ml of water/bag. Plants were not fertilized throughout the course of experiment, and were set out in a split design during the two seasons, while the subplot was devoted to media, with 3 replicates; each treatment contained 12 plants Mead *et al.*, (1993) (3 media × 4 pollution tr.× 3 rep. × 5plants = 180 plants).

At the end of each season (October, 30th), the following data were recorded: survival (%), plant height (cm), stem diameter at the base (mm), number of branches and leaves/plant, aerial parts and roots fresh and dry weights (g) and the longest root length (cm). The pollution resistance index (%), as a real index for pollution resistance was calculated from the following equation (Wilkins, 1957):

PRI (%) = Mean root length of polluted transplants/mean root length of the control x 100.

In fresh leaf samples taken from the middle parts of the plants in the second season only, photosynthetic pigments (chlorophyll a, b and carotenoids content (mg/g f.w.) were measured according to the method of Moran (1982). Moreover, the content of Pb, Cd and Ni (ppm) was determined in dry leaf and root samples according to the methods described by Jackson (1973).

Data were then tabulated and statistically analyzed according to SAS program (1994) using Duncan's Multiple Range Test (1955) to verify the significance level among the treatments means.

Table a : Some physical and chemical properties of the used sand and loam in the two seasons

Soil media	Particle size distribution (%)				Saturate ion (%)	pH	E.C. (ds/m)	Cations (meq/l)				Anions (meq/l)		
	Coarse sand	Fine sand	Clay	Silt				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{--}
Sand	89.03	2.35	0.42	8.20	23.10	7.88	3.76	7.50	1.63	33.60	0.50	3.20	22.00	18.03
Loam	10.20	46.15	19.50	24.15	35.00	7.93	3.28	17.50	9.42	20.00	0.79	3.80	10.00	33.91

RESULTS AND DISCUSSION

Effect of heavy metals combinations, media and their interactions on:

I. Survival (%), vegetative and root growth parameters and pollution resistance index (PRI %):

From data averaged in Table (1), it is clear that survival (%) was significantly decreased in response to T_3 and T_4 treatments in both seasons, but was improved in response to application of either compost or loam, with the superiority of compost treatment, which gave the utmost high means in the two seasons. The least survival means were however found attributed to planting in pure sand under the highest concentration of heavy metals (T_4), as this combined treatment gave 36.50% in the first season and 36.67% in the second one. This means that the compost application helps Murraya transplants to resist metallic toxicity more than loam.

Similar observations were also gained concerning plant height (cm), stem diameter (mm) and number of branches and leaves/plant, as well as aerial parts and roots fresh and dry weights (g), as the means of these parameters Tables (1 and 2) were gradually declined with rising heavy metals concentrations, but were significantly increased as a result of amendment with either compost or loam. The prevalence was also due to compost treatment which gave the highest records in most cases of both seasons. The opposite was the right regarding root length (cm), which was significantly decreased in response to either heavy metals treatments or compost and loam treatments Table (3). The shortest roots in the two seasons, were recorded by plants polluted with T_4 treatment and planted in the medium which contained 20% loam.

The reduction of vegetative and root growth parameters may be due to accumulation of toxic metals in tissues of Murraya transplants (as indicated in Table (3) which usually leads to depression of vital processes, such as photosynthesis, inhibition of some enzymatic systems and blocking the formation of proteins and chlorophylls (Mengel and Kirkby, 1979). In addition, the organic Pb was found to derange the spindle fiber mechanism of cell division in plants Fay *et al.,* (1978). A reduction in glutathione reductase activity in relation to Cd and Ni stress was registered by (Sckickler and Caspi 1999) on *Alyssum argentium.* Improvement of growth due to compost application may explain the role of organic matter in chelating the toxic elements and preventing their harmful effects, besides improving soil structure, porosity, water holding capacity and fertility (Erhart and Hartl, 2006).

As for the pollution resistance index (PRI %), data in Table (3) showed a gradual reduction in the means of such trait with elevating toxic metals concentration. This may be attributed to the gradual reduction in root length under excessive stress of heavy metals. On the other side, addition of either compost or loam significantly improved this character comparing with planting in pure sand in most cases of both seasons. In general, PRI means were above 59%, even for plants grown in pure sand and subjected to the highest level of toxic metals (T_3). This may indicate the ability of Murraya plants to withstand heavy metals toxicity.

The previous results are in accordance with those of Shahin *et al.,* (2002) on *Salvia splendens* and *Vinca rosea,* Laypheng *et al.,* (2004) on *Bougainvillea spectabilis, Ixora coccinea* and *Heleconia sp.* and Abdalla and Mahmoud (2008) on *Acalypha wilkesiana, Asclepias curassavica, Tabernaemontana divarigata* and *Dodonea viscosa* shrubs.

II. Chemical composition:

Data presented in Table (4) exhibit that chlorophyll a, b and carotenoids content (mg/g f.w.) in the leaves was cumulatively decreased as the concentrations of heavy metals increased to reach the minimum values in the leaves of plants subjected to T_4 treatment. Such constituents, were, on the other hand, increased due to application of either compost or loam, with the mastery of compost treatment which gave the best records. The reduction of pigments may be attributed to the direct effect of heavy metals on photosystems related to the disturbances caused by these metals in Calvin cycle reactions and down regulation or even feedback inhibition of electron transport by the excessive amounts of ATP and NADPH Krupa *et al.,* (1993), while the increase in the content of pigments due to compost treatment may indicate the role of compost in providing plants with some nutrients necessary for biosynthesis reactions (Erhart and Hart, 2006), as well as its role in sequestration of toxic metals and stopping their deleterious effects (Patra and Bhowmifee, 2006).

On the contrary of pigments results, the contents of Pb, Cd and Ni in the leaves and roots were gradually increased with increasing their level in the medium, but were decreased as a result of amendment with either compost or loam. The role of compost in reducing metals uptake by plants was more pronounced than that of loam. This may be reasonable because composted organic wastes may act as surfaces for chelting toxic metals (Arvanitoyannis and Kassaveti, 2007).

According to the aforestated results, it is preferable to provide sandy soil with 20% of compost, rather than loam to help *Murraya paniculata* transplants to grow well in sandy soil polluted with Pb, Cd and Ni metals.

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Table 1 : Effect of heavy metals concentrations, media and their interactions on survival % and some vegetative growth parameters of (*Murraya paniculata* L.) Jack plants during 2008 and 2009 seasons

Media / Pb+Cd+Ni Concentration (ppm)	Survival (%)				Plant height (cm)				Stem diameter (mm.)				No. branches/plant				No. leaves/plant			
	Sand	S+C	S+L	Mean	Sand	S+C	S+L	Mean	Sand	S+C	S+L	Mean	Sand	S+C	S+L	Mean	Sand	S+C	S+L	Mean
First season: 2008																				
0.0+0.0+0.0(T_1)	100.00a	100.00a	100.00a	100.00a	50.11b	54.18a	51.00b	51.76a	7.71cb	10.27a	8.20b	8.73a	3.80b	5.33a	4.00ba	4.38a	42.30cb	52.38a	45.00b	46.56a
500+50+25 (T_2)	100.00a	100.00a	100.00a	100.00a	30.70d	36.78c	31.56d	33.01b	5.75cd	7.53cb	6.18c	6.49b	3.25cb	5.00a	3.47b	3.91ab	40.41c	45.10b	45.00b	43.50b
1500+150+75 (T_3)	60.10c	100.00a	85.76b	88.76b	28.61e	37.00c	30.51d	32.09b	4.70de	5.76cd	5.00d	5.15c	2.81cd	3.38b	3.00c	3.06b	32.10e	36.00d	34.15de	34.08c
2500+250+125 (T_4)	36.50d	80.33b	92.51c	59.78c	25.50f	30.28d	27.33e	27.70c	3.86e	4.87d	4.00e	4.24d	2.15d	3.00c	2.26d	2.47c	21.76g	27.44f	24.20gf	24.47d
Mean	74.15c	95.08a	87.07b		33.73c	39.56a	35.10b		5.51b	7.11a	5.85b		3.00b	4.18a	3.18b		34.14c	40.23a	37.09b	
Second season: 2009																				
0.0+0.0+0.0(T_1)	100.00a	100.00a	100.00a	100.00a	52.61b	57.43a	53.96b	54.67a	8.13b	10.00a	8.70ba	8.94a	4.00b	5.00a	4.33ba	4.44a	43.61cb	55.56a	48.76b	49.31a
500+50+25 (T_2)	83.33b	100.00a	100.00a	94.44a	31.66ed	40.08c	33.40d	35.05b	5.90cd	7.95b	6.23c	6.69b	3.45cb	5.00a	3.70b	4.05ab	42.18c	47.71b	47.10b	45.66b
1500+150+75 (T_3)	66.67c	100.00a	83.33b	83.33b	27.50fe	38.56cd	30.36e	32.14cb	4.63de	6.00c	5.00d	5.21c	2.90cd	3.60b	3.18c	3.23b	33.21e	38.00d	35.33ed	35.51c
2500+250+125 (T_4)	36.67d	76.88cb	58.46c	57.34c	24.72f	33.10d	28.72ef	28.85c	3.95e	5.09d	4.21ed	4.42d	2.33d	3.20c	2.46d	2.66c	22.85g	29.15f	26.12gf	26.04d
Mean	71.67c	94.22a	85.45b		34.13c	42.29a	36.61b		5.65b	7.26a	6.04b		3.17b	4.20a	3.42b		35.46c	42.61a	39.33b	

- S+C = Sand amended with 20% compost, and S+L = Sand amended with 20% loam.
- Means within a column or mean line having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

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Table 2: Effect of heavy metals concentrations, media and their interactions on aerial parts and roots fresh and dry weights of (*Murraya paniculata* L.) Jack plants during 2008 and 2009 seasons

Media / Pb+Cd+Ni concentration (ppm)	Aerial parts f.w. (g)				Aerial parts d.w. (g)				Roots f.w. (g)				Roots d.w. (g)			
	Sand	S+C	S+L	Mean	Sand	S+C	S+L	Mean	Sand	S+C	S+L	Mean	Sand	S+C	S+L	Mean
	First season: 2008															
0.0+0.0+0.0(T_1)	7.96bc	9.63a	8.47b	8.69a	2.51b	3.85a	3.37ab	3.24a	4.60bc	6.77a	4.89b	5.42a	3.20cb	4.73a	3.42b	3.78a
500+50+25 (T_2)	6.32c	9.20a	6.71c	7.41b	2.38bc	3.62a	2.68b	2.89b	3.61c	5.17b	3.97c	4.25b	2.63cd	3.57b	2.80c	3.00b
1500+150+75 (T_3)	4.13e	5.83d	4.36e	4.77c	1.64cd	2.33bc	1.75c	1.91c	2.63ed	4.11cb	2.87d	3.20c	1.90d	2.88c	2.01d	2.26c
2500+250+125 (T_4)	3.71f	4.81ed	3.98f	4.17c	1.46d	1.92c	1.60dc	1.66c	1.67e	2.76d	1.86e	2.10d	1.36e	1.93d	1.45e	1.58d
Mean	5.53b	7.37a	5.88b		2.00c	2.93a	2.33b		3.13b	4.70a	3.40b		2.27b	3.28a	2.42b	
	Second season: 2009															
0.0+0.0+0.0(T_1)	8.33b	10.21a	8.97b	9.17a	3.12b	4.12a	3.68ab	3.64a	4.73bc	6.58a	5.20b	5.50a	3.36cb	4.60a	3.60b	3.85a
500+50+25 (T_2)	6.73cd	9.57a	7.13c	7.81b	2.56cb	3.88a	2.86bc	3.10b	3.90c	5.46b	4.25c	4.54b	2.70cd	3.77b	2.93c	3.13b
1500+150+75 (T_3)	4.38fe	6.30d	4.67ef	5.12c	1.80cd	2.50cb	1.90c	2.07c	2.71ed	4.35cb	2.98d	3.35c	1.93d	3.00c	2.10d	2.34c
2500+250+125 (T_4)	3.97f	5.10e	4.22f	4.43c	1.53d	2.03c	1.70dc	1.75c	1.87e	2.90d	2.00e	2.26d	1.41e	2.02d	1.54e	1.66d
Mean	5.85b	7.80a	6.25b		2.25c	3.13a	2.54b		3.30b	4.82a	3.61b		2.35b	3.35a	2.54b	

- **S+C** = Sand amended with 20% compost, and **S+L** = Sand amended with 20% loam.
- Means within a column or mean line having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

Table 3 : Effect of heavy metals concentrations, media and their interactions on root length and pollution resistance index (PRI) of (*Murraya paniculata* L.) Jack plants during 2008 and 2009 seasons

Media / Pb+Cd+Ni concentration (ppm)	Root length (cm)				PRI (%)			
	Sand	S+C	S+L	Mean	Sand	S+C	S+L	Mean
	First season: 2008							
0.0+0.0+0.0(T1)	33.98a	28.33b	24.50c	28.94a	100.00a	100.00a	100.00a	100.00a
500+50+25 (T2)	32.10a	26.81cb	21.46d	26.79b	94.47a	94.63a	87.59b	92.23b
1500+150+75 (T3)	23.50dc	22.00d	20.00e	21.83c	69.16d	77.66c	81.63cb	76.15c
2500+250+125 (T4)	20.31e	18.91fe	17.31f	18.84d	59.77e	66.75ed	70.65d	65.72d
Mean	27.47a	24.01b	20.82c		80.85b	84.76a	84.97a	
	Second season: 2009							
0.0+0.0+0.0(T1)	36.28a	31.10b	26.53c	31.30a	100.00a	100.00a	100.00a	100.00a
500+50+25 (T2)	35.00a	30.50b	23.63de	29.71b	96.47a	98.07a	89.07b	94.54b
1500+150+75 (T3)	24.11d	24.32d	21.90e	23.44c	66.46de	78.20dc	82.55c	75.74c
2500+250+125 (T4)	21.82e	20.80ef	18.87f	20.50d	60.14e	66.88de	71.13d	66.05d
Mean	29.30a	26.68b	22.73c		80.77b	85.79a	85.69a	

- S+C = Sand amended with 20% compost, and S+L = Sand amended with 20% loam.
- Means within a column or mean line having the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

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الملخص العربي

تأثير إضافة الكومبوست أو الطمي لمساعدة شتلات الموارايا المنزرعة فى تربة رملية على تحمل سمية بعض العناصر الثقيلة.

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أجريت تجربتان من تجارب الأصص في العراء بالمزرعة التجريبية بمعهد بحوث البساتين، الجيزة، مصر خلال الموسمين المتتاليين ٢٠٠٨ ، ٢٠٠٩ و ذلك للتعرف على دور إضافة الكومبوست أو الطمي إلى التربة الرملية بمعدل ٢٠% (بالحجم) في خفض التأثيرات الضارة لعناصر الرصاص، الكادميوم و النيكل (في توليفات) بالتركيزات التالية: صفر جزء في المليون لكل عنصر (كمقارنة)(T_1) ، ٥٠٠ جزء في المليون رصاص + ٥٠ جزء في المليون كادميوم + ٢٥ جزء في المليون نيكل للمعاملة الثانية (T_2) ، و كذلك ثلاثة و خمسة أضعاف هذه التركيزات للمعاملتين الثالثة (T_3) و الرابعة (T_4) ، على الترتيب، و ذلك على النمو و التركيب الكيميائي لشتلات الورايا عمر سنة *Murraya paniculata* L.) Jack) المنزرعة في أكياس بلاستيك سوداء قطرها ٢٠سم ملأت بحوالي ٥,٢ كيلو جرام من أحد مخاليط التربة المذكورة آنفاً.

و لقد أوضحت النتائج المتحصل عليها أن النسبة المئوية للبقاء على الحياة، و كذلك قياسات النمو الخضري و الجذري قد انخفضت تدريجياً كلما زاد تركيز العناصر الثقيلة، بينما تحسنت هذه الصفات عند اضافة الكومبوست أو الطمي، مع تفوق معاملة الكومبوست و التي أعطت أعلى المتوسطات بكلا الموسمين. أما طول الجذر فقد انخفض معنوياً نتيجة للمعاملة إما بتوليفات العناصر الثقيلة أو بإضافة الكومبوست أو الطمي. كما لوحظ أيضاً حدوث انخفاض تدريجي في النسبة المئوية لمعامل مقاومة التلوث (PRI%) كلما زاد تركيز العناصر الثقيلة، بينما أدت اضافة الكومبوست أو الطمي إلى تحسين هذا القياس بدرجة كبيرة. أيضاً فقد انخفض محتوى الأوراق من كلوروفيللي أ، ب و الكاروتينويدات انخفاضاً متزايداً كلما زاد تركيز العناصر الثقيلة في وسط النمو، بينما زاد محتوى الأوراق و الجذور من عناصر الرصاص ، الكادميوم و النيكل بشكل متصاعد بزيادة تركيز تلك العناصر. أما تحسين التربة الرملية باضافة ٢٠% من الكومبوست أو الطمي فقد أدى إلى خفض محتوى هذه العناصر بشكل ملحوظ في كلٍ من الأوراق و الجذور. و لقد ارجعت الزيادة في جميع القياسات السابقة للمعاملة بالكومبوست و التي أعطت أفضل النتائج على الاطلاق.

و عليه، فإنه يمكن التوصية باصلاح التربة الرملية باضافة ٢٠% من الكومبوست (بالحجم) لخفض التأثيرات الضارة للعناصر الثقيلة و لتحسين نمو و جودة شتلات الموارايا *Murraya paniculata* L.) Jack) النامية في الأراضي الرملية الملوثة بتلك العناصر.