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Industrial Orange Wastes as Organic Amendments in Citrus Orchards

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Abstract: A field experiment was conducted during the two successive seasons (2012/2013 and 2013/2014) on 22 years old "Valencia" orange trees budded on sour orange grown in a private orchard have sandy soil texture located at Southern El-Tahreer Province, Behaira Governorate, Egypt. The main objective of this study is to investigate the effect of two dried orange wastes (Pulp and peel) as organic fertilizer on nutritional status, leaf chlorophyll content, fruit set and yield of "Valencia" orange trees. Dried orange wastes were separately amended to trees at doses: 200,400,600 and 800 g /tree. Organic fertilization with industrial orange wastes produced an improvement in nutritional status; fruit set and yield progressively with dose amended to trees up to highest dose (800 g/tree). Superiority of pulp waste over peel one was observed in exerting the abovementioned beneficial effects.

Key words: "Valencia" Orange · Organic Fertilization · Industrial Orange Wastes · Nutritional Status · Chlorophyll · Fruit Set · Yield

INTRODUCTION

Economic citrus productivity increased with extension in orange juice industry, which produces large quantities of sold wastes. In Egypt, many factories in field of food industries saving costs of the traditional orange waste. Huge amounts of wastes are simply left to rot exerting serious environmental consequences. The reuse of industrial orange wastes as organic fertilizer could represent a sustainable approach to recycling nutrients and reinterring organic matter to soil. Importance of organic fertilization has been reported by many researchers [1-4]. It improves chemical properties by increasing cation exchange capacity, holds water, makes soil wormer, gives better aerated soil and promotes microbial activity. Nutritional status of orange trees considered the most important factor affect on growth and productivity [5, 6]. Adequate supply of N, P, K, Ca and Mg are important for citrus growth [7]. Application of industrial orange waste is certainly impeded by limited knowledge and little researches on composition [8] and its effect on crop response [9]. To identify the effective and valuable re-use of citrus agro-industrial waste as organic fertilizer. This research was designed to study the effect of different doses of industrial orange wastes (Pulp and peel) as supplemental amendments on nutritional status, chlorophyll content, fruit set and yield of "Valencia" orange trees.

MATERIALS AND METHODS

This study was carried out during the two successive seasons 2012/2013 and 2013/2014 on 22 years old "Valencia" orange trees grown in a private orchard located at Southern El-Tahreer province, Behaira Governorate, Egypt. The trees were budded on sour orange, planted at 6 x 4 m distance (175 trees/feddan, one feddan = 0.42 ha), soil is sandy texture. The physical and chemical properties of soil are given in Table 1.

In October 2012, thirty six trees uniform in vigour and size were chosen to receive treatments of industrial orange wastes (Pulp and peel). All experimental trees received the same management applied for the orchard. Treatments inducted in this study were as follows:

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Table 1: Physical and chemical properties of the experimental soil site.

Properties	Value
Physical analysis:	
Gravels more than 2 mm %	4.22
Coarse sand %	62.00
Fine sand %	24.30
Silt and clay %	9.48
Soil texture	Sandy
Chemical analysis:	
pH	7.32
Calcium carbonate %	4.10
Organic matter %	0.51
Total soluble salts %	3.00
Total nitrogen	0.08
Total phosphorus	0.25
Total potassium	0.04

Table 2: Physical and chemical characteristics of orange wastes (dry matter).

Parameter	Pulp	Peel
Organic matter %	75.2	86.1
Total nitrogen (N%)	1.7	1.2
Total phosphorus (P_2O_5%)	0.8	0.3
Total potassium (K_2O %)	2.2	1.4
Total calcium (Ca %)	1.1	0.8
Total magnesium (Mg %)	0.2	0.1
Total iron (Fe ppm)	260	36

- Control (received only the usual treatments of the orchard)
- 200g/ tree of pulp (2 pp)
- 400g/ tree of pulp (4 pp)
- 600g/ tree of pulp (6 pp)
- 800g/ tree of pulp (8 pp)
- 200g/ tree of peel (2 pl)
- 400g/ tree of peel (4 pl)
- 600g/ tree of peel (6 pl)
- 800g/ tree of peel (8 pl)

Above-mentioned rates of orange wastes were mixed with the soil around canopy of trees at December 2012 and 2013. Orange wastes (Pulp and peel) used in this experiment were collected from an orange-juice factory located at Burg El Arab region, Alexandria, Egypt. Orange wastes dried separately at 30°C for 10 days. During the drying process, wastes mixed daily to evaporate water retention and to obtain homogeneous materials. Each kind of two wastes was grounded to obtain an average size of 20mm. One sample of each kind of orange waste (0.5kg) was subjected to analysis: nitrogen, phosphorus, potassium [10, 11, 12], respectively. Calcium and magnesium determined by method of Chang and Bray [13]. Iron was determined by atomic absorption spectrophotometry according to Kahan [14]. The Physical and chemical characteristics of orange wastes are presented in Table 2.

Mineral nutrients: N, P, K, Ca and Mg in leaf samples were determined by above mentioned methods. Total leaf chlorophyll content was determined by spectrophotometer according Bruinsma [15]. In February, fruit set was determined by choosing and lablelling 4 secondary branches/tree nearly uniform in basal diameter. At the blooming time in March, flowering twigs in each branch were tagged and the number of flowers per twig was collected in full blooming. Fruit numbers and its percentage of initial flower number were calculated in July. Data subjected to analysis of variance to determine the significant differences and Duncan's multiple range test [16] was used for means in comparison when F test significant at $P \geq 0.5$.

RESULTS AND DISCUSSION

Data presented in Table 3 showed that leaf mineral content was increased due to applied doses of the two kinds of orange waste over the two seasons. The increases were significant compared to control in some cases and non significant in the others. Also, it was observed that pulp applications produced higher leaf mineral content than did peel ones. Fast mineralization of organic matter contained in orange pulp and its higher contents of minerals may be responsible for superiority of pulp over peel in exerting beneficial effects on leaf mineral content. Data concerning leaf chlorophyll a and b, percentages of fruit set and yield are shown in Table 4. It cold be seen that amendments of orange wastes to trees produced an increments in chlorophyll a and b, fruit set and yield. Application of pulp accompanied by higher increases in above mentioned parameters studied. The highest values produced by highest dose of pulp (8pl), while the lowest dose of pulp (2pl) produced values closely near control. The relatively higher increments of chlorophyll content, fruit set and yield observed with pulp doses over peel ones may be due to relatively higher contents of nutrients as shown in Table 1. In the light of well known that Mg^{++} occurrence at the center of chlorophyll molecule and its required as cofactor in all enzymes concerning phosphorylation process [17] and its role in activation other enzymes [18], relatively high photosynthesis rate due to pulp doses are expected compared to peel ones. Nitrogen turnover into organic

Table 3: Leaf mineral content of some nutritional elements of "Valencia" orange trees amended with different rates of pulp and peel orange wastes (g/tree).

	Elements (%)									
	1st season					2nd season				
Treatments	N	P	K	Ca	Mg	N	P	K	Ca	Mg
Control	2.12cd	0.05b	0.31d	3.46d	0.51c	2.09d	0.07cd	0.31f	3.42b	0.48c
(2 pp)	2.23bcd	0.07b	0.34bcd	3.50d	0.59bc	2.26bcd	0.07cd	0.36de	3.48b	0.53c
(4 pp)	2.33bcd	0.10b	0.39abcd	3.55cd	0.66ab	2.29bcd	0.12a	0.36de	3.53b	0.70ab
(6 pp)	2.51abc	0.13a	0.40abc	3.87ab	0.71a	2.54abc	0.12a	0.39cd	3.86a	0.71ab
(8 pp)	2.85a	0.16a	0.45a	4.10a	0.75a	2.81a	0.16a	0.47a	4.10a	0.76a
(2 pl)	2.19cd	0.07b	0.33cd	3.46d	0.53c	2.22cd	0.06d	0.31f	3.42b	0.50c
(4 pl)	2.23bcd	0.09b	0.37abcd	3.48d	0.53c	2.27bcd	0.11bc	0.35e	3.46b	0.51c
(6 pl)	2.35bcd	0.11a	0.40abc	3.50d	0.56bc	2.30bcd	0.11bc	0.42bc	3.52b	0.56bc
(8 pl)	2.59ab	0.11a	0.43ab	3.77bcd	0.59bc	2.55ab	0.16a	0.43b	3.72b	0.59bc

Means of each column followed by same letter (s) are not significantly different at 5% level.

Table 4: Leaf chlorophyll a and b contents, fruit set and yield of " Valencia" orange trees amended with different rates of pulp and peel orange wastes (g/tree).

	1st season				2nd season			
Treatment	Chlorophyll a (μmole m^{-2})	Chlorophyll b (μmole m^{-2})	Fruit set (%)	Yield (kg/tree)	Chlorophyll a (μmole m^{-2})	Chlorophyll b (μmole m^{-2})	Fruit set (%)	Yield (kg/tree)
Control	3.14g	1.19g	25.8e	50.3d	3.20d	1.20f	25.0e	50.0e
(2 pp)	3.21e	1.22f	28.2c	50.3d	3.25c	1.24e	27.8cd	50.0e
(4 pp)	3.33c	1.30c	30.0b	52.0b	3.35a	1.28d	29.2bc	53.2bc
(6 pp)	3.35b	1.34b	31.8a	54.8a	3.38a	1.36bc	30.0b	55.1ab
(8 pp)	3.47a	1.37a	33.0a	55.9a	3.38a	1.39a	34.0a	55.5a
(2 pl)	3.17f	1.20e	26.3e	48.2e	3.20d	1.20f	24.2e	47.1f
(4 pl)	3.30d	1.27d	27.8c	51.3c	3.30b	1.27d	26.1de	52.2c
(6 pl)	3.32c	1.33b	29.0bc	53.2b	3.30b	1.35c	28.3bc	53.4bc
(8 pl)	3.35b	1.33b	30.1b	54.3a	3.35a	1.37b	30.0b	54.4ab

Means of each column followed by same letter (s) are not significantly different at 5% level.

form remains in the plant, then synthesis of high molecular weight N compounds takes place include proteins and nucleic acids. All these compounds are influenced by plant nutrition and particular by supply of N [19]. Phosphate plays an important role in metabolism throw its formation of phosphate bonds which allow energy transfer. Therefore, increased rates of phosphate uptake associated with higher metabolic activity [20]. Potassium have been reported to enhances translocation of assimilates [21, 22], promotes rate of CO_2 assimilation [23, 24]. Calcium is required for cell division and elongation [25], also plays a comparatively minor role in enzyme activation [26]. The highest beneficial effects on nutritional status produced by pulp treatments compared to peel ones reflected on high relatively photosynthesis rate [27]. Previously, Domingo *et al.* [28] observed that carbohydrate availability in citrus trees directly affected on fruit set. Application of orange wastes as organic fertilizer has been reported by Abbate *et al.* [29]. Moreover, long-term application of orange wastes as organic fertilizer produced yields similar to mineral fertilizers [30].

It can be concluded that using orange wastes as organic fertilizer could represent a sustainable approach to recycling nutrients, solve environmental problems related to the citrus processing industry and reduce costs related to disposal.

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