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ORIGINAL RESEARCH

# Effects of the onion residue compost as an organic fertilizer in a vegetable culture in the Lower Valley of the Rio Negro

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**Abstract**
*Purpose* Farming production in the lower part of Río Negro Valley (Argentina) has increased considerably during recent years, causing soil degradation and, specifically, decreasing the organic matter contents. This fact requires recovery measures, as organic amendments for soils, to improve its quality. The marked objectives for the present research is to evaluate compost as organic fertilizer, based on a mix of onion waste and bovine manure.
*Methods* The experiment was carried out in a completely randomized design, involving five treatments and one control, with ten copies of each one. Tests were performed in a greenhouse, using flowerpots and experimental plots, in a typical soil of the region (Aridisol), pH 8.3 and 2.2% of organic matter, mixed with different compost dosages (20, 40, 60 and 80 Mg ha$^{-1}$) and the chemical treatment, Urea (0.26 Mg ha$^{-1}$). A horticultural farming of 1 lettuce was sowed (*Lactuca sativa*). A conventional handling was carried out for the whole cultivation period, and at the end was harvested. Ten plants per plot were taken and were determined total fresh weight, aerial part fresh weight, root part fresh eight. In the dry controls total dry weight, aerial dry weight and root dry weight was determined.
*Results* Results show, with an error ($p < 0.05$), significant differences in the fresh weight per plant calculated, between treatments and control; a noticeably greater effect can be observed in the treatments with 6 and 8 kg m$^{-2}$ compost amending and urea treatment. There is no evidence of the existence of significant differences ($p < 0.05$) between treatments and control, according to the values obtained for root size as well as aerial dry weight and root dry matter.
*Conclusions* It can be concluded that the addition of organic fertilizer to soils, has positive effect on the Fresh weight of the plant, recommending the use of doses of 6 kg m$^{-2}$ while the dose of 8 kg m$^{-2}$ could replace the use of chemical fertilizers such as Urea.

**Keywords** Organic amendments · Compost application · Cultivation · Horticultural production

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## Introduction

The application of biosolid as a fertilizer in agricultural cultivation is a common practice in many countries (Shahrzad and Meheran 2012). Intensive use of soils, specifically those oriented to horticultural production, has caused the decrease of organic matter and nutrient; that has been identified as one of the most important threats to the quality of soils (Bevacqua and Mellano 1994; Maynard

1995; Khoshgoftarmanesh and Kalbasi 2002; Hu and Barker 2004; Maftoun et al. 2004; Campitelli and Ceppi 2008; Amusan et al. 2011; Kabirinejad and Hoodaji 2012; Sohrabi et al. 2013; Giannakis et al. 2014; Rajaie and Tavakoly 2016; Dotaniya et al. 2016; Kalaivanan and Hattab 2016).

Through the studies carried out about different horticultural labors, fruit trees and cereal crops, many authors pointed that the application of organic amendments to soil, coming from the composting process of different kinds of wastes (urban solid wastes, manure, gardening and tree pruning), yields a significant improvement in the nutritional condition of the plant; as well as in the performance and quality of harvested fruits (Arancon et al. 2004; Lee et al. 2004; Gutiérrez-Miceli et al. 2007; Singh et al. 2008; Suthar 2009; Tejada and González 2009; Batlle-Bayer et al. (2010); Amusan et al. 2011; Giannakis et al. 2014).

The need for decreasing the reliance on chemical products in crops fertilization and the ever-growing land degradation, as a result of intensive use and unsuitable crop management, puts an obligation on growers to search for more reliable and sustainable alternatives, Lal (2007). Thus, the use of organic amendments represents a source of carbon and some other nutrients, which favors the microbial activity and enhances the soil structure, creating an enabling environment for plant growth. The recovery of organic matter content from soils, determines that the use of composts, coming from degradation of agricultural wastes, as humic amendment for agricultural soils, represents one of the most frequently used options (Benitez et al. 2000; Boixadeira and Teira 2001; Abad and Puchades 2002; Soliva and Paulet 2003; Kale 2004; Schuldt 2006; Bachman and Metzger 2008; Canet and Albiach 2008; Moral and Muro 2007). Classen and Carey (2004) considered the conversion from organic waste to relatively stable compounds, like compost, allows its later use as soil condition-enhancing organic amendment. In fact, from the agricultural and environmental point of view, the application on soil of composted organic wastes is a recommended practice, to achieve the remediation of degraded soils and the nutrient supply to plants (Tejada et al. 2002; Larney and Angers 2012).

Compost holds a direct effect over the macrostructure of agricultural soils, mainly in arid zones, having influence over pore volume, and promoting soil moisture distribution and gas exchange (Costa et al. 1991). Apparent density is downsized, so consequently, permeability and stability of aggregates are increased. Furthermore, it increases water-retention capability and decreases land erosion (Zebarth et al. 1999).

Several studies point to the benefits of the compost addition over edaphic chemical properties, increasing buffer capacity and cationic interchange capacity (CIC), with the associated increase in soil fertility and nutrient supply, particularly N, P, K, Ca and Fe (Bruun et al. 2006; Kowaljow and Mazzarino 2007). Likewise have shown the positive effect over biological properties (García-Gil et al. 2000).

Although, the use of fertilizers and amendments is in widespread use, there is not neither clear standard nor technical-scientific support about the management practices used in irrigation zones of Argentina. In general, type of fertilizer, dose, stages and form of use are stipulated by an empirical way and are highly varying among the growers (Bermejillo and Filippini 2007).

Fertility of these soils could be enhanced by the use of recycled organic wastes, such as framing sub-products, including animal manure, food processing waste. Wastes, generally, have high levels of organic matter and nutrients, and its agricultural use can contribute to close ecologic natural cycles (Montemurro et al. 2004; Montemurro and Maiorana 2008). Vermicomposting, a tool for manure management can be employed as a means for manure treatment with the aim of enhancing nutritive value of forage (Aminu et al. 2012).

To perform an agronomic research of the possible commodities to use for compost manufacture, next stages must be rigorously considered (Abad et al. 1993) such as: (a) Materials characterization (physical, chemical and biological); (b) Properties critical review (c) Simple enhancement, if appropriate, of these properties; and (d) Plant growing tests. The present document evaluates the effect between the implementation of different compost dosages and the output of a lettuce (*Lactuca sativa*) cultivation, type "Prize Head". Compost, used as organic amendment, has been prepared from a mix of onion wastes and cattle manure. Collaterally, it is assessed if its use would be a viable alternative for waste recycling and, probably, could replace commercial inorganic fertilizers in intensive horticultural production.

## Materials and methods

For two consecutive years, tests were performed under a controlled environment in the Universidad Nacional del Comahue-CURZA greenhouse, located in the city of Viedma (40°49′S), Argentina. Experiences in plant pots and plots were conducted in a chapel-type greenhouse, with iron structure, LDT polyethylene roof and wall covering (thickness 150 μ) and sideways ventilation. Some of the soil properties are showed in Table 1, in which appear a low cationic exchangeable capacity.

The application of different compost dosages was performed on a typical Lower Valley soil, classified as Aridisol, alluvial nature, sandy-clay-loam texture, coming from a horticultural lot, with low content of organic matter.

**Table 1** Composition of soil and compost used during the tests

| | pH | EC (ds $m^{-1}$) | Ct (g $kg^{-1}$) | N (g $kg^{-1}$) | OM % | Pe (%) | Kdisp (%) | CEC (cmol $kg^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| Compost (2009) | 7.6 | 1.9 | 87 | 9.7 | 19.3 | 0.18 | 0.76 | 35.1 |
| Compost (2010) | 7.8 | 1.8 | 98 | 9 | 21.6 | 0.23 | 0.98 | 39.8 |
| Soil (2009) | 8.3 | 1.6 | 14 | 1 | 2.2 | 0.02 | 0.04 | 8.60 |
| Soil (2010) | 7.9 | 2.1 | 16 | 1.2 | 2.4 | 0.03 | 0.04 | 8.20 |

*EC* electric conductivity, *Ct* total carbon, *N* total nitrogen, *OM* organic matter, *Pe* extractable phosphorus, *Kdisp* disposable potassium, *CIC* cationic exchange capacity

## Test performed in plants pots

Two test were performed, one during the first year and the other throughout the following year. 5 l capacity pots were used in both experiments, filled with 5 kg of soil collected from a greenhouse lot under intensive production. This soil was mixed with varying quantities of compost, to achieve treatments with high, medium and low dosage, which were compared to a control and a chemical fertilization treatment (urea).

Compost and chemical fertilizer dosages, to apply per pot, were calculated depending of N content, using volumetric baseline, and supposing a 0.15 m ground depth and an apparent density of 1.3 mg $m^3$.

In each pot, the corresponding compost quantities were mixed with the soil, that afterwards were watered and, 3 days later, three lettuce seeds were sown. When the seedlings reached 2nd and 3rd true leaf stage, thinning was carried out, leaving only one plant per pot.

The experiment was completely randomized, involving five treatments with a control, fifteen replications per treatment, which are outlined below:

| Treatment | Dosage |
|---|---|
| Control | No compost |
| T1 | Compost, 20 Mg $ha^{-1}$ (200 kg N $ha^{-1}$) |
| T2 | Compost, 40 Mg $ha^{-1}$ (400 kg N $ha^{-1}$) |
| T3 | Compost, 60 Mg $ha^{-1}$ (600 kg N $ha^{-1}$) |
| T4 | Compost, 80 Mg $ha^{-1}$ (800 kg N $ha^{-1}$) |
| T5 | Urea, 0.26 Mg $ha^{-1}$ (120 kg N $ha^{-1}$) |

There was daily irrigation, carried out manually according to the cultivation needs in every pot, until harvesting about 90 days later. Weed control was accomplished manually.

At the end of cultivation cycle, plants were extracted out of the pots. In every plant was determined: total fresh weight (TFW), aerial part fresh weight (AFW), and root part fresh weight (RFW). Dry weight was obtained after putting controls into an oven at 60 °C for 72 h, until constant weight. In dry controls, total dry weight (TDW), aerial dry weight (ADW) and root dry weight (RDW). Root length (cm) was also measured.

## Test in experimental plots

Two tests were conducted in plots located in the greenhouse, one during the first year and the other throughout the following year. Treatments were placed in 4 $m^2$ (experimental unit) plots, with a completely randomized design, which were six treatments, three repetitions per treatment, as is shown below:

| Treatments | Dosage |
|---|---|
| Control | No compost |
| T1 | Compost, 20 Mg $ha^{-1}$ (200 kg N $ha^{-1}$) |
| T2 | Compost, 40 Mg $ha^{-1}$ (400 kg N $ha^{-1}$) |
| T3 | Compost, 60 Mg $ha^{-1}$ (600 kg N $ha^{-1}$) |
| T4 | Compost, 80 Mg $ha^{-1}$ (800 kg N $ha^{-1}$) |
| T5 | Urea, 0.26 Mg $ha^{-1}$ (120 kg N $ha^{-1}$) |

Seeds were sown in black polypropylene seedling starter trays, with 128 cells, and 22 $cm^3$ volume. When seedlings reached 3rd–4th true leaf stage, were transplanted to the plots, over 0.70 m ridges and 0.30 m planting distance, in double row plantation.

Previously, amendment was manually added in the first 0.15 m depth. Urea was applied in two dosages, the first at transplantation, and the second 45 days later (around the middle of cultivation cycle), matching with handling carried up by local agricultural producers. The greenhouse was not heated, watering was carried out by drip irrigation, according to crop requirements, and weed control was carried out in a manual way.

About 90 days, the cycle was completed and all the plants of the plot were harvested, to evaluate the yield. Ten plants per plot were taken and were determined total fresh weight (TFW), aerial part fresh weight (AFW), root part fresh weight (RFW). In the dry controls total dry weight (TDW), aerial dry weight (ADW) and root dry weight (RDW) were determined.

To study the effect of different compost dosages application over macronutrient content in lettuce leafs; at harvest time some controls of lettuce leafs were taken, dried at 60 °C until constant weight and were determined total quantity of N (Bremner and Mulvaney 1982), K and P quantities throughout wet digestion (Johnson and Ulrich 1959) and subsequent plasma emission spectrometry determination. Data were analyzed by an analysis of variance (ANOVA). Measures were compared by Tukey's test at 5% (INFOSTAT 2011).

## Results and discussion

### Test in experimental pot

In the first year, the variables "total fresh weight" (TFW) and "aerial part fresh weight" (AFW) showed significant differences between treatments: chemical treatment had the highest values compared to control (S) and organic amendments treatments (Fig. 1a). Probably the fertilizing action of urea the urea fertilizing action emerges in an immediate way, to reach a prompt N availability for the cultivation (Rotondo et al. 2009). In contrast, composts get mineralized slowly and only 10–15% of applied N is available for the first cycle of application (Petersen et al. 2003; Gutser et al. 2005; Moral and Muro 2007). The effects of compost application and inorganic fertilization over production variables have been studied in one asparagus cultivation and another of peas, and higher values have been obtained applying mineral fertilizer. Also, significant differences were found in favor of composted treatments against unfertilized controls (Zamora et al. 2006). In this trial, conducted in the lettuce cultivation, there were no differences between control, T1 and T2, while in highest dosage treatments, T3 (60 Mg ha$^{-1}$) and T4 (80 Mg ha$^{-1}$), the differences were significantly higher than Control and T1.

T2 and T5 showed the higher root fresh weight, with significant differences concerning only to Control and T1 (Fig. 1a). These results agree with logged by Rotondo et al. (2009), who also evaluated the application of organic amendment from earthworm-compost from domestic waste, earthworm-compost from rabbit and horse manure and rice husk bed mixed with chicken manure, to one lettuce cultivation and to another broccoli cultivation.

López-Mosquera et al. (2003) founded further responses in horticultural cultivations, using increasing dosages of organic amendment from chicken manure fermented into a vegetal matter bed. Short time periods are not enough to observe the response of organic aggregate in cultivation yield, and continuous applications are required to support the appropriate nutrient level (Ullé et al. 2004). It is necessary that the progressive combination of organic and inorganic fertilizers, particularly compost, to reach a balance in nutritional levels added to the ground (Añez and Espinoza 2003). Total fresh weights obtained in the second year of the pot-test (2011), were lower than obtained in the second year (Fig. 1b).

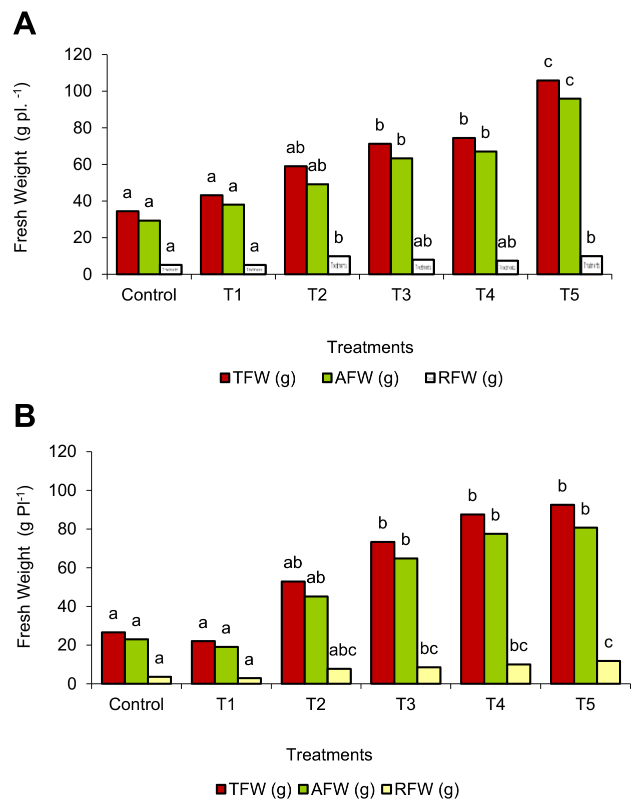


Fig. 1 Effect of different compost and mineral fertilizer dosages over the fresh weight of pot-planted lettuce. **a** First year, **b** second year. *TFW* total fresh weight, *AFW* aerial fresh weight, *RFW* root fresh weight

Although the trend was similar, treatments with higher compost dosages (60 years 80 Mg ha$^{-1}$) showed the highest values for this variable. The chemical treatment, even though having produced the highest plant weight, did not differ from organic amendment treatments. The control and the lowest compost dosage registered similar weights. The aerial fresh weight marked same tendency than total fresh weight. Differences between highest compost dosages and urea treatment were not detected (Fig. 1b). Root fresh weight was higher in T5, having significant differences from it to control and T1.

In reference to aerial component, it showed same tendency than total fresh weight. No differences were detected between the highest compost dosages and the urea treatment (Fig. 1b). Root fresh weight was higher in T5, concerning to significant differences with control and T1. Relating to dry weight (total, aerial and root), during the first year trial, it was observed a tendency similar to detected at fresh weight; urea application produced highest values in contrast to the other treatments (Fig. 2a). Highest compost dosages showed higher root dry weight than T1 and T2. In the second year, the trend in total dry weight was similar than observed in fresh weight (Fig. 2b). Lower values were detected in control and T1. Significant differences were not found between 80 Mg ha$^{-1}$ and urea treatment, but those values were significantly higher than showed in the control and the lowest compost dosage.

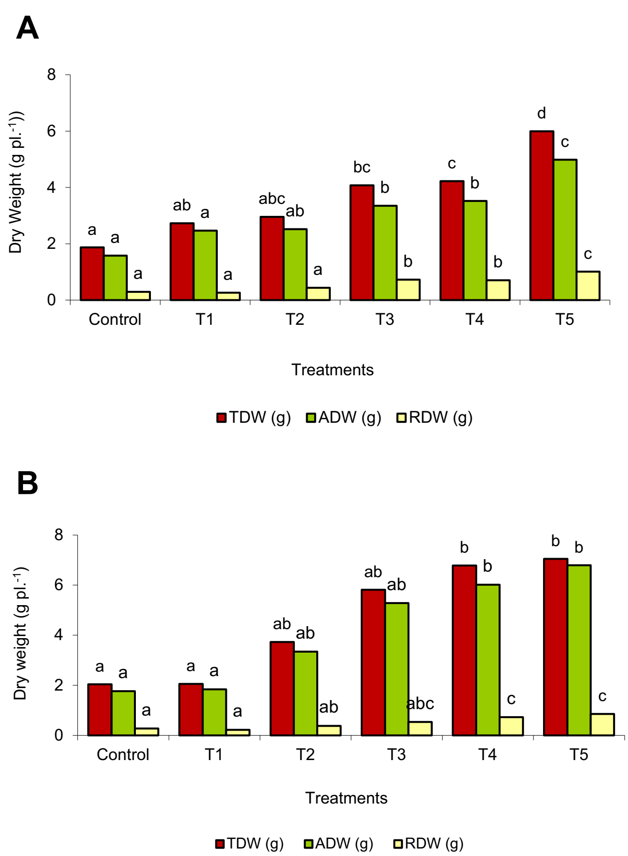


**Fig. 2** Effect of different compost and mineral fertilizer dosages over the dry weight of pot-planted lettuce. **a** First year, **b** second year. *TFW* total fresh weight, *AFW* aerial fresh weight, *RFW* root fresh weight

**Table 2** Effect of different compost and mineral fertilizer dosages over lettuce cultivation yield (Mg ha$^{-1}$)

| Year | Control | T1 | T2 | T3 | T4 | T5 |
|---|---|---|---|---|---|---|
| 2010 | 13.9 a | 16.9 a b | 19.3 b c | 22.3 c | 21.6 b c | 21.6 b c |
| 2011 | 14.4 a | 17.7 a b | 22.4 b c | 25.9 c d | 26.9 c d | 29.3 d |

## Test in experimental plots

For the first year, all treatments produced higher yields than the control (Table 2). Higher values were found at T3, T4 and T5. The T1 treatment did not differ from the control. Along the second year, all the treatments produced higher yields than the control. Chemical fertilization registered the highest value, but did not differ statistically from 60 and 80 Mg ha$^{-1}$ organic treatments.

For the first year, the higher values for total fresh weight and aerial fresh weight were detected in organic treatments T2, T3 and T4, and the urea treatment, as observed for the "yield per hectare" variable (Fig. 3a). Application of onion-manure at rates over 600 kg N ha$^{-1}$ (80 Mg compost ha$^{-1}$) caused a diminution for the growing of the lettuce cultivation. This result could be assigned to the larger amount of total C contributed, which could immobilize the N, as reported by Kokora and Hann (2007). Eriksen et al. (1999) also detected immobilization of

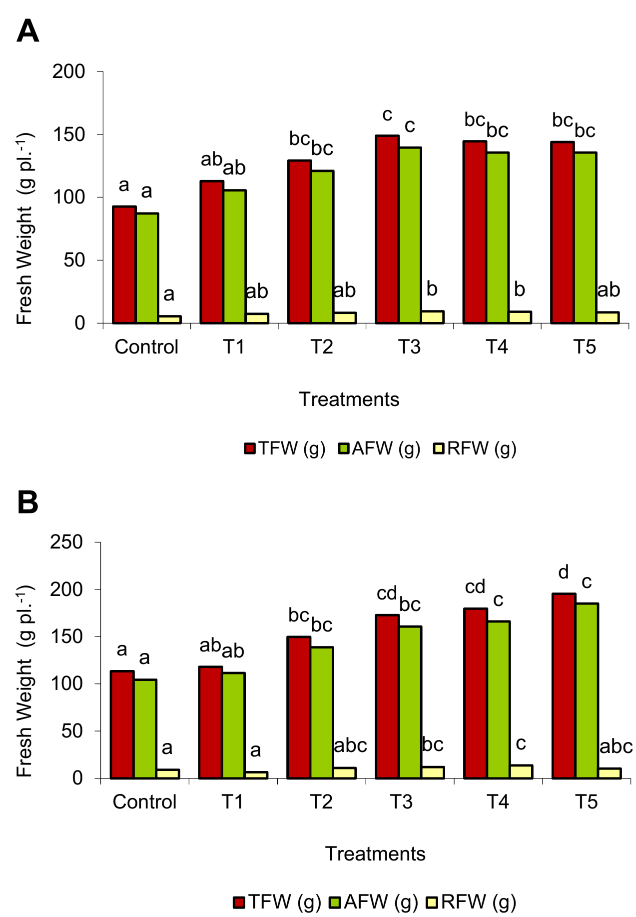


**Fig. 3** Effect of different compost and mineral fertilizer dosages over the fresh weight of lettuce harvested in experimental plots. **a** First year, **b** second year. *TFW* total fresh weight, *AFW* aerial fresh weight, *RFW* root fresh weight

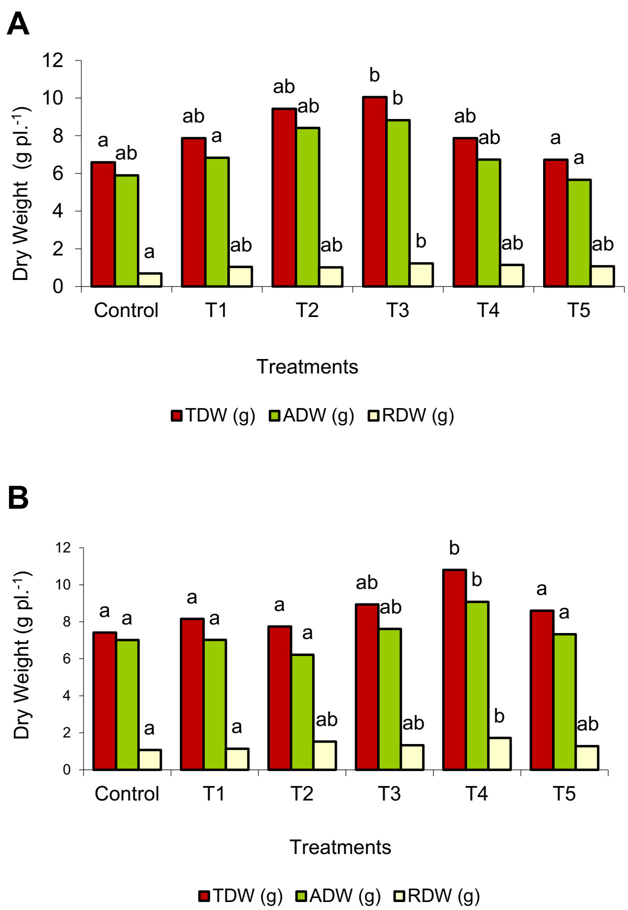


**Fig. 4** Effect of different compost and mineral fertilizer dosages over the dry weight of lettuce harvested in experimental plots. **a** First year, **b** second year. *TFW* total fresh weight, *AFW* aerial fresh weight, *RFW* root fresh weight

nitrogen in soil, after the application of 310 kg N ha$^{-1}$ of compost from urban solid wastes.

The total fresh weight obtained for the second year were higher than obtained the first one (Fig. 3b). Urea treatment produced the highest values, about 200 g pl$^{-1}$, without any significant concerning to the highest compost dosage treatments.

In relation to the control treatment, T2, T3, T4 and T5 were significantly higher than control. Aerial fresh weight showed the same trend than total weight. The highest root fresh weights were registered in T4 (80 Mg ha$^{-1}$), with significant differences concerning to control and T1. For the first year, the highest value for total dry weight was obtained from 60 Mg ha$^{-1}$ compost dosage (Fig. 4a). T1 and T2 did not show significant differences concerning to the control. Chemical treatment showed the lowest values of dry matter, like control did. In 2011 test, the highest values for dry weight per plant (11 g), were registered by applying 80 Mg ha$^{-1}$, having significant differences with regard to control T1, T2 and T5 (Fig. 4b). Aerial dry weight showed a similar trend. T4 also showed the highest root dry weight, with significant differences regarding to control and T1.

## Conclusions

The study showed that every treatment produced higher yields than control, while underlining that the usage of growing compost dosages caused the increase of production variables, which were measured after harvesting. Furthermore, it is observed that application of urea and 60-years 80 Mg ha$^{-1}$ compost dosages produced the highest fresh weights and total weights, detecting that the largest root lengths are evidenced with chemical fertilization and the highest compost dosages.

In the end, the highest N, P and K contents in lettuce leafs were observed in the urea treatments and in the highest compost dosages, meanwhile the highest compost dosages could replace chemical fertilization with satisfactory results.

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