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SHORT COMMUNICATION

# Agronomic application effects of organic wastes on a squash crop production

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## Abstract

**Purpose** The objective of the study was to evaluate the application effects of different doses of onion residue mixed with bovine manure compost as an organic fertilizer on a hybrid *Tetsukabuto squash* crop cultivated in a field.

**Method** The experimental design required randomly dividing blocks with three replicates. The experiments were designed with different dose combinations in experimental units (4 m wide x 8 m long deep). There were three treatments: organic fertilization (two compost doses 6 and 8 kg $m^{-2}$); mineral fertilization (45 kg N $ha^{-1}$ urea), unfertilized control. The number of leaves, main guide length per plant and dry matter were determined.

**Results** The results obtained during the first 15-day sampling showed significant differences ($p < 0.05$) in both number of leaves and main guide length per plant between the treatments with compost doses and the control without fertilization. The treatment with the compost dose of 6 $kgm^{-2}$ produced the highest effect. . Furthermore, there were no significant differences ($p < 0.05$) among the three treatments in both the number of leaves and main guide length per plant during the second post-sowing 60-day sampling, as well as in the dry matter during the first sampling. During the second sampling, the percentage of dry matter in the control differed significantly from the two fertilized treatments.

**Conclusion** Compost of onion residue mixed with bovine manure can be applied as an organic fertilizer with similar positive effects to mineral fertilization in the first squash crop implantation stage.

**Keywords** Agricultural waste management, Sustainable development, Recycling behavior, Dry matter content, Organic fertilizer, Lower Valley of Rio Negro (Argentina)

## Introduction

In the last few decades, agricultural production has substantially increased, and large quantities of agricultural solid waste have been generated in many world regions (Chandra et al. 2019). Solid waste crop associated with agricultural activities involving crop production is no exception (Diacono et al. 2019), and one of the most relevant sensitive cases is the horticultural production of solid waste generated from the cultivation and maintenance of horticultural plants (Adejumo and Adebiyi 2019). This constant generation of waste deriving from agricultural production requires urgent management to be reused and recycled, to be recovered and re-introduced into the production chain (Ferronato et al. 2019; Vargas-Pineda et al. 2019). Studies have addressed some agricultural solid waste challenges and proposed suggestions about how they can be properly managed through, for example, "integrated waste management" (Díaz 2007). In line with this, recycling is a key action to minimize the environmental impact caused particularly by agricultural and municipal wastes (EEA 2016). In fact, good environmental protection can be accomplished by recycling and composting because vast

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amounts of organic fraction are associated with environmental impacts (Ikhlayel 2018).

Circular economy could be the answer to improve current solid waste management activities worldwide as it denotes waste valorization and recycling principles to boost developing economies (Ferronato et al. 2019; Vargas-Pineda et al. 2017 and 2019). Nowadays, composting is an eco-friendly technology that is presented as an alternative scheme for solid waste management and valorization, especially for the organic fraction of agricultural solid waste (Awasthi et al. 2020). The application of compost to soil implies considerable interest in maintaining a suitable soil structure, and for adding organic material to soil whose organic matter content has been reduced by intensive agriculture (Tittarelli et al. 2007). Strategic compost applications to degraded soil can benefit soil properties (Kranz et al. 2020), but composts from different substrate types have distinct characteristics (Eggerth et al. 2007).

Onion-producing companies have produced a large amount of waste in Argentina, which has resulted in vast quantities of discarded bulbs affected by pathogens of fungal origin and loose cataphiles. Shedding control must be carried out; otherwise, these large amounts of organic waste are dumped in the environment or left in municipal garbage dumps, and are even burned in some cases. The consequence of these processes is their dispersion, which poses the risk of contaminating air, water and soil, and eventually affects human health. In parallel, traditional Argentina cattle farming has increased in the Lower Valley of Rio Negro (Argentina) and, consequently, implies substantial manure generation. Such waste has a strong environmental impact on the region.

Low soil fertility and a gradual reduction in crop productivity caused by erosion, loss of nutrients due to intensive soil use, especially in horticultural production, and lower organic matter levels, among other factors, have stimulated the use of organic amendments and fertilizers of different types of residues to recover soil quality and crop production (Pellejero et al. 2017). The response of horticultural crops, especially squash, to organic fertilization with compost, vermicompost, manures and plant materials (green manures, stubble) has been optimal, with increased yields and dry matter accumulation in different plant parts (Filippi and Guiñazú 2007; Ayastuy et al. 2011).

The need to reduce dependence on chemical products in crop fertilization and increasing soil resource degradation as a result of intensive use and inadequate management forces producers to search for more reliable sustainable alternatives. For this reason, the use of amendments and organic fertilizers constitutes a source of carbon and other nutrients that favor microbial activity and improve soil structure by creating a suitable medium for plant growth. Recovering organic matter contents from soil can determine the use of compost from agricultural residue degradation as one of the most widespread options as humic amendments for agricultural soils (Bachman and Metzger 2008).

Despite applying numerous organic amendments to soil to support crop production, they basically fall into six major categories. Composting is one of the most known treatments. Although the use of fertilizers and amendments is very widespread, there is no clear criterion or technical-scientific support for the management practices used in the irrigated areas of Argentina. Fertilizer type, dose, times and application forms are generally stipulated empirically, and they vastly vary from one producer to another (Tisdale et al. 1993; Papadopoulos et al. 2011; Ashraf et al. 2014).

Most agricultural waste is a valuable resource that should be recycled (Al Seadi and Holm-Nielsen 2004). In order to avoid the environmental contamination of this organic waste, recycling by clean biotechnologies like composting is proposed as an alternative. This alternative is sustainable, respects the environment and allows fertilizer to be obtained to facilitate the recovery of nutrients and organic matter in production systems. Thus, composted waste bulbs and onion cataphile are mixed with cattle manure to transform this residue into an organic fertilizer of agronomic quality (Pellejero et al. 2021a, b). Scotti et al. (2015) stated that the sustainable practices which provide organic amendments can be a useful tool to maintain or increase organic matter content in agricultural soils by preserving and improving soil fertility.

The regulations recently approved by the "Secretaria de regulación y gestión sanitaria y secretaría de alimentos y bioeconomía (Secretary of Regulation and Health Management and Secretary of Food and Bioeconomy) in Argentina require compliance with good practices in the agri-food sector. For this reason, large generators of agricultural waste must recycle their waste to comply with the aforementioned regulations.

Horticultural production in the Lower Valley of Río Negro has intensified notably in recent years, and squash Tetsukabuto (a hybrid; a cross between Cucurbita maximum and Cucurbita moschata) cultivation is one of the most relevant crops. However, these intensive crops have caused deterioration, degradation, and particularly low organic matter content in soils. As soil is a dynamic natural system that lies at the earth-air-water-life interface, and also provides a critical ecosystem service for humanity's sustenance, it is necessary to take recovery measures, such as using compost, to replace or combine chemical fertilization with organic fertilization to improve soil physico-chemical and biological properties, and the performance of horticultural crops. There is little available information on the effect of compost on squash growth. In line with these bases, the main objective of this work was to apply mixture compost of onion wastes and cow manure to the most important horticultural crops in the Lower Valley of Río Negro, such as squash. To do so, the intention was to evaluate reducing the environmental impact of organic waste and the application of different onion residue compost doses to be mixed with bovine manure as organic fertilizer *versus* a urea mineral fertilizer and an unfertilized control in a Tetsukabuto hybrid squash field crop.

## Material and methods

The climate of the study area is known as a semiarid local steppe climate, with an average temperature of 14 ºC and average precipitation close to 400 mm. The Köppen-Geiger system classifies the climate in the study area as BSk. arid or dry zone, and cold, arid steppes (Zone BSk)

### Experimental design

The experiments in this study were conducted in the field in plot A-444-lot 5 located 20 km from the city of Viedma (40° 49' S and 63° 05' W) in Argentina (Fig. 1). The application of different doses of compost prepared from a mixture (1:1) of onion residues and cow manure was added, as opposed to mineral fertilizer of urea, and an unfertilized control, to squash crop (a hybrid between Cucurbita maximum and Cucurbita moschata Variety F1- *TETSUKABUTO*). The agricultural cycle lasted 140 days. Squash crop was cultivated in Entisols that is characteristic of the Lower Valley of Río Negro. These soils are formed on medium to fine-textured alluvial sediments in a semi-arid environment, classified as Entisols according to Soil Survey Staff (2014) and Regosols in accordance with the IUSS Working Group WRB (2015). This soil (Entisols) was characterized by a sandy clay loam texture and low organic matter content (Table 1).

The experiments were designed with different dose combinations in experimental units (4 m wide x 8 m long). The experimental design was done in randomized blocks with three replicates. Treatments are detailed below:

- •T1, compost 6 kg $m^{-2}$
- •T2, compost 8 kg $m^{-2}$
- •T3, urea 45 kg N $ha^{-1}$
- •Control without fertilization

The entire doses of the fertilizers in the experimental treatments were applied to the prescribed plots during the final land preparation and were incorporated into the soil. The sowing method was followed by blow, with a plantation frame measuring 1 m x 2 m, and irrigation was by furrow. Compost and urea were manually applied as organic and inorganic fertilizers, respectively, in the first 0.10 m of soil depth at the time of sowing.

### Compost preparation

The implemented composting method is based on the principles of windrow technology (Rich et al. 2018), in an open site area under aerobic conditions and provides the microbial population with oxygen from time to time. Furthermore, during the composting process period (10 weeks), temperature and moisture content were monitored on a daily basis. During the composting process, the temperature ranged from 30 to 60 ºC and moisture

**Table 1** The carbon (C), and nitrogen (N) content, electrical conductivty and pH of organic wastes prior to composting

| | C ($gkg^{-1}$) | N ($gkg^{-1}$) | C:N | EC ($dSm^{-1}$) | pH ($H_2O$) |
|---|---|---|---|---|---|
| **Onion waste** | 298 | 6 | 50 | 0.41 | 6.1 |
| **Cattle manure** | 169 | 11 | 15 | 0.53 | 5.8 |

C, Total Carbon; N, Total Nitrogen; EC, Electrical Conductivity; pH

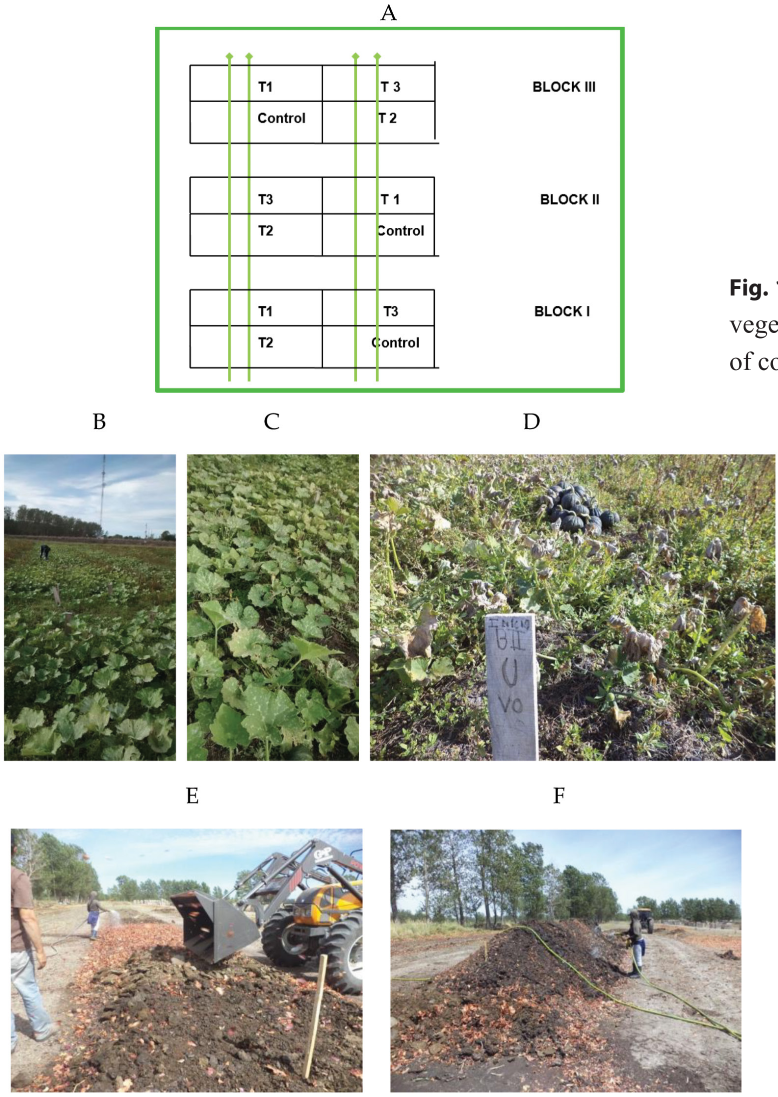


**Fig. 1** Details of the experimental design: A; vegetative stage: B and C; harvest: D; details of composting method implemented: E and F

content varied between 40 and 60%. The applied compost was obtained from the composting process carried out in the field, where three piles (15 m long x 1.60 m high x 3 m base) were assembled with turning. The materials collected for composting were onion waste and dairy cattle manure from a company located 15 km from the study area. Onion waste, which consisted mainly of dry leaves and clippings, was subjected to screening. Onion waste consisted of 80% diseased and beaten discarded bulbs, which were previously crushed by a tractor to induce loss of water and tissue exposure for rapid degradation purposes, and 20% loose cataphile from the packing shed of a certified onion producer and exporter. Both residue types (Table 1) were mixed as layers to achieve a good mixture of materials. Then the mixture was arranged by forming final piles (Fig. 1), which were watered until approximately 70% humidity. Piles were turned over every 15 days. Temperature was measured daily with a digital thermometer. Samples were taken from the beginning of the process to evaluate the mesophilic, thermophilic, maturation, and stabilization stages. Table 1 shows the data of some measured parameters prior to compost formation.

Total nitrogen (N) was determined by the Kjeldahl method (Bremner and Mulvaney 1982) and total carbon (C) by dry combustion (LECO). The pH and electrical conductivity were determined at the 1/5 product/water ratio.

## Plant sampling and measurements

Crop monitoring was similar to the management applied by the horticultural producers in the region. Two initial samplings were carried out in the implantation stage on post-sowing days 15 and 60. Ten plants were taken per plot. The number of leaves and the main guide length per plant were measured, as well as the dry matter.

### Statistical analyses

Data were statistically analyzed by applying ANOVA using version 1.1 of the InfoStat/Professional program, (Di Rienzo et al. 2018). The means of treatments were compared to Tukey's Minimum Significant Difference at 5%.

## Results and discussion

The food industry produces a large amount of onion wastes, making it necessary to search for possible ways for their utilization.

The food industry produces large amounts of onion waste, which renders the search for possible ways to use it necessarily. Onion composition is variable and depends on the environment, agronomic conditions, storage time, bulb section, among others (Downes et al. 2010). In the last decade, the Patagonian Protected Region has become the largest onion producer and exporter in Argentina. During the commercialization process, bulbs are stored in "windrows" outdoors, which involves increased post-harvest diseases, especially those of fungal and bacterial origin (Pozzo-Ardizzi et al. 2012), and vast volumes of discarded bulbs. In order to eliminate the impact of this organic waste on the environment, recycling is applied by clean biotechnologies like composting. Therefore, the main objective of this study was to monitor composting the field piles of the onion waste generated in packing houses, which is mixed with bovine manure to obtain compost. The results show that quality compost was obtained.

As mature compost presents C: N ratio values < 20 (Guo et al. 2102; Rotondo et al. 2009), this parameter was monitored during the composting process, and its values are shown in Fig. 2.

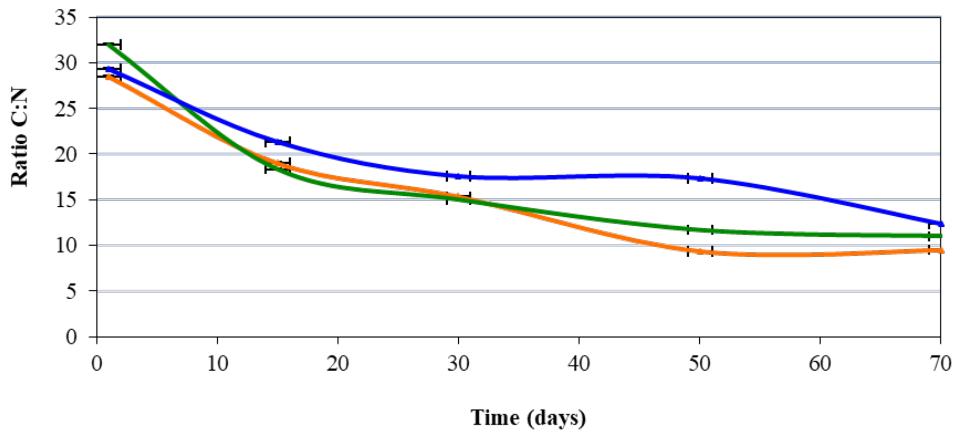


**Fig. 2** Evolution of the C:N ratio during composting

Table 2 indicates the final composition of obtained compost and the main characteristics of the employed experimental soil. The obtained compost was no saline and neutral; values of pH and EC were within the range acceptable for plant growth recommended by Rynk (2003). Compost organic C content was elevated and similar to values cited by Weber et al. (2007). Total N content was low for this type of compost (Tognetti et al. 2007). The different soil parameters are at adequate levels.

**Table 2** Compost composition and soil properties used in the study

| | pH | EC ($dSm^{-1}$) | C (%) | N (%) | OM (%) | P (%) | K (%) | CEC ($cmolkg^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| **Compost** | 8.6 | 0.6 | 15.6 | 1.2 | 26.8 | 0.18 | 0.76 | 35.1 |
| **Soil** | 7.8 | 1.9 | 0.9 | 1.0 | 1.6 | 0.02 | 0.04 | 18.6 |

EC: Electrical Conductivity; C: Total Carbon; N: Total Nitrogen; OM: Organic Matter; P: Extractable Phosphorus; K: Available Potassium; CEC: Cation Exchange Capacity

Similar behavior was observed when comparing the number of leaves and main guide length per plant during the first and second sampling. For the number of leaves, during the first sampling, significant differences were found between T1 (compost of 6 kgm$^{-2}$), which displayed more vegetative growth (Fig. 3), and the control. Despite Treatments 2 and 3 having more leaves than others, there were no significant differences among all treatments during the second sampling. On the first days of squash implantation, the fertilizing action of urea in relation to compost was not immediately manifested, and similar values were obtained in the three fertilized treatments. This coincides with some researchers who have found differences in favor of composted treatments in horticultural crops compared to unfertilized controls (Pellejero et al. 2021a).

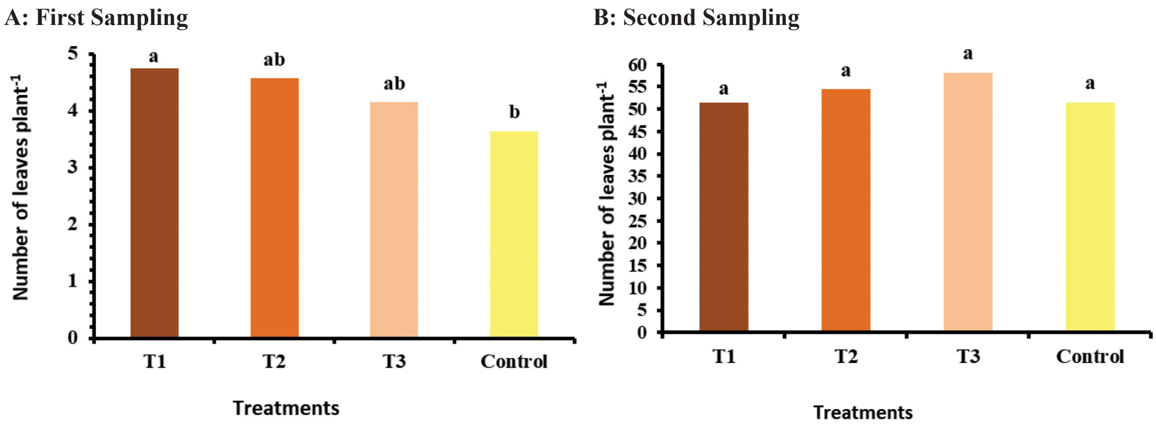


**Fig. 3** Effect of different doses of compost and mineral fertilizer on the number of leaves plant$^{-1}$ in squash

A: first sampling (15 d), B: second sampling (60 d), T1, compost (6 kgm$^{-2}$); T2, compost (8 kgm$^{-2}$); T3, urea (45 kg N ha$^{-1}$).
*Different letters indicate significant differences ($p \leq 0.05$).

No differences were observed between the control and T2 and T3 in this test carried out on the squash crop. These results also coincide with those reported by Rotondo et al. (2009), who also evaluated the application of organic amendments of vermicompost from household waste, vermicompost of rabbit and horse manure, and rice husk beds with chicken manure in a lettuce crop and a broccoli crop.

During the second sampling (60 days after sowing), no significant differences appeared in the number of leaves among all the applied treatments (Fig. 3). Treatment 3 (urea application) obtained more leaves but showed no significant differences from the other treatments. This was probably due to this fertilizer's wider availability and rapid N availability for the crop was achieved. Fewer leaves appeared in the compost-fertilized treatments. The lowest value of the studied variable was for the control.

During the first sampling, significant differences appeared between treatments and the control in the

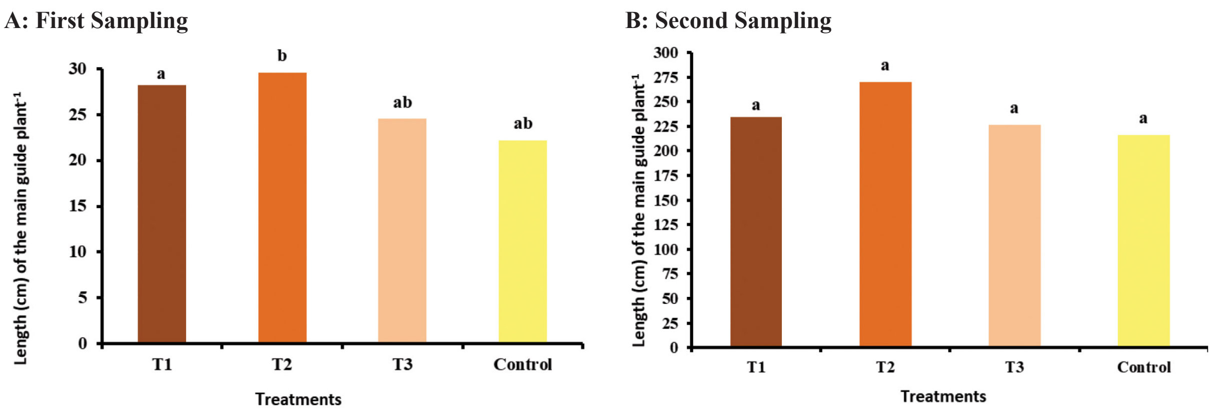


**Fig. 4** Effect of different doses of compost and mineral fertilizer on the length of the main guideplant$^{-1}$ of squash crop

A: first sampling (15 d), B: second sampling (60 d), T1, compost (6 kgm$^{-2}$); T2, compost (8 kgm$^{-2}$); T3, urea (45 kg Nha$^{-1}$). *Different letters indicate significant differences ($p \leq 0.05$).

main guide length per plant (Fig. 4). Treatments 1 and 2 ~~3~~ showed the highest values and were statistically differentiated between them. Despite the chemical treatment obtaining a shorter guide length than the composted treatments, it did not differ significantly from these treatments with organic fertilization.

During the second sampling (60 days after sowing), no significant differences were found between the fertilized and compost treatments for main guide length per plant (Fig. 4). Furthermore, a shorter guide length was observed in the control when monitoring. However, no statistically significant difference between the fertilized treatments was found.

The data in Table 3 show dry matter in plants. The dry matter production of squash was hardly affected by treatments. No significant differences were observed among treatments for the dry matter evaluated during the first sampling. During the second sampling, the percentage of dry matter differed for the control from the three fertilized treatments. These slight differences in dry matter for the studied plant can be attributed to the short time action and direct role of organic manure on plant growth, which did not have the chance to act as a source of all the necessary macro- and micronutrients in available forms during the growth season to improve soil physico-chemical properties.

**Table 3** Plant dry matter (%)

| | T1 | T2 | T3 | Control |
|---|---|---|---|---|
| **First sampling** | 28.52 (±4.4) a | 27.58 (± 0.72) a | 28.37 (± 2.9) a | 26.81 (± 3.7) a |
| **Second sampling** | 28.52 (±0.6) b | 27.58 (± 1.6) a | 28.37 (± 1.9) b | 24.47 (±1.1) a |

The values in parentheses represent the standard error of the samples.

Organic fertilizers are a necessary component in sustainable and long-term agro-ecosystems (Paulauskiene et al. 2018). Indeed, substituting chemical fertilizers with organic fertilizers has become a very important practice with increasing warnings of harmful effects caused by chemical fertilizers, and an especially desired one for agriculture production sustainability and soil fertility maintenance (Abou-El-Hassan et al. 2017). Squash is an excellent source of many minerals (Hashash et al. 2017) but, fundamentally, compost improves some soil properties, especially physical ones, by enhancing plant root growth and, consequently, increasing nutrient root uptake as previously reported (Sarhan et al. 2011; Glala et al. 2012). This is in accordance with our results, which revealed that the increment in the variable length of the plants treated with compost treatments could be due to compost.

The continuous application of chemical fertilizers has a negative impact on human health and several environment threats such as soil erosion, air and water pollution, water logging, and reduction in biodiversity (Singh et al. 2020). Therefore, Recycling and converting of organic waste to organic fertilizers is an ideal solution to reduce environmental problems and increases soil fertility (Kheir et al. 2021; Alharbi et al. 2021). Given environmental concerns, recycling organic waste is once again on the upswing. It conserves energy, reduces air and water pollution and also greenhouse gases, and conserves natural resources. The obtained results represent a new demonstration in this itinerary. Organic amendments have several beneficial effects. By applying organic waste, farmers can reduce the amount of fertilizer needed to provide squash crops with nutrients, which could help their pocketbooks and the environment.

## Conclusion

From the results of this experiment, we conclude that applying compost from a mixture of onion residue and bovine manure has favorable effects as an organic fertilizer on the herein measured parameters, especially on the first 15 days of vegetative squash vegetable crop growth. The dose with the best response in the studied variables, such as the number of leaves and main guide length per plant, was 6 $kg.m^{-2}$ of compost, with similar values to those obtained with mineral fertilization. In practical terms, this research shows that farmers can successfully integrate compost with more quickly released fertilizer sources. The present study suggests that by applying compost, farmers can reduce the amount of fertilizer needed to provide squash cultivation with nutrients.

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## Compliance with ethical standards

**Conflict of interest** The authors declare that there are no conflicts of interest associated with this study.



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