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Compost tea improves growth, nutrients and antioxidants in corms of *Hypoxis hemerocallidea*

Authors:
Timothy I. Jasson[1]
Muhali O. Jimoh[1,2]
Christiaan W. Daniels[1]
Felix Nchu[1]
Charles P. Laubscher[1]

Affiliations:
[1]Department of Horticultural Sciences, Faculty of Applied Sciences, Cape Peninsula University of Technology, Bellville, South Africa

[2]Department of Plant Science, Olabisi Onabanjo University, Ago-Iwoye, Nigeria

Corresponding author:
Muhali Jimoh,
moajay006@gmail.com

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Background: The wild population of *Hypoxis hemerocallidea* continues to decline rapidly because of overharvesting for medicinal use. This has necessitated the development of sustainable cultivation protocols for the species to promote its conservation.

Aim: The impact of varying concentrations of compost tea extract on the growth, nutrient, antioxidant, and phytochemical contents of slow-growing corms *H. hemerocallidea* were investigated.

Setting: Corms of *H. hemerocallidea* were irrigated with municipal water and graded concentrations (0.25, 0.5, 0.75 and 1) of compost tea.

Methods: The nutrient content of the treated plant materials was analysed using the atomic absorption spectrophotometer while phytochemical and antioxidant contents were analysed following referenced methods.

Results: The highest growth parameters were recorded in corms treated with 0.5 of compost tea. The extracted compost tea did not have a significant influence on the phenolic content and antioxidant capacity of the plant; however, significant variability was observed in the flavonols and FRAP (ferric reducing antioxidant power) values at $P < 0.05$. Similarly, the concentration of certain mineral elements such as N, P, K, Ca and Mg varied significantly in the leaves whereas elemental compositions of the treated roots of *H. hemerocallidea*.

Conclusion: The compost tea did not have a significant effect on the phenolic content, oxygen radical absorbance capacity and ABTS (2,2′-azino-bis-(3-ethylbenzothiazoline-6-sulfonic) acid) antioxidant properties and nutrients in the plant although significant differences were observed in the flavonols and FRAP content of leaves, corms and roots.

Contribution: The study contributes to the development of an organic cultivation protocol to conserve wild relatives of *H. hemerocallidea*.

Keywords: African potato; Hypoxidaceae; hypoxoside; inkomfe; organic cultivation.

Introduction

The genus *Hypoxis* contains 76 African species, 40 of which are known to belong to southern Africa, and 16 of which are endemic to South Africa (Singh 2007). The plant was dubbed 'African Potato' after the Afrikaans word 'Afrika patat'. The plant, however, is a compressed underground corm that grows vertically and is known as 'Inkomfe' by African Zulu speakers (Ndhlala, Stafford & Van Staden 2013; Van Wyk 2015). The tubers are large, dark brown and covered in bristly hairs. When freshly sliced, the tubers are bright yellow and bitter (Mofokeng et al. 2020).

Hypoxis hemerocallidea Fisch.Mey. & Avé-Lall. (Hypoxidaceae) is a perennial corm with long, hairy, strap-like leaves and yellow star-shaped flowers borne on five to six long inflorescences in spring (Mofokeng et al. 2020; Ndhlala et al. 2013). The broad leaves are arranged one above the other, resulting in three distinct sections spreading outwards from the plant's centre (Mofokeng et al. 2020). The plant grows in open grasslands and woodlands and is common in South Africa's eastern summer rainfall provinces such as the Eastern Cape, Free State, KwaZulu-Natal, Mpumalanga, Limpopo and Gauteng (Mofokeng et al. 2020; Owira & Ojewole 2009). Plant populations have also been found in Botswana, Swaziland and Lesotho. *Hypoxis hemerocallidea* is fire-tolerant, because it becomes dormant during the fire season and then resprouts (Morris 2021). Fire promotes the growth of new leaves, while the fibres protect the corm from fire damage (Mofokeng et al. 2020). Buried storage organs also allow *H. hemerocallidea* to withstand frost,

tolerate temporary drought even during the dry autumn to winter period, and survive fires, which are common before or shortly after the dormant period (Morris 2021).

Traditional healers admired the species for its ability to treat a wide range of ailments, including rheumatoid arthritis, cancer, anxiety and urinary tract infections (Boukes & Van De Venter 2016b; Ojewole 2008). Previous research has shown that the aqueous extract has anticonvulsant activity, and it is also used to strengthen the immune systems of people recuperating from cancer and HIV (Matyanga, Morse & Gundidza 2020; Ojewole 2008). Hypoxis phytosterols were successfully marketed for their efficacy in the treatment of benign prostatic enlargement, followed by industrially synthesised phytosterols with immune-stimulant properties (Boukes & Van De Venter 2016a; Drewes et al. 2008). According to a market survey and traditional healers' trade usage of *Hypoxis* species, it is one of the most traded plant species in South Africa's KwaZulu-Natal Province (Boukes & Van De Venter 2012; Dold & Cocks 2002).

Because of its selective cytotoxicity against cancer cells, the novel phytochemical in *H. hemerocallidea*, hypoxoside, is a potent prodrug for the treatment of pancreatic cancer (Boukes & Van De Venter 2016b; Kim et al. 2021). The species has potent pharmacological properties for treating relevant inflammations and can be used in patients to treat anti-infective, anti-diabetic, antioxidant and antineoplastic conditions (Owira & Ojewole 2009). Apart from medicinal purposes, the leaves and corms of *H. hemerocallidea* are used to produce a black dye that is used to stain floors and can also be converted into rope (Dold & Cocks 2002; Katerere & Eloff 2008).

The use of compost tea extracts as an organic strategy in the commercial crop cultivation has gradually gained traction (Islam et al. 2016). The ability of compost tea to minimise plant diseases when applied as foliar sprays or soil drenches is of great interest in commercial farming (Seddigh & Kiani 2017). Compost tea extract may be used to improve the vegetative propagation and medicinal efficacy of corms of *H. hemerocallidea*, which are declining in South Africa because of overharvesting of the miraculous potato for its highly valued therapeutic properties (Mofokeng et al. 2020). Compost tea may also provide nutrients to both native and alien microbial populations. Furthermore, the nutrients may have caused the endemic microbial community to shift from a state of scarcity of organic nutrients to a state of dominance or transience (Edenborn et al. 2018; Seddigh & Kiani 2017).

The continued exploitation of naturally occurring populations is exacerbated by South African traditional healers' unwillingness to use cultivated stocks of medicinal plants (Lubbe & Verpoorte 2011; Mofokeng et al. 2020). The scenario has necessitated the development of organic and sustainable cultivation protocols for overexploited species such as *H. hemerocallidea* in order to promote conservation and support potential commercial growers. As a result, the goal of this study was to evaluate the efficacy of compost tea in improving the vegetative growth and medicinal properties of *H. hemerocallidea* while also developing a growth protocol to encourage future commercial cultivation and conservation of its wild relatives.

Research methods and deisgn

Plant materials and experimental design

Before the study commenced, 60 corms of *H. hemerocallidea* produced under a uniform condition were purchased from an Afro-Indigenous Nursery, in KwaZulu-Natal, South Africa. The experiment was conducted under carefully controlled environmental conditions in the tropical greenhouse at the nursery complex, Department of Horticultural Sciences, Cape Peninsula University of Technology (CPUT), Bellville (33°55′56″ S, 18°38′25″ E). The corms were weighed after delivery from the nursery and planted in 15 cm pots containing 1 pine bark chips: 1 vermiculite: 1 perlite substrate.

The corms were then irrigated three times a week with water for 2 months without fertiliser before being moved into the tropical greenhouse to commence experiments (Figure 1). The experiments were conducted in a completely randomised block design using a factorial arrangement, with 10 pots per treatment (n = 10) and plants treated with tap water and crude compost extract serving as negative and positive controls, respectively. Every week, the plants were soaked in 100 mL of compost tea.

Extraction of the compost tea

The mushroom compost utilised in the study was procured from Stanler Farms, situated in Fisantekraal, Cape Town, South Africa. The preparation of treatments involved aerobically resting 500 g of mushroom compost in 40 L of tap water, achieving a ratio of 1: 8 g/L. This resting period lasted for 24 h. The protocol strictly adhered to the prescription provided by Stanler Farms. In the experimental setup, tap water served as the negative control, while crude compost

Source: Picture by T. Jasson

FIGURE 1: Experimental set-up in the greenhouse at Cape Peninsula University of Technology.

extract functioned as the positive control. Other treatments were generated by combining 1 L of municipal water with 250 mL, 500 mL, 750 mL and 1 L of brewed compost tea resulting in distinct concentrations (0.25 v/v, 0.5 v/v, 0.75 v/v and 1 v/v) of the compost tea solution. These specific formulations were stored in separate lidded flasks and subsequently applied to the potted plants (Jasson 2017). The plants were assessed weekly over 20 weeks for their growth responses to the above-mentioned formulations.

Physicochemical analysis of the soil

The physicochemical analysis of the soil was conducted by BEMLAB laboratories, Somerset West, Cape Town, South Africa. The South African National Accreditation System (SANAS) has accredited the laboratory to the standard of the International Organization for Standardization/International Electrotechnical Commission (ISO/IEC 17025) renowned for chemical analyses of soil, leaves, fruit and water, as well as for microbiology on water and fruits. At BEMLAB, all testing was conducted using internationally accepted standard protocols.

Collection of data and sample analysis

At the end of the trial, growth parameters such as corm diameter, leaf length and root length were measured with a metre rule while corm weight, leaf weight and root weight were measured on a laboratory scale for various parts of *H. hemerocallidea* (Table 1). The weight of the freshly harvested leaves and corms of *H. hemerocallidea* were recorded (Table 2) and later oven-dried at 40°C for 1 week and re-weighed on an electronic weighing balance (Electronic Precision Balance, Model No: FR-H).

Determination of nutrient content

The nutrient content of dry leaf samples was analysed as described by Jimoh, Idris and Jimoh (2020) using the atomic absorption spectrophotometer facility at BEMLAB Laboratories, Somerset West, Cape Town, South Africa.

Preparation of crude extracts

Crude extracts were prepared by stirring about 0.5 g of finely ground dry rhizomes in 50 mL of 80% ethanol (Saarchem, South Africa) and centrifuged for 5 min at 4000 rpm. Unmacerated tissues were eliminated by running the supernatant through a Whatman No. 1 filter paper inserted in a Buchner funnel linked to an electric vacuum pump. The plant extracts were used for subsequent phytochemical and antioxidant assays (Ngxabi et al. 2021).

Determination of total polyphenol content

The total polyphenolic content of the extracts was determined using the Folin–Ciocalteu method, which was described by Jimoh, Afolayan and Lewu (2019) and Sogoni et al. (2021). Crude extract and diluted Folin–Ciocalteu reagent mixed in a ratio of 1:5 v/v were pipetted in a 96-well microplate. This was reacted with 7.5% sodium carbonate solution and

TABLE 1: Physicochemical properties of the growth media.

Treatments	Soil	pH (KCl)	Resist. (Ohm)	H^+ (cmol/kg)	P Bray II	K	Exchangeable cations (cmol(+)/kg)				Cu	Zn	Mn	B	Fe	C
					mg/kg		Na	K	Ca	Mg	mg/kg					%
0.25 ($\frac{v}{v}$)	Sand	4.85 ± 0.63^a	1095.00 ± 559.00^a	1.19 ± 0.78^a	123.50 ± 81.3^a	358 ± 23.5^a	0.91 ± 0.67^a	0.92 ± 0.6^a	12.56 ± 1.82^{ab}	6.26 ± 2.60^a	4.12 ± 2.50^a	99.20 ± 5.97^a	527.00 ± 46.60^a	1.74 ± 0.06^{bc}	331.50 ± 70.70^a	2.82 ± 0.92^a
0.50 ($\frac{v}{v}$)	Sand	4.80 ± 0.57^a	1525.00 ± 290.00^a	1.34 ± 0.84^a	104.50 ± 16.3^a	282.5 ± 14.8^a	0.61 ± 0.08^a	0.73 ± 0.04^a	12.61 ± 1.69^{ab}	5.52 ± 0.01^a	3.16 ± 1.99^a	56.1 ± 2.59^a	320.00 ± 22.40^a	1.57 ± 0.01^c	240.00 ± 68.30^a	4.10 ± 1.82^a
0.75 ($\frac{v}{v}$)	Sand	4.85 ± 0.59^a	1435.00 ± 163.00^a	1.17 ± 0.74^a	114.00 ± 49.5^a	326.0 ± 33.9^a	0.56 ± 0.02^a	0.84 ± 0.09^a	15.10 ± 0.43^a	5.40 ± 0.17^a	4.29 ± 1.87^a	91.60 ± 5.23^a	564.00 ± 42.50^a	2.15 ± 0.13^a	355.00 ± 79.90^a	3.86 ± 2.39^a
1.00 ($\frac{v}{v}$)	Sand	4.85 ± 0.50^a	975.00 ± 469.00^a	1.14 ± 0.42^a	117.50 ± 2.12^a	421.0 ± 77.8^a	0.86 ± 0.40^a	1.08 ± 0.19^a	11.56 ± 0.16^b	5.20 ± 0.22^a	3.22 ± 1.15^a	85.80 ± 4.86^a	483.00 ± 33.40^a	1.61 ± 0.23^c	256.22 ± 12.81^a	2.25 ± 0.14^a
Compost tea only	Sand	4.95 ± 0.64^a	435.00 ± 247.00^a	1.05 ± 0.70^a	158.50 ± 51.6^a	558 ± 165.0^a	1.20 ± 0.42^a	1.43 ± 0.42^a	14.26 ± 1.70^{ab}	6.34 ± 1.29^a	3.54 ± 1.44^a	83.50 ± 5.98^a	487.00 ± 35.20^a	2.16 ± 0.06^a	314.70 ± 55.00^a	2.10 ± 0.01^a
Soil + water	Sand	4.80 ± 0.28^a	1920.00 ± 157.00^a	0.72 ± 0.11^a	105.5 ± 44.5^a	275.5 ± 23.3^a	0.57 ± 0.04^a	0.71 ± 0.06	12.06 ± 1.77^{ab}	5.32 ± 0.04^a	4.35 ± 0.92^a	107.60 ± 9.73^a	547.00 ± 59.70^a	2.00 ± 0.15^{ab}	294.10 ± 47.00^a	2.37 ± 0.17^a

Means with the same letters are not significantly different at a = 0.05 using the Fisher Least Significant Difference.

incubated at room temperature for 30 min. Absorbance was measured at 765 nm with a Multiskan spectrophotometer (Thermo Electron Corporation, Waltham, MA, USA). The standard curve generated from concentration ranges of 0 mg/L, 20 mg/L, 50 mg/L, 100 mg/L, 250 mg/L and 500 mg/L gallic acid prepared in 10% ethanol was plotted and values were calculated in mg gallic acid equivalent per gram dry weight (mg GAE/g).

Determination of total flavonol content

The total flavonol content of the extracts was calculated from the quercetin standard curve generated from concentration ranges of 0 mg/L, 5 mg/L, 10 mg/L, 20 mg/L, 40 mg/L and 80 mg/L of quercetin dissolved in 95% ethanol. Twelve and a half microlitres of crude extracts were mixed with 12.5 µL of 0.1% HCl (Merck, Africa) in 95% ethanol and 225 µL of 2% HCl for each sample. The mixture was then incubated at room temperature for 30 min (Ngxabi et al. 2021) before taking absorbance at 360 nm. The results were expressed in milligrams of quercetin equivalent per gram of dry weight (mg QE/g).

Determination of ABTS antioxidant capacity

The antioxidant capacity of ABTS was determined following Jimoh, Idris and Lewu (2020) and Unuofin, Otunola and Afolayan (2018a) with a minor amendment. The stock solutions included a 7 mM ABTS solution and a 140 mM potassium peroxodisulphate ($K_2S_2O_8$) solution (Merck, South Africa). About 5 mL of ABTS solution was mixed with 88 µL of potassium peroxodisulphate to prepare the experimental stock solution. The mixture was left in a dark cupboard at room temperature for 24 h. A Trolox (6-Hydrox-2,5,7, 8-tetramethylchroman-2- 20 carboxylic acid) standard was prepared in concentration ranges of 0 µM – 500 µM. A total of 25 µL each of the tested samples and the standard was reacted with 300 µL ABTS in the dark for 5 min at room temperature and the absorbance was measured at 734 nm at 25°C. The obtained data were expressed as µM of Trolox equivalent per g of dry weight (µM TE/g) of tested samples.

Determination of ferric reducing antioxidant power

The ferric reducing antioxidant power (FRAP) assay was carried out using the method described in Idris, Wintola and Afolayan (2017). Ferric reducing antioxidant power reagent was made by mixing 30 mL of acetate buffer (0.3 M, pH 3.6) with 3 mL 2,4,6-tripyridyl-s-triazine (10 mM in 0.1M hydrochloric acid), 3 mL iron (III) chloride hexahydrate ($FeCl_3$ $6H_2O$), 6 mL of distilled water and incubated for 30 min at 37°C (Ngxabi et al. 2021). Thereafter, 300 µL of the FRAP solution was mixed with 10 µL of the crude extract in a 96-well plate and the absorbance of the mixture was read at 593 nm. The FRAP of the tested samples was calculated using an L-ascorbic acid concentration curve ranging from 0 µM to 100 µM (Sigma-Aldrich, South Africa). Results were expressed as µM ascorbic acid equivalents (AAE) per g dry weight (µM AAE/g).

Determination of oxygen radical absorbance capacity

The oxygen radical absorbance capacity (ORAC) experiment was assayed following Ou, Hampsch-Woodill and Prior (2001) and Prior (2015). Calibration standards ranging from 5 µM to 25 µM were prepared by diluting a stock standard solution of trolox (500 M) in phosphate buffer (75 mM, pH 7.4). The Fluoroskan ascending plate reader which was supplied by Thermo Fisher Scientific (Waltham, USA) was set at 37 ºC. The excitation and emission wavelengths of the fluorescence filters utilised were 485 nm and 538 nm, respectively. A phosphate buffer was used to generate a fluorescein stock solution, which was further diluted to a final concentration of 14 µM per well. About 25 mg/mL of 2, 2′-azobis (2-amidino-propane) dihydrochloride dissolved in phosphate buffer was used to generate the peroxyl radical from 4.8 mM 2, 2′-azobis (2-amidino-propane) dihydrochloride constituted in each well. After 5 min, the fluorescence of each of the wells filled with 12 µL of diluted hydrophilic extract was measured. The ORAC fluorescence values were extrapolated from the regression equation '$y = ax^2 + bx + c$' estimated as µM Trolox equivalents per g dry weight (µM TE/g DW) calculated with the area under the curve.

Data analysis

Data were analysed using the MINITAB 17 statistical package. A one-way analysis of variance was computed on MINITAB to compare means, which were then ranked using Fisher's Least Significant Difference (LSD) pairwise comparison. Means were considered significantly different at $\alpha = 0.05$.

Ethical considerations

This article followed all ethical standards for research without direct contact with human or animal subjects.

Results

Physicochemical analysis of the soil

The results of the physicochemical analysis of the soil are shown in Table 1. The table shows the concentrations of soil minerals as affected by dosages of compost tea solutions.

The total fresh analysis of *H. hemerocallidea*

As shown in Table 2, the effect of all treatments on the leaf length, root length and corm diameter of *H. hemerocallidea* were not significantly different at $\alpha = 0.05$; however, marginal variability was recorded in the individual weight of the fresh leaves, corm and root of the compost tea extract-treated plant. The highest weights of the fresh leaves (40.01 g), corm (271.80 g), root (84.98 g) and total fresh weight of 396.79 g were observed in the $(0.5\frac{v}{v})$ compost tea solution treated plants which were higher than other treatments under review whereas the corresponding lowest weights were recorded in the fresh leaves and corms of the untreated plant grown with soil and water only, and roots of soil and water, and compost tea-treated samples both of which had equivalent weight (Table 2).

The total dry weight analysis of *H. hemerocallidea*

Different concentrations of compost tea extract affected the dry weight of *H. hemerocallidea* leaves and corms, but all treatments had an equal effect on the dry root. In the leaves, the highest value of dry weight was recorded at the $(0.5\frac{v}{v})$, $(1.0\frac{v}{v})$ and undiluted compost tea compared to the control (soil + water). Despite plants exhibiting marginal significance in dry corm weight at 0.25 v/v, the 0.5 and 0.75 treatments elicited higher dry corm weights (Table 3).

The nutrient content of dry leaves and rhizomes of *H. hemerocallidea*

The concentration of certain elements namely N, P, Ca and Mg varied in the leaves and rhizomes of *H. hemerocallidea* treated with different concentrations of compost tea extract (Table 4 and Table 5). Except for K, there is variability in the macroelement compositions of the dry leaves, namely N, P, Ca and Mg (α = 0.05) between treatments, whereas all micronutrients showed no variability (Table 4).

The 0.75 $(\frac{v}{v})$ compost tea-treated samples had the highest N and Mg levels, while the undiluted compost tea-treated samples had the highest P and Ca levels. The treatments, however, had no significant effects (α = 0.05) on the nutrient content of the dry rhizomes (Table 5).

Phytochemical and antioxidant assays

Different concentrations of compost tea induced similar effects on the total phenolic content of *H. hemerocallidea* while a significant difference was observed in the total flavonols. The highest flavonol yield was recorded in $(0.75\frac{v}{v})$ and $(1.0\frac{v}{v})$ treated samples of *H. hemerocallidea* while the control (100% compost tea extract) and the $(0.5\frac{v}{v})$ treated samples produced the least values of flavonols. All tested concentrations of compost tea did not induce significant effects on the ORAC and ABTS antioxidant capacity of *H. hemerocallidea*. However, a significant effect was recorded in the FRAP values where the $(0.75\frac{v}{v})$ compost tea solution induced the highest FRAP content of 410.28 µmol AA/g while the lowest FRAP values of 216.80 µmol AA/g was recorded in the $(0.5\frac{v}{v})$ treated samples (Table 6).

Discussion

It has been reported that compost tea could improve crop sustainability without sacrificing yield or fruit quality (Gómez-Brandón et al. 2015; Naidu, Stafford & Van Staden 2010). This could be attributed to the fact that compost tea acts as bio-protectants, biofertilisers or disease-causing organism inhibitors, lowering crop production costs (Marín et al. 2013). However, it is unknown whether the use of compost tea extracts can improve the growth, nutritional content, phytochemical content and antioxidant potential of *H. hemerocallidea* slow-growing corms. This is largely owed to limited research on the use of compost tea on medicinal plants. The variability observed in various growth parameters measured in this study suggested that growing the medicinal species with compost tea extract improved growth over time. This suggests that compost tea can improve the quality of the plant for medicinal use, removing the need for chemical fertilisers in its cultivation. This supports previous research findings that compost tea can be used as a bio-fertiliser to improve crop growth (Gómez-Brandón et al. 2015; Naidu et al. 2010).

Soil minerals are important in the physiological development of plants (Author(s), in press). Uptake and bioavailability of these nutrients may be optimised by adding compost tea as a growth facilitator and as a suppressant for weeds, pathogenic fungi and growth inhibitors (Ibrahim & Balah 2018; St Martin 2014). The findings of this study contradict those of Hargreaves, Adl and Warman (2009) who reported that compost tea treatments had no effect on mineral element uptake, as opposed to this study, which found that different concentrations of compost tea extract significantly affected the nutrient content of dried leaves of *H. hemerocallidea* while rhizome samples were unaffected.

TABLE 3: The total dry weight of *H. hemerocallidea*.

Treatments $(\frac{v}{v})$	Dry leaves (g)	Dry roots (g)	Dry corm (g)	Total dry weight (g)
0.25 $(\frac{v}{v})$	5.25 ± 1.30^{ab}	10.00 ± 2.20^{a}	6.91 ± 1.20^{ab}	22.16 ± 3.43^{a}
0.50 $(\frac{v}{v})$	6.50 ± 1.41^{a}	10.30 ± 2.10^{a}	8.39 ± 1.40^{a}	25.19 ± 2.62^{a}
0.75 $(\frac{v}{v})$	5.50 ±1.04^{ab}	9.30 ± 3.13^{a}	8.65 ± 1.40^{a}	23.45 ± 3.00^{a}
1.00 $(\frac{v}{v})$	7.07 ± 1.40^{a}	9.00 ± 2.22^{a}	7.27 ± 0.10^{ab}	23.34 ± 2.60^{a}
Compost tea only	7.21 ± 1.50^{a}	7.50 ± 2.21^{b}	4.20 ± 0.93^{b}	18.9 ± 3.10^{a}
Soil + water	3.30 ± 0.53^{b}	8.80 ± 2.21^{a}	3.84 ± 0.70^{b}	15.90 ± 3.10^{ab}

Means with the same letter are not significantly different at α = 0.05 using Fisher Least Significant Difference.

TABLE 2: The growth parameters and fresh weight analysis of *H. hemerocallidea*.

Treatments $(\frac{v}{v})$	Leaf length (cm)	Root length (cm)	Corm diameter (cm)	Fresh leaf weight (g)	Corm weight (g)	Root weight (g)	Total fresh weight (g)
0.25 $(\frac{v}{v})$	40.70 ± 6.20^{a}	28.90 ± 3.30^{a}	6.03 ± 0.30^{a}	27.77 ± 6.90^{c}	154.20 ± 19.20^{bc}	64.00 ± 12.30^{bc}	245.97 ± 27.70^{bc}
0.50 $(\frac{v}{v})$	46.60 ± 6.90^{a}	29.10 ± 2.40^{a}	7.39 ± 0.30^{a}	40.01 ± 9.30^{a}	271.80 ± 39.40^{a}	84.98 ± 15.50^{a}	396.79 ± 45.90^{a}
0.75 $(\frac{v}{v})$	40.85 ± 7.60^{a}	27.20 ± 4.10^{a}	7.23 ± 0.20^{a}	31.64 ± 6.20^{b}	241.50 ± 39.20^{ab}	79.13 ± 30.00^{ab}	352.27 ± 40.30^{ab}
1.00 $(\frac{v}{v})$	45.00 ± 6.60^{a}	29.50 ± 2.20^{a}	6.90 ± 0.40^{a}	34.00 ± 6.50^{b}	212.10 ± 29.20^{b}	72.14 ± 15.80^{b}	318.24 ± 29.80^{b}
Compost tea only	39.60 ± 6.10^{a}	26.80 ± 3.10^{a}	7.12 ± 0.40^{a}	19.72 ± 3.70^{a}	190.7 ± 28.60^{b}	58.24 ± 14.80^{c}	268.66 ± 32.15^{bc}
Soil + water	25.90 ± 5.10^{a}	30.75 ± 3.50^{a}	6.91 ± 0.50^{a}	15.90 ± 2.80^{d}	167.3 ± 33.70^{bc}	58.09 ± 1 3.20^{c}	241.30 ± 41.71^{c}

Means with the same letters are not significantly different at α = 0.05 using the Fisher Least Significant Difference.

TABLE 4: The nutrient content of dry leaves of *H. hemerocallidea*.

Treatments	*N* %	*P* %	*K* %	Ca %	Mg %	Na %	Mn (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	B (mg/kg)
0.25 ($\frac{v}{v}$)	0.73 ± 0.04^{b}	0.16 ± 0.01^{ab}	2.07 ± 0.22^{a}	1.18 ± 0.10^{b}	0.26 ± 0.02^{abc}	0.28 ± 0.04^{a}	188.30 ± 45.00^{a}	271.00 ± 31.00^{a}	7.33 ± 0.88^{a}	52.33 ± 9.26^{a}	42.00 ± 4.73^{a}
0.50 ($\frac{v}{v}$)	0.75 ± 0.01^{b}	0.16 ± 0.01^{ab}	2.42 ± 0.08^{a}	1.01 ± 0.01^{bc}	0.30 ± 0.01^{ab}	0.29 ± 0.01^{a}	193.70 ± 28.30^{a}	191.30 ± 57.60^{a}	9.00 ± 0.58^{a}	108.00 ± 61.20^{a}	36.67 ± 1.5^{a}
0.75 ($\frac{v}{v}$)	1.01 ± 0.03^{a}	0.18 ± 0.01^{ab}	2.22 ± 0.22^{a}	1.11 ± 0.06^{b}	0.32 ± 0.02^{a}	0.30 ± 0.05^{a}	166.70 ± 60.70^{a}	133.00 ± 28.60^{a}	10.33 ± 1.76^{a}	72.00 ± 34.00^{a}	34.33 ± 1.86^{a}
1.00 ($\frac{v}{v}$)	0.79 ± 0.11^{ab}	0.14 ± 0.02^{b}	1.99 ± 0.19^{a}	1.04 ± 0.03^{bc}	0.24 ± 0.03^{bc}	0.29 ± 0.06^{a}	154.30 ± 29.80^{a}	496.00 ± 304.30^{a}	12.33 ± 3.18^{a}	41.33 ± 6.06^{a}	32.00 ± 3.21^{a}
Compost tea only	0.92 ± 0.12^{ab}	0.21 ± 0.05^{a}	1.85 ± 0.50^{a}	1.46 ± 0.11^{a}	0.26 ± 0.03^{abc}	0.22 ± 0.02^{a}	261.70 ± 48.80^{a}	331.00 ± 140.00^{a}	12.67 ± 3.53^{a}	45.67 ± 8.37^{a}	41.00 ± 4.16^{a}
Soil + water	0.74 ± 0.04^{b}	0.18 ± 0.02^{ab}	1.85 ± 0.03^{a}	0.85 ± 0.03^{c}	0.22 ± 0.02^{c}	0.21 ± 0.00^{a}	76.0 ± 26.70^{a}	106.00 ± 3.21^{a}	8.33 ± 0.33^{a}	32.00 ± 1.73^{a}	34.33 ± 3.18^{a}

Mean values with the same letters are not significantly different at the α = 0.05 level of significance.

TABLE 5: The nutrient content of dry rhizomes of *H. hemerocallidea*.

Treatments ($\frac{v}{v}$)	*N* %	*P* %	*K* %	Ca %	Mg %	Na %	Mn (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	B (mg/kg)
0.25 ($\frac{v}{v}$)	0.42 ± 0.03^{a}	0.15 ± 0.02^{a}	0.86 ± 0.14^{a}	1.17 ± 0.46^{a}	0.26 ± 0.01^{a}	0.15 ± 0.01^{a}	222.60 ± 46.70^{a}	7212.00 ± 3041.00^{a}	13.00 ± 2.00^{a}	92.70 ± 16.80^{a}	2.67 ± 0.88^{a}
0.50 ($\frac{v}{v}$)	0.43 ± 0.03^{a}	0.11 ± 0.01^{a}	0.69 ± 0.05^{a}	0.77 ± 0.15^{a}	0.32 ± 0.01^{a}	0.13 ± 0.01^{a}	295.00 ± 39.00^{a}	4153.00 ± 1323.00^{a}	10.67 ± 1.45^{a}	98.00 ± 15.90^{a}	13.00 ± 1.73^{a}
0.75 ($\frac{v}{v}$)	0.45 ± 0.03^{a}	0.16 ± 0.02^{a}	1.17 ± 0.21^{a}	0.77 ± 0.05^{a}	0.36 ± 0.02^{a}	0.15 ± 0.01^{a}	297.00 ± 72.40^{a}	2231.00 ± 759.00^{a}	9.33 ± 0.67^{a}	83.67 ± 3.84^{a}	14.33 ± 0.33^{a}
1.00 ($\frac{v}{v}$)	0.51 ± 0.03^{a}	0.12 ± 0.01^{a}	1.10 ± 0.03^{a}	0.76 ± 0.06^{a}	0.30 ± 0.04^{a}	0.15 ± 0.01^{a}	305.70 ± 26.40^{a}	2572.00 ± 491.00^{a}	10.33 ± 0.33^{a}	97.00 ± 3.00^{a}	14.00 ± 0.58^{a}
Compost tea only	0.46 ± 0.03^{a}	0.13 ± 0.01^{a}	0.77 ± 0.07^{a}	0.84 ± 0.10^{a}	0.32 ± 0.03^{a}	0.15 ± 0.01^{a}	343.00 ± 61.80^{a}	4669.00 ± 1332.00^{a}	11.00 ± 1.00^{a}	81.00 ± 4.00^{a}	12.33 ± 1.45^{a}
Soil + water	0.51 ± 0.02^{a}	0.15 ± 0.02^{a}	0.98 ± 0.07^{a}	0.85 ± 0.08^{a}	0.32 ± 0.01^{a}	0.16 ± 0.02^{a}	233.33 ± 2.33^{a}	5328.00 ± 1731.00^{a}	15.33 ± 1.20^{a}	77.00 ± 1.00^{a}	16.33 ± 1.45^{a}

Mean values with the same letters are not significantly different at the α = 0.05 level of significance.

TABLE 6: Total polyphenols, flavonols and antioxidant activities of *H. hemerocallidea*.

Treatments ($\frac{v}{v}$)	Polyphenols (mg GAE/g)	Flavonols (mg QE/g)	ABTS (µmol TE/g)	FRAP (µmol AA/g)	ORAC (µmol TE/g)
0.25 ($\frac{v}{v}$)	58.28 ± 1.12^{a}	5.59 ± 1.47^{ab}	244.54 ± 45.17^{a}	326.72 ± 68.00^{ab}	1512.52 ± 350.95^{a}
0.50 ($\frac{v}{v}$)	44.60 ± 1.44^{a}	3.61 ± 2.65^{b}	193.26 ± 4.82^{a}	216.80 ± 6.09^{bc}	1507.94 ± 574.62^{a}
0.75 ($\frac{v}{v}$)	80.47 ± 8.63^{a}	8.55 ± 1.52^{a}	284.68 ± 4.03^{a}	410.28 ± 18.46^{a}	2386.25 ± 942.26^{a}
1.00 ($\frac{v}{v}$)	71.79 ± 16.98^{a}	9.20 ± 0.97^{a}	291.37 ± 32.05^{a}	373.00 ± 70.03^{ab}	1906.12 ± 464.90^{a}
Compost tea only	47.10 ± 1.36^{a}	2.81 ± 1.68^{b}	203.60 ± 37.94^{a}	250.20 ± 52.25^{b}	1535.61 ± 665.00^{a}
Soil + water	58.48 ± 3.99^{a}	7.19 ± 4.53^{ab}	225.36 ± 8.71^{a}	287.77 ± 28.60^{b}	1652.19 ± 149.18^{a}

Mean values with the same letters are not significantly different at the α = 0.05 level of significance.
FRAP, Ferric reducing antioxidant power; ORAC, oxygen radical absorbance capacity.

Overharvesting of *H. hemerocallidea* for medicinal and commercial purposes has resulted in habitat degradation and population loss for the species. Certainly, the bioactive compounds that confer medicinal potency on this important African medicinal species are the main target of harvesters. It has been established in the literature that polyphenols influence antioxidant properties in plants (Smith 2018; Unuofin, Otunola & Afolayan 2018b; Jimoh et al. 2019). Although the compost tea extracts influenced the growth characteristics and nutrients of *H. hemerocallidea*, they had no effect on the plant's polyphenolic content, ORAC and ABTS antioxidant properties. This contradicts the findings of Ros et al. (2020) who discovered that foliar application of compost tea extract significantly improved the vegetative growth, polyphenolic content and antioxidant capacity of *Spinacia oleracea* L.

In contrast, the findings of this study agree with the results of Pant et al. (2009) that compost fertilisation had very limited effects on the phenolics and antioxidant activity of *Brassica rapa* L. despite influencing growth and mineral nutrients in *B. rapa*. Nevertheless, significant variability was observed in this study in the flavonols and FRAP values of the species at α = 0.05 level of significance (Table 6). Thus, the manifold effects of compost fertilisation as manifested in the growth and quality yield of the *H. hemerocallidea* are also in tandem with Gómez-Brandón et al. (2015) albeit with a marginal influence on the screened phytochemicals.

Conclusion

The compost tea extract had no significant effect on the plant's phenolic content, ORAC and ABTS antioxidant properties, but it did have a significant effect on the species' flavonols and FRAP values. Nonetheless, the compost tea extracts had manifold effects on the species' growth and yield quality, and they may have influenced the selective uptake and accumulation of certain mineral elements like N, P, Ca and Mg in various parts of the plant. More research is needed to uncover the various mechanisms responsible for the species' selective uptake and bioaccumulation of nutrients and phytochemicals.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

The following authors were responsible for handling different aspects of the study: conceptualisation, C.P.L., C.W.D., F.N. and T.I.J.; methodology, T.I.J., F.N. and C.P.L.; validation, C.W.D. and C.P.L.; formal analysis, M.O.J.; investigation, T.I.J.; resources, C.P.L.; data curation, M.O.J. and F.N.; writing – original draft, T.I.J. and M.O.J.; writing – review and editing, M.O.J., C.W.D. F.N. and C.P.L.; supervision, C.W.D., F.N. and C.P.L. All authors have read and agreed to the published version of the article.

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Data availability

All data associated with this research are available on reasonable request from the corresponding author M.O.J.

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