Differential growth and yield attributes responses of *Solanum tuberosum* (L.) to soil solarization/compost/compost tea under field conditions.

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Abstract

To increase the production of irish potato (*Solanum tuberosum* L.) in the Adamawa- Cameroon, a trial was conducted to evaluate the influence of solarization, compost and compost tea on growth and yield of this plant. The experiment was conducted on a 145.75 m² surface area, in a completely randomized block design comprising 8 treatments each repeated three times. Growth and yield parameters were assessed and the results displayed have revealed the improvement of soil physico-chemical properties by soil solarization. The compost used had a pH closed to neutrality (7.43), a low salinity and a richness in organic matter that were favorable for plant growth. The number of stems per tuber was significantly ($p < 0.001$) more elevated in solarized soil + compost treatment (7.06) compared to the control (5.23). Solarized soil amended with compost and applied with compost tea resulted in increased plant height and early flowering. The average tubers diameter per plant, the fresh average tuber weight per plant were higher in solarized soil + compost + compost tea treatment than in other treatments. Solarized soils that were amended with compost and applied with compost tea (SsCpCt), as well as the non-sterilized soils that were amended with compost and compost tea (CpCt), yielded respectively 2.5 and 2.7 times more tubers than the control. Taking into consideration these results, and despite the fact that the experiment was not repeated over time the treatment soil solarization + compost + compost tea could be suggested to growers for a sustainable production of irish potato in the region.

Keywords: Soil solarization, compost, compost tea, Solanum tuberosum L., growth, yield.

Introduction

Solanum tuberosum L. is an important crop for human consumption worldwide, with a record production of 376 million tons [1]. An increase of a yearly production million tons has been observed worldwide, demonstrating the ever-increased importance of demand for this crop [2]. Potato is a versatile tuber product, but also a selected income crop for consumers and farmers [3]. Considered as a staple food to prevent malnutrition in developing countries, it is rich in energy resources, packed with essential vitamins, minerals and antioxidants compounds [4]. The plant has been cultivated in Cameroon by rural women since the years 1940, at 1000-3000 m altitude within six of the ten regions, including West, North-West, South-West, Adamaoua, Littoral and Far North [5]. The yearly consumption has been reported to range from 4 to 10 kg/inhabitant [6], a source of significant income, with the excess production being sold in the local market or exported to neighboring countries. comon in other growing zones, cultivation of *Solanum tuberosum* has been practiced for years with relatively low yield, mainly attributed to low soil fertility, increased soils pathogens that enhance the severity of diseases to the host plants, the acidity of soils, the low soil organic matter, the insect attacks, as well as the poor cultural practices, resulting to reduced food security [7].

Under these production constraints, several solutions have been proposed, including the use of chemical fertilizers, which

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often provide an immediate solution to the mineral deficit problem in general. These inputs can improve production by around 82% [8], although very few poor farmers can afford to obtain, in addition to the lack of control over their uses and risks that can upset the environmental balance [9]. According to Margni et al. [10], the excessive use of chemical inputs severely and durably affects the environment, the bio-functioning of soil and present risks to human health. Therefore, the implementation of healthy agricultural strategies, less expensive and ecologically friendly that increase the fertility of the soil, crop yields, and the quality of the harvested products are necessary for potato production. Some of these strategies have been reported such as the uses of microbial biofertilizers (*Rhizobium*) or Mycorrhiza, as a supplement to cultural practices to improve mineral nutrition, plants vigor and growth [11], or the use of organic amendments (compost and compost tea) that improve soil structure and fertility [12], as well as the use of soil solarization that sterilizes and mineralizes the soil [13]. The utilization of organic fertilizers such as chicken manures [14], or compost [15] have been reported to improve the soil quality and crop yields. Other previous researches have revealed the improved potato production, as the result of the implementation of soil solarization and mycorrhizal inoculation on the growth and yield of potato [13, 16]. To the best of our knowledge, no study has yet been conducted to investigate on the effect of the combination of soil solarization/compost/compost tea on potato production in this region. The aim of this study was therefore, to evaluate the influence of both soil solarization, compost and compost tea on growth and yield of irish potato at Dang-Ngaoundere.

Material and Methods

Description of the study area

The study was conducted in the field within the campus of the University of Ngaoundere, Adamawa region of Cameroon, with GPS coordinates 33° 87'50" North latitude and 82° 07'45" East longitude at 1079 m altitude. It is located at about 13 km from the town of Ngaoundere on the Ngaoundere-Garoua national road. The Adamawa region is located between the 6th and 8th degrees north latitude and between the 11th and 15th degree of east longitude, it covers about 62000 km^2 and belongs to the agro-ecological zone known as high Guinean savannas [17]. The climate of the region is of Sudano-Guinean type, influenced by stable and dry continental air in the north and unstable and humid maritime air in the south. The dry season ranges from November to March, whereas the rainy season extends from April to October, the average annual rainfall varying from 900 mm to 1500 mm. The minimum temperatures (10-19°C) are observed in December and January, while the maximum temperatures (27 to 34°C) are detected in March [17]. The vegetation is dominated by high-altitude savanna trees such as *Daniellia oliveri* and *Lophira lanceolata*, whereas soils are basaltic and granitic thus favorable for agriculture and livestock.

Composting process

The method consisted of placing organic wastes (chicken manures) and the inoculum (soil containing composting microorganisms) in a pile of 1.5 m² and 1 meter in height **(Figure 1)** as described by Havouvang et al. [15]. In total, 300kg of organic materials were used. The whole pile was covered with a transparent white polyethylene plastic. During the composting process, piles were regularly returned and watered at 14 days interval until complete degradation of the organic matter. At maturity, compost was sieved and stored in bags.

Soil Solarization technic

The experimental site was first cleared from plant debris, then ploughed and stirred deeply (25-35 cm) to move out seeds and roots weeds. A total of 24 sub-experimental units were established. Soil solarization was performed on (2.5×4.5) m^{2}surface area covered with a white polyethylene plastic sheet for three months. Edges of plastic were buried at 5 cm deep around the perimeter of piles to ensure that plastic is held in place, thereby preventing heat from escaping and allowing wind to set beneath [18]. To increase the transmission of heat through the soil and enable resting structures more sensitive to high temperature, soil was maintained smooth on the surface and wetted prior to solarization.

Sampling and physico-chemical analysis of soil and compost

Composite samples of compost, solarized and non-solarized soils were taken at a single depth of 0-25 cm for each elementary plot after thoroughly mixture. Samples were sun dried, stored in 1kg sterile plastic bags, labeled and sent to the

Figure 1. *Composting pile made up of chicken manures.*

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Ngaoundere Institute of Technology Laboratory for physico-chemical analysis following the methods recognized and recommended by Simmons et al. [19].

Production of compost tea and plant material

Compost tea was extracted by mixing compost and tap water in a ratio 1/25 (kg /L), before homogenization and filtration through a <0.001 mm sieve [12]. The obtained filtrate was anaerobically fermented for 24 hours and the ferment **(Figure 2)** kept in the fridge at 4°C for further uses. The potato cultivars of the Cipira variety (white skin, purple flowers, growth cycle ranging from 70 to 75 days) used was purchased from a phytosanitary store in Ngaoundere **(Figure 3)**.

Experimental design and treatments

The experiment was set up in a completely randomized block design, comprising 8 treatments, each of which was repeated three times. The experimental field was laid out on a 145. 75 m^2 surface areas consisting of 24 elementary plot units grouped into 4 blocks. Each block was subdivided into 06 experimental units (4 m^2 each) arranged randomly, and separated 50 cm apart. On each experimental plot unit, 12 seed tubers separated 30 cm each other were sown in two lines distanced 60 cm apart. Treatments consisted of: Plants growing on non-solarized soil, but spread with compost tea (Ct); Plants growing on solarized soil (Ss); Control plants growing on non-solarized soil, not amended with compost, not applied with compost tea (Ctrl); Plants growing on solarized soil and applied with compost tea (SsCt); Plants growing on non-solarized soil, amended with compost and applied with compost tea (CpCt); Plants growing on solarized soil and amended with compost (SsCp); Plants growing on solarized soil, amended with compost and applied with compost tea (SsCpCt); Plant growing on non-solarized soil, but amended with compost (Cp) **(Table 1).**

To ensure a rapid seed tubers emergence, seeds were previously soaked for 5h30 min into tap water, to stimulate the physiological functions of tubers. Pregerminated seed tubers were planted in each experimental plot unit at 10 cm depth, before they were covered with a soil layer to protect tubers from damages caused by against rodents. The seeding density was 24 seed tubers (12 tubers in a row) per experimental plot unit. Compost was applied following the method described by Ngakou et al. [20], consisting of introducing 50g of previously weighed compost in each planting hole at 10 cm depth **(Figure 4A)**. Compost tea was foliar spread on all the aerial parts of the plant (stem, leaves and flowers) using a hand-held sprayer **(Figure 4B)**.

Assessment of growth parameters

The germination rate expressed in percentage (%) was evaluated at 15 days after planting, by counting the number of shoots emerging from a seed tuber in all the treatments using the following formula:

Germination rate = (Number of plants raised × Number of pregerminated tubers sown) × 100.

During the vegetative phase, growth parameters such as stem number per seedling and plant height were evaluated on 10 randomly selected plants from each experimental unit at 15-

Figure 2. *Compost tea ready to be use.*

Figure 3. *Pregerminated potato seed tubers.*

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day intervals from 30, 45 to 60 days after plantlets emergence [21]. The date of first flowering was recorded observing and detecting flower buds on plants in each experimental unit, until 50% and 100% flowering for each treatment. The number of stems per seeded tuber was obtained by manual counting, while the size (cm) of each plant was measured by measuring the height of each of the 10 plants per experimental unit from the soil to the highest apex of the plant [22].

Evaluation of yield parameters

The mean diameter (cm) of harvested tubers was determined on 30 randomly selected tubers per treatment. Tuber diameter was measured with a caliper at the top third of each tuber **(Figure 5)**. Thus, the average diameter per treatment was obtained by the following formula:

Average tuber diameter (cm) = $\frac{1}{n}\sum_{i=1}^{ni} D$ where, n = number of tubers and D the tuber diameter

The average fresh tuber weight (kg) at harvest was determined on 30 randomly selected tubers per treatment after weighing using by the following formula:

Fresh average tuber weight (Kg) = $\frac{1}{n}\sum_{i=1}^{mi}$, where n = total number of tubers and m_i the tuber mass. At maturity, tuber yield (Kg) was evaluated by weighing the tubers from 30 randomly selected plants per treatment, using a 1/100 scale electronic scale. The yield per hectare was estimated for each treatment from the experimental unit surface and the weight of tubers per treatment using the following formula [23].

Yield (t/ha) = (Yield of UP x 10000 m2)/S, where, S represents the surface area a plot unit (4m²), 10000 m2 the surface of one hectare and UP the weight of tubers harvested from an experimental unit.

Statistical analysis

The Microsoft Excel 2016 software was used to encode the raw data in digital format and to plot graphs. The results were statistically analyzed using the "Statgraphics plus version 5.0" software, which performs analysis of variance (ANOVA) to discriminate means between treatments. Duncan's multiple range test was used to judge differences between f treatments, while the Pearson correlation test was performed using the "SPSS 16.03" software to study the relationship between different studied parameters.

Results

Physico-chemical composition of compost and soil before and after solar sterilization

The physical and chemical parameters of different soil samples varied depending on whether the soil was been sterilized or not. A significant difference was observed between the non-solarized and solarized soil as far as the ash content ($p < 0.0001$), nitrogen content ($p = 0.002$), organic matter content ($p < 0.0001$), phosphorus content ($p = 0.008$), pH ($p = 0.02$), and electrical soil conductibility ($p < 0.0001$) are concerned **(Table 2 and Table 3)**. Soil solarization reduced the ash content, but resulted in the increase of all the aforementioned parameters. On the reverse, soil solarization did not have an effect on the dry matter and moisture contents ($p = 0.994$).

Compared to solarized and non-solarized soils, compost from chicken manures was rich in organic matter (18.78%), and has a very high electrical conductibility 73 µs/cm **(Table 4)**. In contrast, nitrogen and phosphorus contents in compost and solarized soil were almost similar.

Table 1. *Significance of the different treatments.*

Treatments	Significance
Ctrl	Control plants growing on non-solarized soil, not amended with compost, not applied with compost tea.
Ct	Plants growing on non-solarized soil, but spread with compost tea.
Ss	Plants growing on solarized soil
Cp	Plant growing on non-solarized soil, but amended with compost.
SsCt	Plants growing on solarized soil and applied with compost tea.
CpCt	Plants growing on non-solarized soil, amended with compost and applied with compost tea.
SsCp	Plants growing on solarized soil and amended with compost.
SsCpCt	Plants growing on solarized soil, amended with compost and applied with compost tea.

(A) **(B)**

Figure 4. *Amendment of compost pockets (A) and application of compost tea (B).*

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Figure 5. *Evaluation of potato tubers diameter using a caliper.*

Table 2. *Physical composition of the soil.*

Physical Parameters of soil (%)				
Samples	**DMC**	**AC**	**MC**	**OMC**
Untreated soil	94.16 ± 0.14a	88.78 ± 0.10b	5.83 ± 0.14a	6.27 ± 0.16a
Solarized soil	94.16 ± 0.09a	55.76 ± 0.06a	5.83 ± 0.09a	8.83 ± 0.07b
p-value	0.9945	p < 0.0001	0.9945	p < 0.0001

DMC: dry matter content; AC: ash content; MC: moisture content; OMC: organic matter content. NB: Values with the same letters on the same column are not significantly different at the 5% threshold

Table 3. *Chemical composition of the soil.*

Chemical Parameters of soil				
Samples	**N** (g/100gDM)	**P** (g/100gDM)	**pH**	**EC** (µ s/cm)
Untreated soil	4.22 ± 0.59a	1.25 ± 0.10a	6.57 ± 0.20a	39.31 ± 0.18a
Solarized soil	7.11 ± 0.48b	2.66 ± 0.49b	7.43 ± 0.39b	70.5 ± 1b
p-value	0.0028	0.0085	0.0283	p < 0.0001

N: nitrogen content; P: phosphorus content; pH: hydrogen potential; E: electrical conductivity. NB: Values with the same letters on the same column are not significantly different at the 5% threshold

Table 4. *Physico-chemical characteristics of compost.*

Physico-chemical parameters	**Average**
Ash content (%)	71
Alcalimetry (°F)	22
Organic matter content (%)	18.78
pH	6.63
Electrical conductivity (µ s/cm)	73
Orthophosphate content (mg/l)	9.92
Ammonia content (mg/l)	0.05
Potassium content (mg/l)	1.89
Total Nitrogen (mg/g)	6.56
P_2O_5 content (mg/g)	3.36
K_2O content (mg/g)	5.78

Influence of different treatments on growth parameters

Variation of germination rate between treatments

(Figure 6) shows the germination rate of tubers from different treatments applied. It appears that all tubers began to emerge as early as the seventh day after sowing. The germination rate of solarized soil + compost + compost tea and compost treatments were significantly higher ($p < 0.05$), with respectively 54.16% and 61.11% compared to that of the control (45.88%). Thus, a non-solarized soil amended with 50g of compost appeared to be the indicated treatment to induce fast emergence of pregerminated potato seed tubers.

Effect of different treatments on the number of stems emerging from a tuber

The average numbers of stem per tuber increased with time, but did not significantly change between the 30th and 45th day after planting ($p > 0.05$). However, at 60 days after planting solarization and compost significantly ($p = 0.006$) increased the stems number per tuber compared to that of other treatments **(Table 5)**. Therefore, treatment solarized soil + compost and compost were the best that promoted a maximum increase in the number of stems per potato tubers.

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Effect of treatments on plant height

The average plant height varied with the treatment applied and gradually with time **(Table 6)**.

The analysis of variance performed at each sampling date indicated a significant difference (p < 0.0001) between the mean heights of the plants. At any of the date after emergence, treatments compost (Cp, compost tea (Ct) and soil solarization (Ss) significantly (p<0.0001) enhanced the plant height more than other treatments, the best treatments being Cp, SsCp, and SsCpCt, respectively at 30, 45 and 60 days after emergence.

Responses of treatments to flowering rate

(Figure 7) illustrates the influence of the different treatments on flowering dates and shows that each of the treatments had a clear influence on each flowering period. This indicates that all the treatments contributed to stimulating the flowering of potato plants, depending on the period.

Responses of treatments to tuber yield parameters

The average tuber diameter was significantly affected by different amended treatments (p < 0.0001) as shown on Figure 8. Solarized soil amended with compost (SsCp) or solarized soil amended with compost on which plants were applied with compost tea (SsCpCt) showed average tuber diameters higher (4.52 ± 0.62 and 4.60 ± 0.78 cm) than that of the control treatment (3.672 ± 0.439 cm). The average fresh weight of the tubers **(Table 7)** was also significantly affected by different treatments (p < 0.0001). The fresh weight of tubers from solarized soil + compost + tea compost treatment was better improved (1.58 ± 0.41 kg), while that of the control was the lowest (0.62 ± 0.03 kg). The tuber yield per hectare was significantly influenced by all treatments with amendments (p < 0.0001). Moreover, solar sterilized plots that were amended with compost and applied with compost tea (SsCpCt), as well as the non-sterilized units

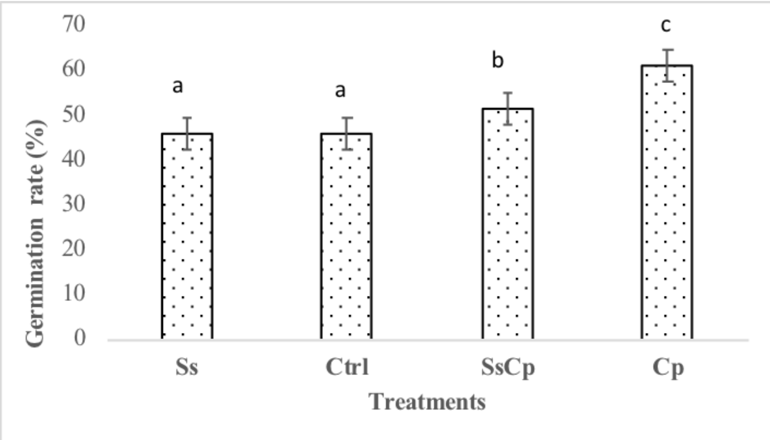

Figure 6. *Differences in germination rate between treatments.*

Bars affected with the same letters are not significantly different at the indicated level of significance. **Ss**: Plants growing on solarized soil; **Ctrl**: Control plant growing on non-solarized soil, not amended with compost, not applied with compost tea; **SsCp:** Plants growing on solarized soil and amended with compost; **Cp**: Plant growing on non-solarized soil, but amended with compost

Table 5. *Variation of the stem number emerging from a seed tuber between treatments at different days after emergence.*

Treatments	Time: days after emergence (DAE)		
	30 **DAE**	45 **DAE**	60 **DAE**
Ct	2.3±1.02[a]	3.6±11.35[b]	5.23±1.83[c]
Ss	2.56±1.33[a]	3.95±11.91[ab]	5.1±2.32[c]
Ctrl	2.16±1.14[a]	3.83±1.66[ab]	5.76±1.95[bc]
SsCt	2.66±1.42[a]	4.1±2.04[ab]	5.73±2.14[bc]
CpCt	2.53±1.85[a]	4.72±3.43[a]	6.2±2.64[abc]
SsCp	2.93±1.89[a]	4.71±2,08[a]	7.06±2.18[a]
SsCpCt	2.93±1.70[a]	4.33±2.20[ab]	6.1±2/32[abc]
Cp	2.5±1.59[a]	4.56±1.94[ab]	6.83±2.50[ab]
p-value	0.4690	0.3092	0.0068

At each date after emergence, values in a column affected with the same letters are not significantly different at the indicated level of significance. **Ct**: Plants growing on non-solarized soil, but spread with compost tea; **Ss**: Plants growing on solarized soil; **Ctrl**: Control plant growing on non-solarized soil, not amended with compost, not applied with compost tea; **SsCt**: Plants growing on solarized soil and applied with compost tea; **CpCt**: Plants growing on non-solarized soil, amended with compost and applied with compost tea; **SsCp:** Plants growing on solarized soil and amended with compost; **SsCpCt:** Plants growing on solarized soil, amended with compost and applied with compost tea; **Cp**: Plant growing on non-solarized soil, but amended with compost.

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Table 6. *Variation in Plant height at different date after emergence.*

Treatments	Time: days after emergence (DAE)		
	30 **DAE**	45 **DAE**	60 **DAE**
Ct	19.3±7.45cd	22.83±7.52e	25.36±7.60e
Ss	18.26±4.67 cd	22.9±4.72e	26.35±4.69e
Ctrl	17.06±6.72d	24.23±7.34de	25.36±6.68e
SsCt	21.8±6.78bc	27.01±7.16cd	30.96±6,21d
CpCt	23.13±6.95b	29.8±7.16bc	36.8±7.74bc
SsCp	28.07±8.46a	34.56±7.86ab	39±7.49ab
SsCpCt	24.13±7.04b	31.03±8.47ab	42.13±7.92a
Cp	29.1±8.06a	32.56±8.17ab	34.9±9.85c
p-value	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$

At each date after emergence, values in a column affected with the same letters are not significantly different at the indicated level of significance. **Ct**: Plants growing on non-solarized soil, but spread with compost tea; **Ss**: Plants growing on solarized soil; **Ctrl**: Control plant growing on non-solarized soil, not amended with compost, not applied with compost tea; **SsCt**: Plants growing on solarized soil and applied with compost tea; **CpCt**: Plants growing on non-solarized soil, amended with compost and applied with compost tea; **SsCp:** Plants growing on solarized soil and amended with compost; **SsCpCt:** Plants growing on solarized soil, amended with compost and applied with compost tea; **Cp**: Plant growing on non-solarized soil, but amended with compost.

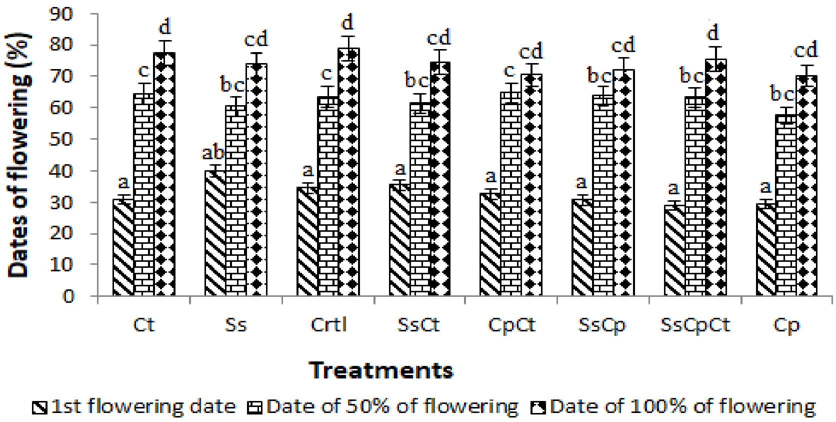

Figure 7. *Flowering rates of irish potato plants as influenced by treatments.*

Ct: Plants growing on non-solarized soil, but spread with compost tea; **Ss**: Plants growing on solarized soil; **Ctrl**: Control plant growing on non-solarized soil, not amended with compost, not applied with compost tea; **SsCt**: Plants growing on solarized soil and applied with compost tea; **CpCt**: Plants growing on non-solarized soil, amended with compost and applied with compost tea; **SsCp:** Plants growing on solarized soil and amended with compost; **SsCpCt:** Plants growing on solarized soil, amended with compost and applied with compost tea; **Cp**: Plant growing on non-solarized soil, but amended with compost DAE : days after emergence.

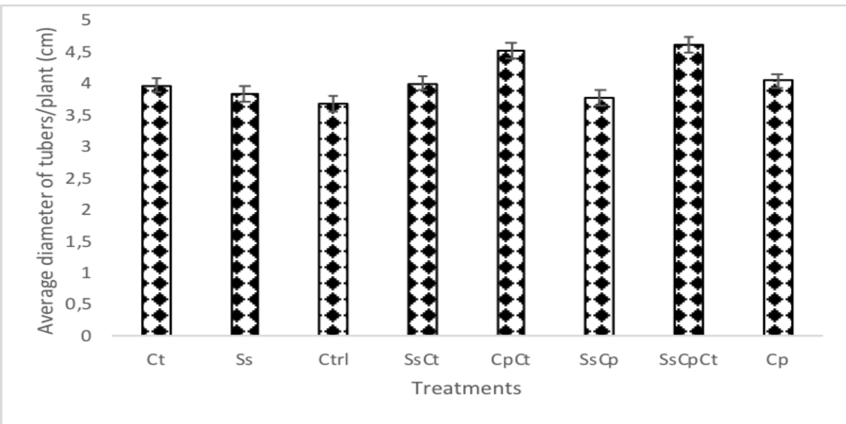

Figure 8. *Changes in tuber diameter as influenced by applied treatments*

Bars affected with the same letters are not significantly different at the indicated level of significance. **Ct**: Plants growing on non-solarized soil, but spread with compost tea; **Ss**: Plants growing on solarized soil; **Ctrl**: Control plant growing on non-solarized soil, not amended with compost, not applied with compost tea; **SsCt**: Plants growing on solarized soil and applied with compost tea; **CpCt**: Plants growing on non-solarized soil, amended with compost and applied with compost tea; **SsCp:** Plants growing on solarized soil and amended with compost; **SsCpCt:** Plants growing on solarized soil, amended with compost and applied with compost tea; **Cp**: Plant growing on non-solarized soil, but amended with compost.

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Table 7. *Variation of fresh weight of tubers (kg) per plant and tuber yield between treatments (t /ha).*

Treatments	Tuber's fresh weight (Kg)	Tuber's yield (t/ha)
Ct	0.74±0.11cd	13.62cd
Ss	0.93±0.22bcd	15.25bcd
Ctrl	0.62±0.03d	10.95d
SsCt	0.91±0.19cd	16.72bc
CpCt	1.17±0.47abc	24.88ab
SsCp	1.17±0.47abc	22.16abc
SsCpCt	1.58±0.41a	27.84a
Cp	1.39±0.26ab	23.20abc
p-value	p < 0.0001	P < 0.0001

In a column yields affected with the same letters are not significantly different at the indicated level of significance. **Ct**: Plants growing on non-solarized soil, but spread with compost tea; **Ss**: Plants growing on solarized soil; **Ctrl**: Control plant growing on non-solarized soil, not amended with compost, not applied with compost tea; **SsCt**: Plants growing on solarized soil and applied with compost tea; **CpCt**: Plants growing on non-solarized soil, amended with compost and applied with compost tea; **SsCp:** Plants growing on solarized soil and amended with compost; **SsCpCt:** Plants growing on solarized soil, amended with compost and applied with compost tea; **Cp**: Plant growing on non-solarized soil, but amended with compost

that were amended with compost and compost tea (CpCt), respectively yielded 2.5 and 2.7 times more tubers than the control.

Discussion

Soil solarization, compost and compost tea are agricultural practices for healthy and sustainable agricultural production. Sterilization of soil with solar rays was reported to improve like in the present study, the physical, chemical and biological properties of soils [13, 24]. During solarization, must of the resident microbiota are killed and degraded, thus liberating mineral nutrients, increasing the amount of nitrogen, due to liberation of ammonium and/or nitrate in the soil [25, 26]. The relative concentration of each soil element was revealed to depend on the reducing nature of the soil physical properties and the presence of nitrifying microorganisms such as *Nitrobacter* and *Nitrosomonas* [27]. Therefore, in soils harboring high organic matter, solarization may kill most of the soil microbiota and produce micro-aerobic conditions, favoring the accumulation of ammonium. In addition to nitrogen, other mineral nutrients in soil including extractable phosphorus, potassium and calcium might have greater concentrations after solarization [24]. The pH of compost (6.63) was lower than the one obtained by Rodriguez et al. [28], who revealed a high pH range of between 8.6 to 9.3 at the end of the composting process from liquid poultry and barley wastes. Compost was rich in organic matter, with concentration lower than that of Quiroga et al. [29], who reported organic matter in the range of 600-850 g/kg from poultry wastes. The observed electrical conductivity values were lower than those reported by Abdelhamid et al. [30], Salam et al. [31] during composting of rice straw. Our results on phosphate concentration were lower than 12-39 g/kg reported by Quiroga et al. [29], who have also reported N values for mature compost ranged from 25.7 to 40.9 g/kg [32], 15-18 g/kg, which are higher than the observed value (6.56 g/kg) in the present study.

As far as growth parameters are concerned, germination rate of seed tubers was significantly higher in compost amended than in unamended treatments, indicating the importance of choosing chicken manures as compost substrate, known to be rich in phosphorus. Indeed, phosphorus is an important element for growth and fruiting of plants [33]. These results are in accordance with those obtained by Thepsilvisut et al. [14] during assessment of chicken manure on the yield and qualities of white mugwort. Similar results were reported by Haouvang et al. [34], when assessing the effect of organic fertilizers on the survival of Moringa under greenhouse conditions.

The development of plant and microbial community from solarized soil + compost treatment was higher than that of the control, due to their reported effect on water absorption and availability, as well as reduction of plant transpiration [35]. In fact, solarized soil and compost were shown not only to accumulate organic matter, but also, to play a role in the slow and regular release of mineral elements, in the retention of water, thus in the reduced effect of water stress on plants [36]. According to Chellimi and Mirusso [37], soil solarization preceding lettuce cultivation positively affected plant productivity. Similarly, compost was indicated to work by improving the physical, chemical and biological properties of the soil, while influencing the plant nutrient supply [34]. According to Grünzweig et al. [38], soil solarization is known to considerably increase the main soil elements such as nitrogen, phosphorus and potassium, thus to enhance irish potato growth, similar to previous findings by Niemira et al. [39]. These results line with enhanced soybean production following soil solarization and rhizobial seeds inoculation at sowing [22].

The cumulated effect of soil solarization, compost and compost tea contributed to a significant increase of irish potato agricultural performance, in agreement with the improved soil properties in a spinash cropping system on cucumber growth parameters after organic treatments [36]. Yield parameters with reference to tuber number/plant was higher in compost + tea treatment, attributed to huge amount of nutrients provided by this treatment, which positively influences the vegetative phase, thus improving plant development and crop yield. According to Gonzalez-Hernandez et al. [40], compost + compost tea as combined treatment was shown to promote root development and accelerates the maturity of the plant, corroborating other results by Ngakou et al. [12], on improved growth or yield parameters of tomato after compost and compost tea application.

The average diameter of the tubers, the average fresh tuber weight and the yield/ha were higher for solarized soil + compost + compost tea treatment compared to those of other treatments, thus attributed to stimulation of mobile the nutritive resources necessary for plant production. Soil solarization was revealed to induce production of organic molecules or humic substances with a growth hormone effect, favoring a high productivity of plants. By controlling weeds, damaging soil pathogen, or mineralizing the soil, soil solarization was confirmed to increase the growth and plant yield beyond expected levels, or improving essential soil nutrients such as nitrogen, calcium and magnesium accounting for increased plant growth [24].

Conclusion

This study has indicated the benefits of compost from organic wastes and the effectiveness of solarization as soil mineralization strategy for enhanced tubers yield of *Solanum tuberosum*. Considering that irish potato crops are influenced by nutrient status in the soil, the combined effect of soil solarization, compost and compost tea could be considered as a sustainable strategy for smallholder farmers to increase their potato production. Further studies are needed to evaluate the effect of these three ecological strategies on nutrient accumulation and nutritional quality of potato tubers.

Declarations

Author contribution statement

Mohamadou Moussa; Gomoung Doloum; Yoradi Nadjilom, Haouvang Laba Christophe Performed the experiments; Analyzed and interpreted the data; wrote the paper.

Steve Takoukam Toukam; Serge Kononer Rapmo: Contributed reagents, materials, analysis tools or data.

Albert Ngakou: Conceived and designed the experiments.

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Additional information

No additional information is available for this paper.

References

1. Lal MK, Tiwari RK, Kumar A, et al. Mechanistic concept of physiological, biochemical, and molecular responses of the potato crop to heat and drought stress. Plants. 2022;11(21):2857.
2. Hossain MA, Hasan MK, Naher Q. Assessment of technical efficiency of potato producers in some selected areas of Bangladesh. J Agric Rural Dev. 2008;6(1&2):113-8.
3. Bach D, Bedin AC, Lacerda LG, et al. Sweet potato (Ipomoea batatas L.): a versatile raw material for the food industry. Braz Arch Biol Technol. 2021;64:e21200568.
4. Hellmann H, Goyer A, Navarre AD. Antioxidants in Potatoes: A Functional View on One of the Major Food Crops Worldwide. mol. 2021; 26: 2446.
5. Mengui KC, Oh S, Lee SH. The technical efficiency of smallholder Irish potato producers in Santa subdivision, Cameroon. Ag. 2019;9(12):259.
6. Veronese N, Stubbs B, Noale M, et al. Fried potato consumption is associated with elevated mortality: an 8-y longitudinal cohort study. Am J Clin Nutr. 2017; 106(1):162-7.
7. Gleń-Karolczyk K, Bolligłowa E, Luty L. Health parameters of potato tubers under the influence of soil applied bio-preparations and bio-stimulants. Appl. Sci. 2022; 12(22):11593.
8. Islam MS, Bell RW, Miah MM, et al. Unbalanced fertilizer use in the Eastern Gangetic Plain: The influence of Government recommendations, fertilizer type, farm size and cropping patterns. Plos one. 2022; 17(7):e0272146.
9. Zhang L, Yan C, Guo Q, et al. The impact of agricultural chemical inputs on environment: global evidence from informetrics analysis and visualization. Int. j. low carbon technol. 2018; 13(4):338-52.
10. Margni MD, Rossier D, Crettaz P, et al. Life cycle impact assessment of pesticides on human health and ecosystems. Agric. Ecosyst. Environ. 2002; 93(1-3):379-92.
11. Ngakou A, Nwaga D, Ntonifor NN, et al. Contribution of Arbuscular Mycorrhizal Fungi (AMF), rhizobia and Metarhizium anisopliae to cowpea production in Cameroon.
12. Ngakou A, Koehles H, Ngueliaha HC. The role of cow dung and kitchen manure composts and their non-aerated compost teas in reducing the incidence of foliar diseases of Lycopersicon esculentum (Mill). Int. j. agric. res. innov. technol (IJARIT). 2014; 4(1):88-97.
13. Safdar ME, Safdar M, Ali A, et al. Soil solarization improves soil fertility in addition to weed management in sesame under subtropical conditions of Pakistan. WSSA. 2021; 39:e020219464.
14. Thepsilvisut O, Chutimanukul P, Sae-Tan S, et al. Effect of chicken manure and chemical fertilizer on the yield and qualities of white mugwort at dissimilar harvesting times. Plos one. 2022;17(4):e0266190.
15. Haouvang LC, Albert N, Martin Y, et al. Growth response of Moringa oleifera Lam. as affected by various amounts

of compost under greenhouse conditions. Ann. Agric. Sci. 2017; 62(2):221-6.

16. Duffy EM, Cassells AC. The effect of inoculation of potato (Solanum tuberosum L.) microplants with arbuscular mycorrhizal fungi on tuber yield and tuber size distribution. Appl. Ecol. 2000; 15(2):137-44.

17. Dai Y, Senge M, Yoshiyama K, et al. Influencing factors, effects and development prospect of soil solarization. Agric. Rev. 2016; 4:21-35.

18. Simmons CW, Higgins B, Staley S, et al. The role of organic matter amendment level on soil heating, organic acid accumulation, and development of bacterial communities in solarized soil. Appl. Ecol. 2016; 106:37-46.

19. Ngakou A, Toukam ST, Nkot LN, et al. Appropriate compost/soil ratios for sustainable production of garlic (Allium sativum L.) under mycorrhization in pots experiment.

20. Afek U, Menge JA, Johnson EL. Interaction among mycorrhizae, soil solarization, metalaxyl, and plants in the field.

21. Megueni C, Ngakou A, Makalao MM, et al. Responses of soybean (Glycine max L.) to soil solarization and rhizobial field inoculation at Dang Ngaoundere, Cameroon.

22. Liu K, Meng M, Zhang T, et al. Quantitative Analysis of Source-Sink Relationships in Two Potato Varieties under Different Nitrogen Application Rates. Agronomy. 2023; 13(4):1083.

23. Stapleton JJ. Soil solarization in various agricultural production systems. Crop protection. 2000; 19(8-10):837-41.

24. Gill HK, Aujla IS, De Bellis L, et al. The role of soil solarization in India: How an unnoticed practice could support pest control. Front. Plant Sci. 2017; 8: 278908.

25. Hasson AM, Hassaballah T, Hussain R, et al. Nitrogen: Effect of solar soil sterilization on nitrification in soil. J. Plant Nutr. 1987; 10(9-16):1805-9.

26. Guerra-Rodríguez E, Vazquez M, Díaz-Raviña M. Dynamics of the co-composting of barley waste with liquid poultry manure. J. Sci. Food Agric. 2003; 83(3):166-72.

27. Quiroga G, Castrillón L, Fernández-Nava Y, et al. Physico-chemical analysis and calorific values of poultry manure. Waste Manag. Res. 2010; 30(5):880-4.

28. Abdelhamid MT, Horiuchi T, Oba S. Composting of rice straw with oilseed rape cake and poultry manure and its effects on faba bean (Vicia faba L.) growth and soil properties. Bioresour. Technol. 2004; 93(2):183-9.

29. Salman AK, Al-Rajhi MA, El-Rayes AI, et al. Rapid composting of rice straw with some agriculture green residues and animal waste under full control systems. J. Agric. Eng. 2011; 2(12):1229-42.

30. Kelley TR, Pancorbo OC, Merka WC, et al. Accumulation of elements in fractionated broiler litter during re-utilization. Poult. Sci. J. 1998; 7(1):27-34.

31. Razaq M, Zhang P, Shen HL, et al. Influence of nitrogen and phosphorous on the growth and root morphology of Acer mono. PloS one. 2017;12(2):e0171321.

32. Christophe HL, Albert N, Martin Y,et al. Effect of organic fertilizers rate on plant survival and mineral properties of Moringa oleifera under greenhouse conditions. Int. J. Recycl. Org. Waste Agric. 2019; 8:123-30.

33. Simmons CW, Guo H, Claypool JT, et al. Managing compost stability and amendment to soil to enhance soil heating during soil solarization. Waste management. 2013;33(5):1090-6.

34. Hernández-Lara A, Ros M, Cuartero J, et al. Effects of solarisation combined with compost on soil pathogens and the microbial community in a spinach cropping system. Agric. Ecosyst. Environ. 2023; 346:108359.

35. Chellemi DO, Mirusso J. Optimizing soil disinfestation procedures for fresh market tomato and pepper production. Plant disease. 2006; 90(5):668-74.

36. Grünzweig JM, Katan J, Ben-Tal Y, et al. The role of mineral nutrients in the increased growth response of tomato plants in solarized soil. Plant and Soil. 1999; 206:21-7.

37. Niemira BA, Safir GR, Hammerschmidt R, et al. Production of Prenuclear Minitubers of Potato with Peat-Based Arbuscular Mycorrhizal Fungal Inoculum. Agronomy Journal. 1995; 87(5):942-6.

38. González-Hernández AI, Pérez-Sánchez R, Plaza J, et al. Compost tea as a sustainable alternative to promote plant growth and resistance against Rhizoctonia solani in potato plants. Sci. Hortic. 2022;300:111090.

39. Muscolo A, Cutrupi S, Nardi S. IAA detection in humic substances. Soil Biology and Biochemistry. 1998; 30(8):1199-202.

40. Stapleton JJ, Quick J, DeVay JE. Soil solarization: effects on soil properties, crop fertilization and plant growth. Soil Biol. Biochem. 1985; 17(3):369-73.

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