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Potentials of compost, compost tea and aqueous neem leaves extract in reducing some diseased plants and boosting onion (*Allium cepa* L.) production in the field at Gapring-Lara in t he Department of Mayo Kani (Cameroon)

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ABSTRACT

With a view to promoting the onion sector, we studied the behavior of onion following the application in fields of Cow Dung compost, compost tea and the aqueous extract of neem leaves during the 2018/2019 and 2019/2020 growing seasons. The device used was a complete randomized block comprising 10 treatments including compost (Cp), compost tea (CpT), Neem extract (Nex), compost + compost tea (Cp+CpT), compost+Neem extract (Cp+Nex), compost tea+Neem extract (CpT+Nex), compost+Compost Tea+Neem Extract (Cp+CpT+Nex), Control (Ctrl), Chemical Pesticide (ChP) and Chemical Fertilizer (ChF) with 3 repetitions each. The work focused on agronomic and phytopathological parameters. The results reveal that Cp+CpT+Nex treatment had a highly significant influence on the germination rate (92.33%) than Ctrl treatment (44%). He was significantly increased the number of leaves, size and yield compared to other treatments with 22.16 leaves, 52 cm and 114.74 t/ha (2018/2019) and 20.83 leaves and 53.84 cm; but yield was higher by ChF with 47.49 t/ha (2019/2020). Nex, Cp+Nex and CpT+Nex treatments reduced attack of *Delia antiqua* compared to control. And significant reduction in number of plants attacked by onion mildew was observed in Cp+CpT+Nex treatment. In view of the results obtained, organics fertilizers can be used in onion production.
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Keywords: Compost, compos t tea, aqueous extract of neem leaves, *Allium cepa*.

INTRODUCTION

Onion (*Allium cepa* Linne) is a Liliacea originating from Central Asia and widespread in Asia, Europe and Africa (Abdou, 2014). Onion has been known for several years to be an effective health plant, with a very broad spectrum of actions. It is best known for its richness in antioxidants, anti-infective and anti-inflammatory drugs. Raw onions have antibiotic properties and can reduce bacteria and protozoa contamination, or traditionally cure intestinal worms, dysentery, injuries, keloids, asthma and diabetes (Charles, 2013). In Cameroon and more precisely in the Far North region, it has been cultivated for several years for medicinal purposes against

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rheumatism, skin infection and high fever (Iyébi-mandjek et al., 2000), but also as culinary ingredient. Onion bulbs are eaten as vegetables, cooked, raw or fried, while early leaves before bulb formation, are eaten raw, alone or within salad (Cathala et al., 2002).

In Africa, onion production has significantly increased from the 1970's, and Niger quickly became the leading African producer with 200.000 tonnes yearly (FAO, 2002). In the Far North region of Cameroon, onion cultivation covers more than 965 ha and is exploited by more than 13.600 growers, for an annual production of averagely 38.72 t/ha (AGRISTAT, 2012).

Unfortunately, garden cultivation of onion mostly occurs near water points (rivers, lakes, wells), where it is subjected to massive and uncontrolled use of pesticides and chemical fertilizers which are very expensive and very harmful to plant and human health (Mills, 2002). Considery, the derived low production rate and the potentially harmful effects of chemical inputs used in the field, it would be important to propose alternatives that not only boost yields, but also reduce negative impacts on the environment. Organic fertilizers such as compost and its extracts, or even plant extracts as biopesticide could be used as alternative, because of advantages they have of being biodegradable, non-persistent in the nature, inexpensive, and more accessible to small producers (Mahmoud et al., 2015). The current trend is the formulation of natural substances such as biopesticides and biofertilizers (Sagoua, 2009; Ekra, 2010; Mouria et al., 2013; Traore et al., 2015; Pale et al., 2021). Previous researches carried out in northern Cameroon have shown the effecacy of compost and their extracts in improving growth and yield as well as reducing the incidence of plant diseases (Ngakou et al., 2008; 2012; Anguessin et al., 2021). Other studies have demonstrated the effectiveness of neem extracts in the control of crop pests while improving the yields (Issa et al., 2017; Barry et al., 2019). Despite its economic and culinary importance and to the best of our knowledge, no study has yet been conducted to assess the combined effects of compost, compost tea, and neem extracts on onion production. Hence, the main objective of this study was to investigate the degree of efficiency of individual or combined effects of compost, compost tea and neem extracts in enhancing onion yield, through reduction of some common disease damages in the field.

MATERIALS AND METHODS

Description of the study site

Composting and field work were carried out at Gapring-Lara in the Mayo Kani division. The study site is geographically coordinated at 10 ° 07'45 "N latitude, 14 ° 32'54" E longitude at 403m elevation. The region has a Sudano-Sahelian climate of dry tropical type with a long dry season from November to May. Southwesterly winds appear timidly in June. The rainy season begins in June and ends in October. The annual temperature fluctuates between 21 and 22 °C with a daily thermal amplitude varying between 6 and 7 °C (IRAD, 2015). Annual rainfall averages decrease over time. Thus, the interannual averages of the area above 850 mm before 1999 were only 700 mm over the period 2000 - 2005 (UNDP, 2010).

Composting process and preparation of compost tea

Compost used was produced from cow dung collected from the breeding sites at Lara and was then used to extract compost tea. Compost was obtained from the pile composting technic as described by Ngakou et al. (2008). Inoculum was prepared from 15 kg of kitchen wastes and 5 kg of agricultural soil. Mixture was incubated for 7 days to allow the proliferation of decomposing microorganisms. During composting, 200 kg of cow dung was used per pile. The principle consisted of alternating successive layers of cow dung wastes and the inoculum (5 kg per pile), to form a 1.5 m in diameter and 1 m in height pile, on which ventilation holes were made using a stick. Pile was then covered with a white plastic sheet. Piles were turn and watered after every two weeks if necessary, during composting process (three months). From the mature compost obtained, compost tea was produced as described by Ngakou et al. (2014), based on the ratio 1/15 (kg/L: compost/water). Mixture was homogenized for 10 minutes, then filtered through a 0.001 mm mesh sieve. Filtrate obtained was then left to ferment for four (04) days in a non-aerated condition (Figure 1).

Neem leaves extract

Neem leaves were harvested at Lara and used to prepare the neem aqueous extract. Method developed by Issa et al. (2017) was used for the production of the neem leaves extract. Fresh neem leaves were crushed in a mortar, and then macerated in 2L of water for 12 hours for a concentration of 500 g/L (Figure 2). The obtained filtrate was diluted to 10% (v/v: neem leaves extract/water) during spraying.

Establishment of the nursery plantlets

Allium cepa seeds of the local variety Goudami were used. These seeds were graceously offered by local producers of the village Gapring-Lara, which is an onion production basin in the department of Mayo Kani. Seeds obtained after two growing seasons (bulb production the first year the second year) were store in a calebash until use (PRODEX, 2012).

The establishment of planteles in the nursery was performed as described by PRODEX (2012) for 45 days between august and september of each cropping season of 2018-2019 and 2019-2020. Sowing was carried out on 1.5 m^2 on which seeds were buried by hands. Plots were covered with millet straws to maintain humidity. Watering was regular in the mornings and evenings. After seed germination that occurs on the 14 days, millet straws were removed and but seedlings continued to be watered. Half a month after sowing, plantlets were ready for transplantation in the field.

Transplantation of plantlets in field and application of treatments

Experimental set-up was a completely randomized block with ten (10) treatments each of which was repeated three times. The basic unit has been a 2.25 m^2 plot separated by 40cm apart, on a total of 98.58 m^2 surface area. Field trials were carried out from September 2018 to February 2019, and 2019-2020. Treatments include: cow dung compost (Cp); compost tea CpT); aquous neem leaves extract (Nex); cow dung compost + compost tea (Cp+CpT); cow dung compost + aquous neem leaves extract (Cp+Nex); compost tea + neem aquous neem leaves extract (CpT+Nex); cow dung compost + compost tea + neem aquous neem leaves extract (Cp+CpT+Nex); negative control (Ctrl); chemical pesticide (ChP); chemical fertilizer (ChF).

After 45 days in the nursery, the plantlets were transplanted in the field at 2 cm depth. The different treatments were applied from the day 14t after transplanting, then after every thirty 30 days, thus three times during the trial. Compost was applied at the rate of 22.22 t/ha (5kg per experimental unit). Compost tea and aquous neem leaves extract were applied to plants using a ULVA sprayer at a rate of 0.5-1L per experimental unit. The chemical fertilizer was applied according to the required standards (Pesticide was applied to use a ULVA-sprayer at a rate of 1.125 mL water was added to 5.625 mg/m^2 pesticide, whereas the chemical fertilizer NPK 20-10-10 was applied at a rate of 45 g/m^2). Chemical fertilizer was applied to the soil; but the chemical pesticide was sprayed on the aerial part of the plant.

Assessment of the physico-chemical characteristics of soil, compost and compost tea

Temperature was taken using a precision thermometer in the compost piles, after every four days throughout the composting process at 50 cm depth and at a fixed time (10:00 hours) during the day at 10 differents points of a pile. Soil pH was determined in a 1/2.5 (w/v) solution (soil/water), using a pH-meter.

For elemental elements, sampled soils were first air dried and crushed to pass through a 0.5- 2 mm sieve. Total nitrogen was determined from humic acid (Buondonno et al., 1995) and analyzed colorimetrically (Anderson and Ingram, 1993). The available phosphate (P) was extracted and then analyzed using the molybdate blue method described by Murphy and Riley (1962). Iron (exchangeable microelements) was extracted using the Mehlich-3 method and determined by flame atomic absorption spectrophotometer (Clement et al., 1975). Exchangeable cations (Ca, Mg and K) were extracted using ammonium acetate and cations were determined by atomic absorption spectroscopy using the absorption spectrophotometer. In the compost, total N, P and Fe were expressed in mg/ kg; K, Ca and Mg were expres sed in mg/100g. Ca, K and Mg were extracted by dry incineration in a muffle furnace, diluted using a dilute acid mixture of HCl/HNO_3, and analyzed using the atomic absorption spectrophotometer reported in ppm. The mineral elements contained in the compost tea were analyzed according to standard methods. Total N_2 and P were determined by the colorimetric method of Nkonge and Ballance (1982) and Tran and Simard (1993) respectively. Potassium (K) was analyzed by atomic emission, while Mg, Ca and Fe were quantified using the atomic absorption spectrophotometer (Clement et al., 1975).

Characterization of the bacterial microbiome of compost and compost tea

Serial dilution technic was used for the isolation of bacteria. Suspensions sample solutions were prepared separately by adding 5 g of compost and 5 ml of compost tea to 50 mL of sterile saline water (0.85% w/v) and shaking vigorously for 20 minutes. The diluted solution was then sedimented for a short 5 minutes. Sterile saline dilution as blanks (9 mL) were sequentially labeled starting from 1 to 4. One mL of the stock solution was transferred to dilution blank 1 using a fresh sterile pipette. One mL of dilution 1 was transferred to tube 2 for each subsequent step, then from 2 to 3, then from 3 to 4. At each dilution tube, 0.5 mL of dilution was transferred to Nutritive culture agar medium and incubated at 37 °C for 24 hours. The Nutritive Agar (NA) culture medium consisted of 0.5% peptone, 0.3% yeast extract, 0.5% NaCl, 0.25% glucose, 1.5% agar, distilled water, adjusted to pH 7 ± 0.2. After successful growth of microorganisms, bacteria pure cultures were subcultured in NA slant, incubated at 37 °C for vigorous growth (Saha and Santra, 2014). Cultural characterization of colonies on Nutritive agar medium through Gram staining was carried out to observe the colonies and the cell morphology, the motility. Biochemical tests for the production of catalase, the triple sugar iron and citrate was carried out as described by Collins et al. (1989).

Determination of specific metabolites in aqueous neem leaves extract

In the laboratory, aqueous extract of neem leaves was analyzed by colorimetric method for the quantitative determination of azadirachtin and limonoids. Vanillin analysis was used to quantify azadirachtin in the aqueous extract. The colorimetric process consisted of mixing 2 mL of a freshly prepared vanillin solution (1g/100 mL) to 70% sulfuric acid and 1 mL of aqueous extract. Then the solution was allowed to stand on a water bath at 20 °C for 15 minutes, before the assessment of the maximum absorbance 577 nm wavelength (Scalbert et al., 1989). The concentration of azadirachtin was obtained from the formula:

$$A577nm = 9.0024 \times CAZ/0.92 = 9.4752 \times CAZ$$

Where, A577nm is the absorbance measured at 577nm; CAZ is the standard concentration of azadirachtin at 95% purity expressed in mg/mL.

Limonoids were quantified using the "two-phase-two-step" colorimetric method developed by Dai (1999), consisting of mixing 0.7ml dichloromethane limonene to 0.2 mL methanol and 0.02 mg/mL vanillin. The mixture was left at room temperature for 2 minutes before 0.3 mL of 98% concentrated sulfuric acid was added in 0.1 mL three steps of 10 second each by stirring. After addition of methanol that stimulate the development of the blue-green color, the maximum absorbance was measured at 625 nm. The concentration of limonene was determined as:

$$A625nm = 52.145 \times C\ (\text{limonène})$$

Where, A625nm is the absorbance measured at 577nm; C (limonène) is the concentration of dichloromethane de limonène (mg/mL).

Assessment of growth and yields parameters

Germination rate (%) in the nursery was evaluated after 14 days as the ratio between the germinated seeds and total sown seeds germination rate (Haouvang, 2019). The number of leaves per plant was counted on 10 randomly selected plants per elementary plot at 21 days after transplanting, then after every 21 days until harvest (Challita, 2004). Plant size (cm) was measured using a plastic ruler graduated from 0 to 50 cm on 10 randomly selected plants per elementary plot (Challita, 2004). The survival rate was evaluated by comparing the number of transplanted plants to that of plants at harvest (Ngakou et al., 2014):

Survival rate (%) = (Number of plants at harvest/Number of plants transplanted) × 100.

At harvest, bulbs yield was estimated per square meter by weighing bulbs on 10 randomly selected plants per elementary as indicated by Kalle (2012).

$$\mathbf{R\ (g/m^2) = Mt\ (g)/S}$$

where, R is yield (g/m²); Mtis the total mass of bulbs; S is the surface area (m²).

The yield expressed in t/ha was obtained by extrapolation using the yield/m² above (Traore et al., 2015):

$$\mathbf{Ri\ (t/ha) = (S1\ /\ 3x\ Su2) \sum PSu}$$

where, Ri is the yield (t/ha) for a treatment i; S1 is area in hectares; PSu is the production of useful surface, Su is useful surface.

Statistical analysis

Analysis of variance (ANOVA) and Duncan's test were performed using Statgraphic plus version 5.0 software to compare the means.

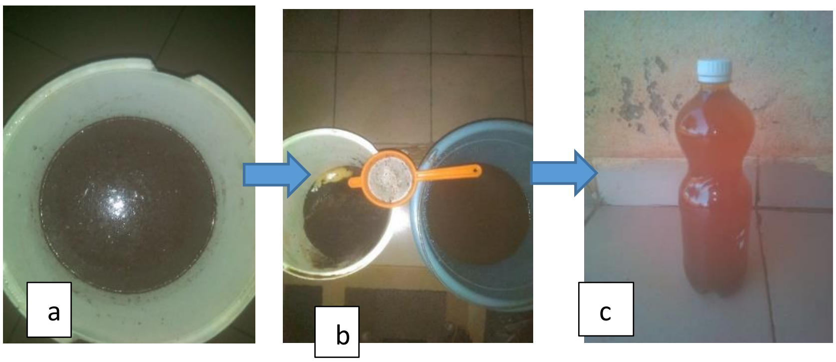


Figure 1: Extraction steps of compost tea.
a : Compost + water mixture; **b**: Filtration through a 0,001mm sieve; **c**: Storage in a bottle.

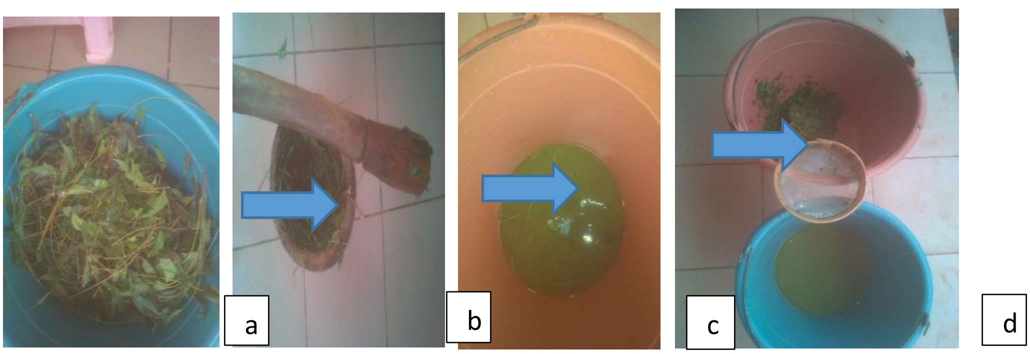


Figure 2: Aquous extraction steps neem leaves.
a: Neem leaves; **b**:Grinding of leaves in the morta; **c** : Maceration; **d**: Filtration through a 0,001mm sieve.

RESULTS

Physico-chemical and microbiological characteristics of soil, compost, compost tea and aqueous extract of neem leaves

Composting temperature

During the composting process, it was observed a rapid rise in temperature (57.2 °C) at beginning of the process. Temperature then dropped quickly over the next ten days. After the monitoring of composting pile at 10, 34 and 66 days, a peak of temperature was observed (Figure 3). Throughout the composting process, the thermal curve generally was grouped into three periods: the first between 1-30 days with peaks at 57.2-60.1 °C; the second from 38-70 days characterized by a decrease T °C which stabilizes at 30 °C.

Variation of pH, Nitrogen, Phosphorus and Potassium in compost

pH of soils, compost, and compost tea varied from neutral, weak base, and weak acid, which are within the optimum pH range for plant development (Table 1). High concentrations of nutrients in compost and compost tea have been reported.

Bacterial microflora of compost

Total number of bacteria in compost and compost tea did not significantly differ between compost and compost tea ($p > 0.05$), although there were 60.33 bacteria more in compost tea than in compost (Table 1).

Phytochemical characteristics of aqueous neem leaves extract

Colorimetric analysis revealed that the neem extract contains 24.30 mg/mL of azadirachtin and 77.25 mg/mL of limonoids (Table 1).

Influence of treatments on agronomic performances of onion in the field

The variation in the lifting rate of the onion seeds as affected by treatment id illustrated in Figure 4. The highest emergence rate (92.33%) of onion seeds was obtained from treatment of cow dung compost + compost tea + aqueous neem leaves extract (Cp + CpT + Nex), while the lowest (44%) was attributed to the control (Ctrl).

Plant sizes was taken at 21, 42, 63 and 84 DAT during the 2018-2019 (Figure 5A), and 2019-2020 (Figure 5B) cropping seasons. During the first year, a significant better growth ($p<0.0001$) was noticed from 63 to 84 DAT in treatments Cp + CpT + Nex and ChF, compared to other treatments, the lowest plant size accounting for the control (Ctrl) treatment. In the second cropping season, the chemical fertilizer treatment (ChF) provided the best growth size from 21 to 63 DAT, but at 84 days after transplanting, it is treatment Cp + CpT + Nex that stimulated better growth, with an average size of 53.24 ± 7.59 cm, compared to the ChF treatment (52.60 ± 5.61cm).

During the two cropping seasons (Figure 6), the organic treatments generally had the best effect on the number of onion leaves at 21, 42 and 63 DAT, but as from 84 DAT, it is instead tretments Cp + CpT + Nex and ChF that better stimulated leafing, with respectively 22 and 21 as the average highest number of leaves/plant, whereas the lowest (10 leaves/plant) was fron the control treatment.

Impact of treatments on the survival rate of plants in fields.

Survival rate of the plants in different treatments at harvest (%) is reported in Table 2, from which the best rates survival rates were observed in the compost (Cp) and Compost + Compost tea + Neem extract (Cp + CpT + Nex), with respectively 79.66% and 77.33% during the 2018-2019 cropping season, while the chemical fertilizer treatment (ChF) had the lowest survival rate (42%). In the 2019-2020 trial, the best survival rate accountered from treatment neem leaves extract (Nex) with a survival rate of 77.33%, whereas, the control treatment (Ctrl) exhibited the lowest survival rate at 52.33%.

Impact of treatments on onion yield

Bulb yield was expressed in tonnes per hectare (t/ha) for all treatments (Table 3). During the 2018-2019 cropping season, best yields were obtained for treatments compost tea and compost + compost tea + neem extract with respectively 110.47 ± 0.70 (t/ha) and 114.74 ± 0.93 (t/ha). However, the chemical pesticide (ChP) and control (Ctrl) treatments provided the lowest yields with 54.22 ± 0.07 (t/ha) and 54.74 ± 0.07 (t/ha) respectively. During the second cropping season, chemical fertilizer and compost + neem extract treatments provided the best yields with respectively 47.49 ± 0.25 and 34.74 ± 0.15 (t/ha), but the lowest yield was observed in the control treatment with only 14.74 ± 0.15 (t/ha).

Phytopathological characteristics

Table 4 shows the variation in the number of infested plants between treatments, following the onion fly attack during the 2018-2019 and 2019-2020 experimental trials. The control treatment indicated a high number of symptomatic plants compared to other treatments at 21s and 42 DAT. At 63 DAT, treatments Chemical Pesticide, Neem leaves extract, Compost + Neem extract and Compost tea + Neem extract considerably reduced the number of plants attacked, with averagely only 11, 14, 14 and 14 plants attacked respectively, against 18 controlled attacked plants during the 2018-2019 season.

During the two cropping seasons (Table 5), the number of diseased plants increased with time, but the number of infested plants was always significantly (0.004<p<0.0095 in 2018-2019; p =0.03 in 2019-2020 cropping seasons) greater in the control than that of all the other treatment. For each of the cropping season and at each sampling date, there was a difference between the number of diseased plants from treatments compost (Cp), neem leaves extract (Nex), compost tea (CpT), compost- compost tea (Cp + CpT), compost +neem leaves extract (Cp + Nex), compost + compost tea +neem leaves extract (Cp + CpT+ Nex), although it was not significant.

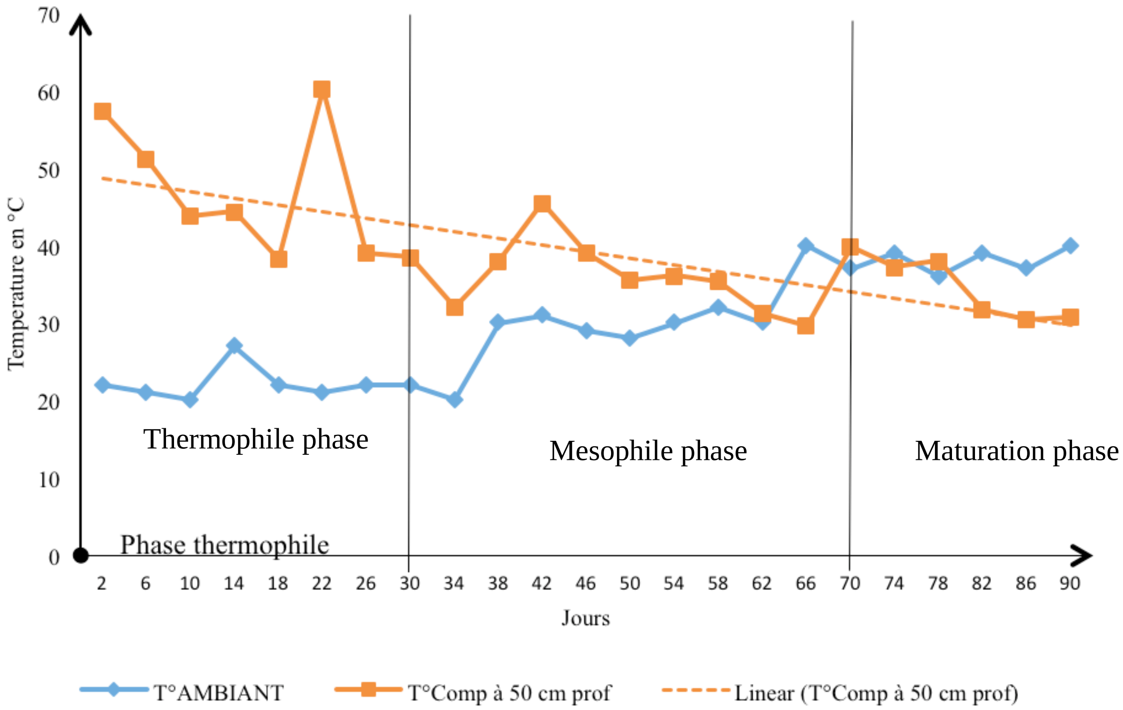


Figure 3: Dynamic of temperature during the composting process.

Table 1: Chemical and microbiological characteristics of soil, compost, compost tea and neem leaves extract.

	pH	N	P	Fe	K	Ca	Mg	Total Bacteria (UFC)	Azadirachtin (mg/ml)	Limonoïdes (mg/ml)
		----- mg/Kg---------------------				----------mg/100g----				
Soil 2018-2019	7.64	21.45	1.47	0.47	1.46	85.68	61.2	-	-	-
Sol 2019-2020	7.12	27.05	2.49	0.85	1.8	89.76	65.28	-	-	-
Compost	8.27	48.57	41.52	3.00	3.00	100.64	70.72	799.00±54.99[a]	-	-
		-----------------------------mg/l------------------------------								
Compost tea	6.5	18.49	7.56	3.17	7.56	38.08	91.12	859.33±47.71[a]	-	-
Neem leaves extract	8.10	-	-	-	-	-	-	-	24.30	77.25

pH: potentiel d'hydrogène; N: azote ; P : phosphore; K : potassium ; Fe : fer ; Ca : calcium; Mg: magnésium; UFC: Unit Forming colonies.

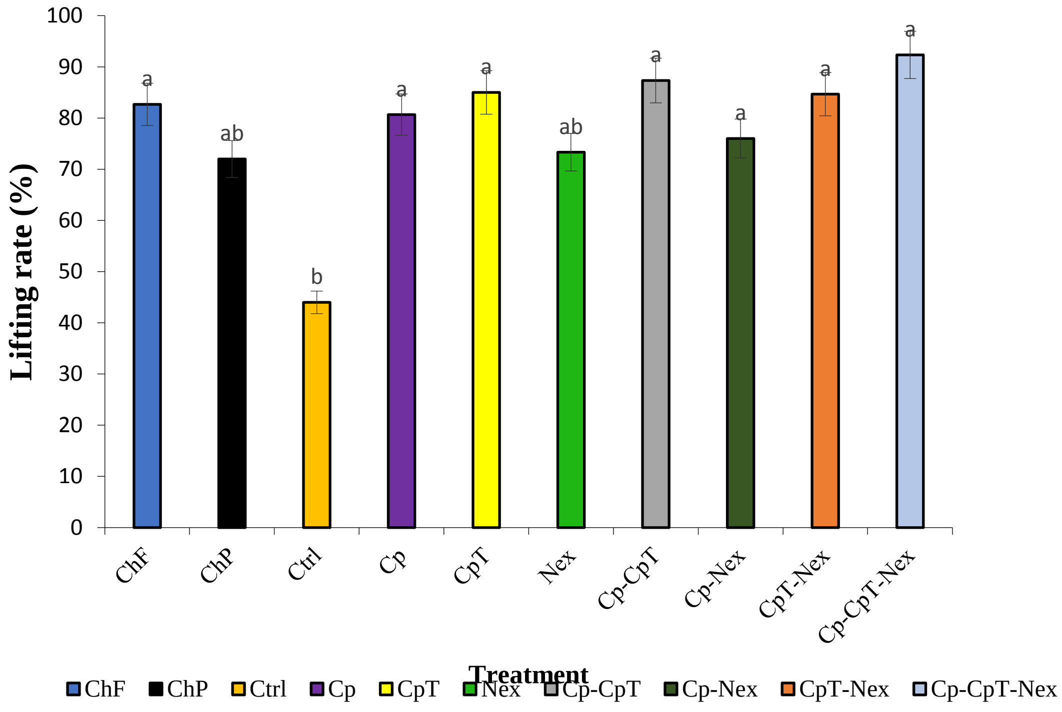


Figure 4: Variation in the lifting rate of *Allium cepa* seeds as influenced by treatments.

Cp: Cow dung compost; **CpT**: Cow dung compost tea; **Nex**: Neem leaves extract; **Cp+CpT**: Cow dung compost + compost tea; **Cp+Nex** : Cow dung compost + Neem leaves extract; **CpT+Nex** : Cow dung compost tea + Neem leaves extract; **Cp+CpT+Nex**: Cow dung compost + Cow dung compost tea + Neem leaves extract;; **Ctrl**: Negative control; **ChP**: Chemical pesticide; **ChF**: Chemical fertilizer.

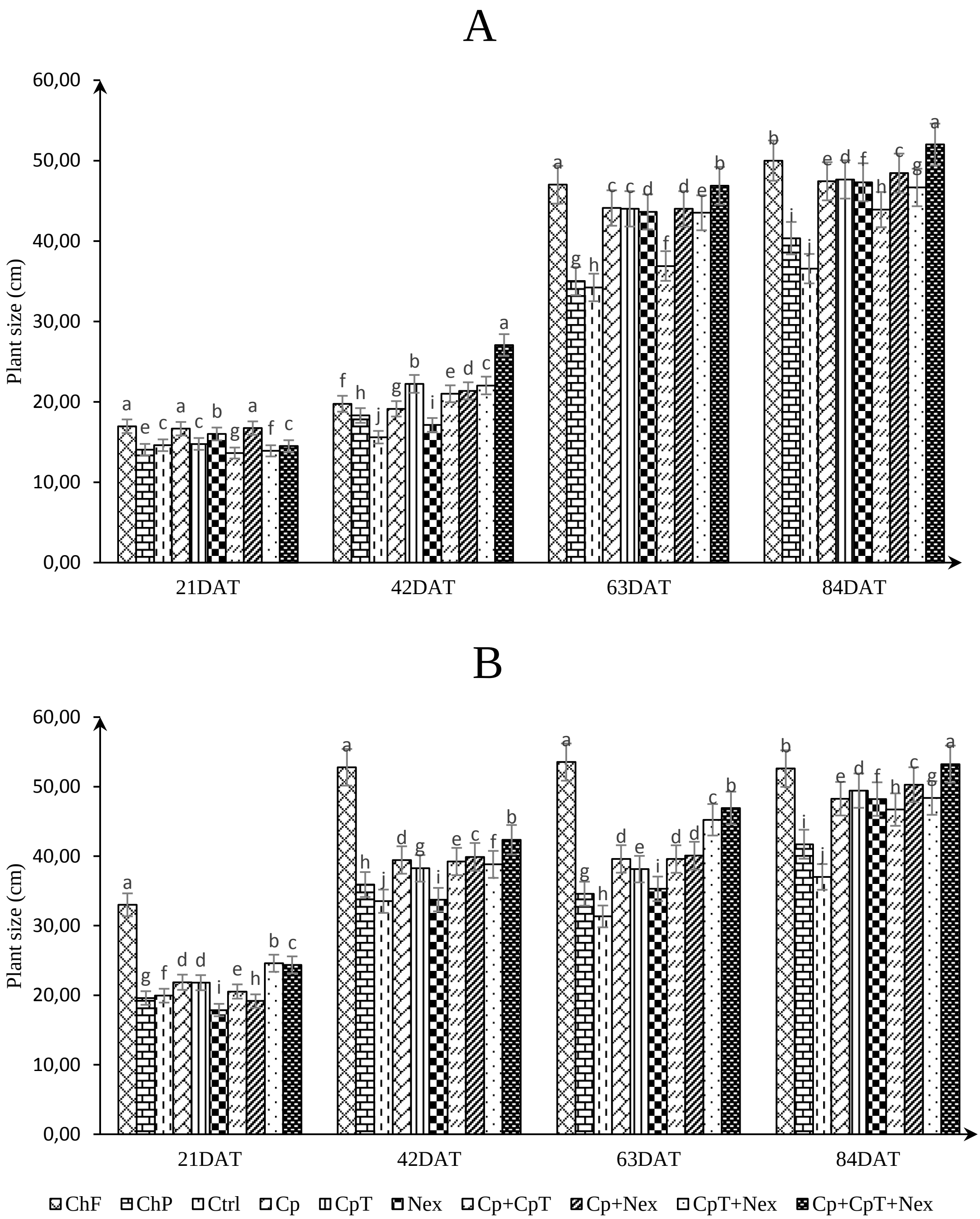
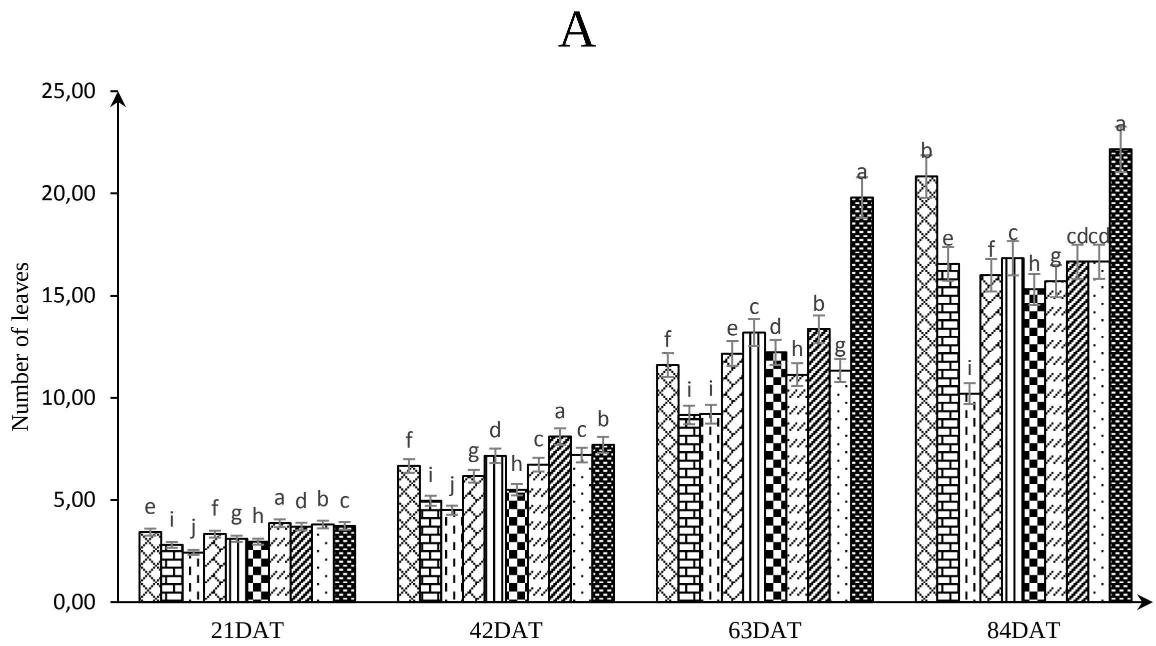
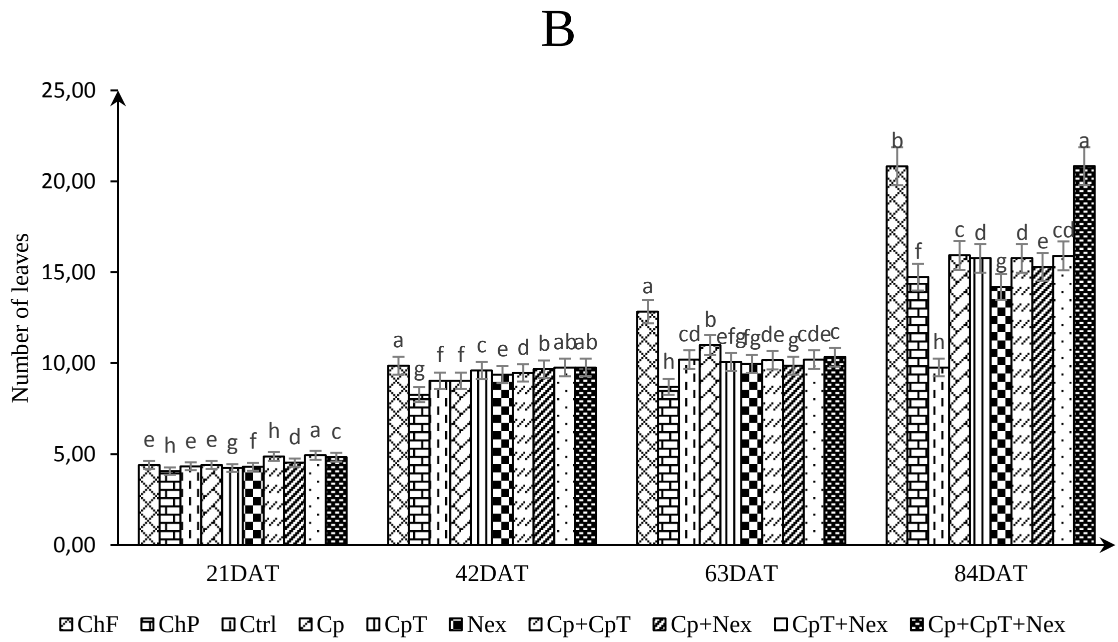


Figure 5: Variation in the plant size as influenced by treatments during years experiment.
A : 2018/2019 ; **B :** 2019/2020; **Cp**: Cow dung compost; **CpT**: Cow dung compost tea; **Nex**: Neem leaves extract; **Cp+CpT**: Cow dung compost + compost tea; **Cp+Nex** : Cow dung compost + Neem leaves extract; **CpT+Nex** : Cow dung compost tea + Neem leaves extract; **Cp+CpT+Nex**: Cow dung compost + Cow dung compost tea + Neem leaves extract;; **Ctrl**: Negative control; **ChP**: Chemical pesticide; **ChF**: Chemical fertilizer.



A



B

Figure 6: Variation in the number of leaves per plant as influenced by treatments during years experiment.

A : 2018/2019 ; **B :** 2019/2020 ; **Cp**: Cow dung compost; **CpT**: Cow dung compost tea; **Nex**: Neem leaves extract; **Cp+CpT**: Cow dung compost + compost tea; **Cp+Nex** : Cow dung compost + Neem leaves extract; **CpT+Nex** : Cow dung compost tea + Neem leaves extract; **Cp+CpT+Nex**: Cow dung compost + Cow dung compost tea + Neem leaves extract;; **Ctrl**: Negative control; **ChP**: Chemical pesticide; **ChF**: Chemical fertilizer.

Table 2: Variation of the survival rate (%) of onion plants in the field as affected by treatments.

Treatments	**Cropping years**	
	2018-2019	**2019-2020**
ChF	42.33	70.33
ChP	71	71.33
Ctrl	50.66	52.33
Cp	79.66	62.66
CpT	67.66	58
Nex	66.66	77.33
Cp-CpT	52	67.66
Cp-Nex	67.66	62.66
CpT-Nex	69.33	73.33
Cp-CpT-Nex	77.33	59

Cp: Cow dung compost; **CpT**: Cow dung compost tea; **Nex**: Neem leaves extract; **Cp+CpT**: Cow dung compost + compost tea; **Cp+Nex** : Cow dung compost + Neem leaves extract; **CpT+Nex** : Cow dung compost tea + Neem leaves extract; **Cp+CpT+Nex**: Cow dung compost + Cow dung compost tea + Neem leaves extract;; **Ctrl**: Negative control; **ChP**: Chemical pesticide; **ChF**: Chemical fertilizer.

Table 3: Differences in onion yields in various treatments.

	Yields (t/ha)	
Treatments	**2018-2019**	**2019-2020**
ChF	97.49 ± 0.08^{ab}	47.49 ± 0.25^{a}
ChP	54.22 ± 0.07^{c}	23.74 ± 0.76^{bc}
Ctrl	54.74 ± 0.07^{c}	14.74 ± 0.15^{c}
Cp	84.74 ± 0.35^{b}	28.87 ± 0.31^{b}
CpT	110.47 ± 0.70^{a}	25.99 ± 0.76^{b}
Nex	94.94 ± 0.52^{ab}	24.99 ± 1.04^{bc}
Cp-CpT	57.44 ± 0.26^{c}	26.24 ± 1.41^{b}
Cp-Nex	87.22 ± 0.32^{b}	34.74 ± 0.15^{b}
CpT-Nex	87.74 ± 0.18^{b}	32.62 ± 1.16^{b}
Cp-CpT-Nex	114.74 ± 0.93^{a}	25.62 ± 0.38^{b}
P values	0.0284	0.0002

Cp: Cow dung compost; **CpT**: Cow dung compost tea; **Nex**: Neem leaves extract; **Cp+CpT**: Cow dung compost + compost tea; **Cp+Nex** : Cow dung compost + Neem leaves extract; **CpT+Nex** : Cow dung compost tea + Neem leaves extract; **Cp+CpT+Nex**: Cow dung compost + Cow dung compost tea + Neem leaves extract;; **Ctrl**: Negative control; **ChP**: Chemical pesticide; **ChF**: Chemical fertilizer.

Table 4: Variation of the number of onion plant infested by *Delia antiqua* larvae between treatments.

	Cropping seasons					
Treatments	**2018-2019**			**2019-2020**		
	21DAT	**42 DAT**	**63 DAT**	**21 DAT**	**42 DAT**	**63 DAT**
ChF	4.67±0.57 [f]	7.33±1.15 [b]	15.33±4.50 [b]	4.00±0.00 [c]	6.67±1.52 [b]	19.33±4.04 [c]
ChP	4.33±0.57 [g]	6.67±0.57 [cde]	11.00±4.58[e]	4.00±0.00 [c]	5.00±1.73 [g]	13.33±5.85 [f]
Ctrl	6.33±0.57 [a]	8.33±2.51 [a]	18.00±10.44 [a]	6.00±2.64 [a]	8.00±1.00 [a]	32.33±4.93 [a]
Cp	5.00±1.00 [e]	6.33±1.52 [def]	15.00±12.28 [bcd]	4.00±0.00 [c]	6.33±0.57 [c]	21.33±5.13 [b]
CpT	4.67±0.57 [f]	6.67±1.52 [c]	14.67±4.16 [def]	4.33±0.57 [b]	6.00±1.00 [d]	22.33±6.50 [b]
Nex	5.00±1.00 [e]	6.33±0.57 [f]	14.33±5.13 [g]	4.33±0.57 [b]	5.33±0.57 [f]	16.33±5.50 [e]
Cp+CpT	5.33±1.52 [c]	7.33±2.08 [b]	15.33±4.72 [bc]	4,33±0.57 [b]	5.67±0.57 [e]	22.00±6.08 [b]
Cp+Nex	5.33±0.57 [c]	6.33±1.15 [ef]	14.33±3.78 [fg]	4.00±0.00 [c]	5.33±0.57 [f]	16,67±5.77 [de]
CpT+Nex	5.67±1.15 [b]	6.67±0.57 [cd]	14.33±4.04 [efg]	4.33±0.57 [b]	5.33±0.57 [f]	17.67±1.52 [d]
Cp+CpT+Nex	5.33±1.52 [c]	6.33±0.57 [f]	15.00±5.00 [cde]	4.00±0.00 [c]	5.33±0.57 [f]	17.00±2.64 [de]
P- values	0.460	0.733	0.990	0.281	0.034	0.013

Cp: Cow dung compost; **CpT**: Cow dung compost tea; **Nex**: Neem leaves extract; **Cp+CpT**: Cow dung compost + compost tea; **Cp+Nex:** Cow dung compost + Neem leaves extract; **CpT+Nex**: Cow dung compost tea + Neem leaves extract; **Cp+CpT+Nex**: Cow dung compost + Cow dung compost tea + Neem leaves extract;; **Ctrl**: Negative control; **ChP**: Chemical pesticide; **ChF**: Chemical fertilizer. **DAT**: Days after transplantation

Table 5: Variation of the number of onion plant infested by Mildew between treatments.

	Cropping seasons					
Treatments	**2018-2019**			**2019-2020**		
	21 DAT	**42 DAT**	**63 DAT**	**21 DAT**	**42 DAT**	**63 DAT**
ChF	10.33±1.52[bc]	26.33±6.50[ab]	28.67±4.04[ab]	12.67±2.51[ab]	24.67±4.72[ab]	24.00±4.00[ab]
ChP	6.67±1.52[d]	17.00±8.00[bcd]	15.33±3.51[c]	6.67±2.08[c]	17.33±8.73[ab]	13.00±4.35[c]
Ctrl	15.67±2.51[a]	34.67±5.03[a]	35.33±1.52[a]	13.67±3.21[ab]	29.00±4.58[a]	32.33±2.51[a]
Cp	13.67±2.88[ab]	25.67±2.51[abc]	22.67±4.93[bc]	14.33±1.15[a]	25.33±4.72[ab]	18.67±3.78[bc]
CpT	12.67±1.52[ab]	18.33±2.08[bcd]	20.33±2.08[bc]	12.67±1.15[ab]	26.00±4.58[ab]	20.33±0.57[bc]
Nex	12.33±2.08[abc]	19.67±7.57[bcd]	23.00±2.00[bc]	11.33±1.51[ab]	18.33±7.23[ab]	25.67±4.98[ab]
Cp+CpT	11.00±1.00[bc]	16.67±2.51[bcd]	27.67±12.34[ab]	12.00±1.00[ab]	12.67±7.02[b]	26.33±14.18[ab]
Cp+Nex	10.67±0.57[bc]	24.00±5.56[bcd]	24.00±4.35[bc]	12.33±3.05[ab]	23.33±7.63[ab]	25.67±2.30[ab]
CpT+Nex	11.67±3.51[bc]	15,33±5.85[cd]	22.67±0.57[bc]	11.67±3.78[ab]	12.33±9.71[b]	25.00±2.00[ab]
Cp+CpT+ Nex	9.67±1.52[cd]	15.00±4.00[d]	22.67±3.05[bc]	9.33±2.02[bc]	16.33±11.37[ab]	25.33±4.93[ab]
P-values	0.003	0.003	0.009	0.031	0.111	0.036

Cp: Cow dung compost; **CpT**: Cow dung compost tea; **Nex**: Neem leaves extract; **Cp+CpT**: Cow dung compost + compost tea; **Cp+Nex** : Cow dung compost + Neem leaves extract; **CpT+Nex** : Cow dung compost tea + Neem leaves extract; **Cp+CpT+Nex**: Cow dung compost + Cow dung compost tea + Neem leaves extract;; **Ctrl**: Negative control; **ChP**: Chemical pesticide; **ChF**: Chemical fertilizer. **DAT**: Days after transplantation

DISCUSSION

Rapid rise in temperature at beginning of the composting process, attributed to the fast biological activity in the substrate, in agreement with enhanced temperature to 55.6 °C during composting of shredded *Acacia cyanophylla* (M'Sadak et al., 2014). Temperature then dropped quickly over the next ten days as the result of depletion of oxygen stock in the composting piles, which would lead to a decrease in microbial activity. After the monitoring, a peak of temperature was observed, indicaing a revitalization microorganisms due to oxygenation and humidity. M'Sadak et al. (2013) explained these temperature increases by the degradation of organic matter due to microorbial activity. Francou (2003) and M'Sadak et al. (2014) demonstrated that during composting, degradable organ ic matter decreases, causing microbial activity to slow down and temperature to drop. M'Sadak et al. (2014) observed that a maturing compost does not heat up after turning.

The neutral pH of compost is in line with the results of Soulama et al. (2020) who showed that the pH of a mature compost is normally between 7 and 8. The decrease in the compost pH from weak base to weak acid in compost tea could be attributrd to development of acidogenic microorganisms during of compost tea production, which produce organic acids (Scheuerell, 2004). The high concentrations of nutrients in compost and compost tea have been reported to be related to degradation of woody components by bacteria and the release of nutrients sequestered in organic matter, thus promoting the fertilizing properties of compost and compost tea (Mohammadi et al., 2011).

This total bacteria high in compost tea than compost could be explained by the significant development of acidifying bacteria during fermentation of compost tea, as revealed by Scheuerell and Mahaffee (2004), who indicated that the average population of total bacterial cells increased with the use of additives or not during the production of compost tea from different compost sources.

Colorimetric analysis revealed the amounts of azadirachtin and limonoïds from neem extract, which is closed to 25.32 mg azadirachtin concentration recently reported in neem extract (Lesueur, 2006), or to 15.9% and 33.8% concentration of azadirachtin and limonoids respectively obtained in neem extract (Dai, 1999). According to Lesueur and Rayssac (2001), the aqueous liquid/liquid extraction fraction contains a small portion of azadirachtin-A compared to the fraction extracted with dichloromethane. The concentration of azadirachtin contained in the leaves harvested during the same season from the same region was vary between 68.5 to 2558.5 mg/kg (Sidhu et al., 2003).

The lifting rate of onion seeds in treatments applied with compost, compost tea and neem extract, could be due to the high content of nutrients and organic matter, they contain, which stimulates lifting of seeds compared to other treatments and in addition, the addition of manure increases soil moisture, which can promote faster emergence compared to the control (Haouvang et al., 2019). Organic matter has also been revealed to play an important role in the soil, favoring to the growth of microorganisms which induce activation of soluble nutrients to be sufficiently available to plants (Serné et al., 2015).

Better stimulation of growth observed in the treatments Cp + CpT + Nex and ChF could be atrributed to the considerable contribution of fertilizing elements such as nitrogen, which is involved in the increment of the biochemical processes in the aboveground part of plants. These results are in agreement with those of Mahmoud et al. (2015), who showed that higher concentration of nitrogen in compost increases the biochemical process, and in turn, the vegetative growth of onion plants. Similar findings were obtained by Geires (2007) and Geries et al. (2012). CRAB (2002) has shown that compost in general and composted cattle manure in particular contain 17% of the immediately available nitrogen, 12% available in the medium term and 71% available in the long term. Compost tea and chemical fertilizers were shown to have a positive effect on the height of *Solanum* *tuberosum* compared to the negative control (Ngakou et al., 2012; Kitabala et al., 2016).

The important stimulation of leaves formation by the treatment Cp + CpT + Nex could be explained by the fact that compost associated with compost tea would have provided a better quantity of nutrients necessary for the foliar development. A recent has shown that onion plots treated with compost had bette r leafiness due to the long-term nutrient availability of the compost (Seran et al., 2010). Sawadogo et al. (2020) has also indicated that organic fertilizers, promote the development of a large number of axillary structures such as branches and leaves, due to its richness in nutrients. The combined organic and chemical inputs might be effective in having better effects than any of individual inputs. Onion plots treated with compost alone was reported to stimulate less leaves development than when combined with other fertilizers (Seran et al., 2010). The decrease in the number of leaves in the control treatment ax from 84 DAT could be due be accentuated by pathogen attacks that might have led to loss of leaves.

The incresed survival rate in the above organic treatment could be attributed to sufficient supply of nutrient content to the plant, and phyto-protective effects by these treatments. Ngakou et al. (2014) reported increase plant survival rate, following application of compost and compost tea to *Lycopersicum esculentum*. The aqueous extracts of neem leaves contain azadirachtin and limonoids as compounds, which have proven insecticidal, bactericidal and fungicidal properties (Dai, 1999). Neem leaf and seed extracts incorporated into a culture medium was reported to reduce the production of aflatoxin by *Aspergillus flavus* by 90 and 75% respectively (Abyaneh et al., 2005). In another research, Issa et al. (2017) revealed the reduction of damages caused by *Cylas puncticollis* on sweet potato after application of aqueous neem leaves extract. The high plant mortality observed in chemical fertilizer treated plants could be attributed to heavy fertilization which would have prevented root development, and consequently plants death. Hence, Zygmunt et al. (2013) have pointed out significantly high graft mortality after heavy NPK mineral fertilization on apple trees.

The highest yields obtained with the compost tea and compost + compost tea + neem extract treatments would suggest that compost tea and compost would have permanently provided plants with nutrients throughout growth until bulb maturity, or compost tea would have provided plant directly with nutrients compared to long run released of nutrients by compost. The combined phyto-protective effects of compost tea and neem extract in addition to the nutritive contributions of compost are favorable attributed to growth and vigor of onion bulbs, leading to hight yield obtained. According to Charland et al. (2001), good compost can increase yields compared to unfertilized soils, even when applied at low rates, in agreement with previous results obtained on onions (Abbaye et al., 2004). Better yield stimulated by chemical fertilizer treatment than organic ones could be explained by the oldnest of and the storage conditions of the compost which could have reduced the nutritional and phytosanitary quality of the compost. Recently, Seran et al. (2010) have reported increased onion yield compared to the control following application of compost and chemical fertilizer. Decline yield observed in the second croppring season could be attributed to drastic climatic conditions which would have negatively impacted on the yield.

Aqueous extracts of neem leaves were revealed to contain metabolites such as azadirachtin, which is effective on soft-bodied insects (Umeth, 2001). Hence, azadirachtin would have had an effect on *Delia antiqua* larvae by inhibiting their growth (Schlenk et al., 2001). Without killing the insect immediately, azadirachtin would modify their growth by preventing them from reproducing, feeding themselves, leading to their death. These results are in line with those obtained by Gouba (2002), Ekra (2010), who showed the positive effect of neem extract on *Helicoverpa armigera* larvae and okra pests repectively. Neem leaves extract, compost and compost tea might contain antifungal and antibacterial substances (Asif, 2012; Jayasree et al., 2014), which have proven to reduce the spoiliage of leaves caused by onion fly larvae. The improvement of the root system under compost amendement was observed by Pharand et al. (2002), who indicated reduced necrosis on tomatoes caused by *Fusariun oxysporum*. Beneficial effect of compost extract has also been reported to to reduce the damping off caused on cucumber seedlings by *Pythium ultimum* (Scheuerell and Mahaffee, 2004).

The significant reduction in the number of diseased plants accounting for treatments Cp + CpT + Nex, CpT + Nex, Cp + CpT, Cp and CpT could be justified by the presence of microorganisms exhibiting abundant activities within comp ost tea during the preparation process, which excrete secondary metabolites such as enzymes responsible for the protection of plants against phytopathogens, or antagonist microorganisms susceptible to induce systemic resistance (Horst et al., 2005). These results are in agreement with those of Znaïdi (2002), Deschênes (2007), who reported the inhibition or suppression of disease symptoms by compost and compost tea due to competition between microorganisms' active ingredients in compost tea and their phytopathogenic antagonists. Similarly, Scheuerell and Mahaffee (2004) showed that non-aerated compost tea produced from garden wastes was able to reduce the damping-off disease better than the inoculated control in five biological trials. Compost extract was also revealed to induce the greatest inhibition percentage of *Phytophthora erythroseptica* mycelial growth and three species of *Fusarium*, species responsible for rotting of potato tubers (Znaïdi, 2002).

Conclusion

This reseach has investigated on whether compost, compost tea and neem leaves extracts could serve as an alternative to synthetic chemical inputs for onion production. As the results, compost + compost tea + neem extract has been revealed as the combined treatment able to significantly increase 2.09 folds the germination rate over the control treatment. This treatment has also positively impacted the number of leaves and the onion size compared to other treatments, with respectively values of 22.16 leaves and 52cm, then 20.83 leaves and 53.84 cm during the 2018-2019 and 2019/2020 cropping seasons. Yield was considerably enhanced by the compost + compost tea + neem extract with 114.74 t/ha during the 2018-2019 cropping year, and by the ChF treatment with 47.49 t/ha during the year 2019-2020. Treatments Neem leaves extract, Compost + Neem extract and Compost tea + Neem leaves extract contributed to reduced attack of onion plants by *Delia antiqua* larvae compared to the control during the two cropping seasons. Significant reduction in the number of diseased onion plants infested by mildew was observed in Cp + CpT + Nex, CpT + Nex, Cp + CpT, Cp and CpT treated plants. These Bio/organic fertilizers could best feet as alternative of synthetic input if a sustainable production of onions is envisioned.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHERS' CONTRIBUTIONS

AH a participated in the construction of the field experimental, data analysis and drafting of the manuscript. NA, HLC and TTS have read and placement experimental, data analysis and supervision of the work and approved the final manuscript.

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