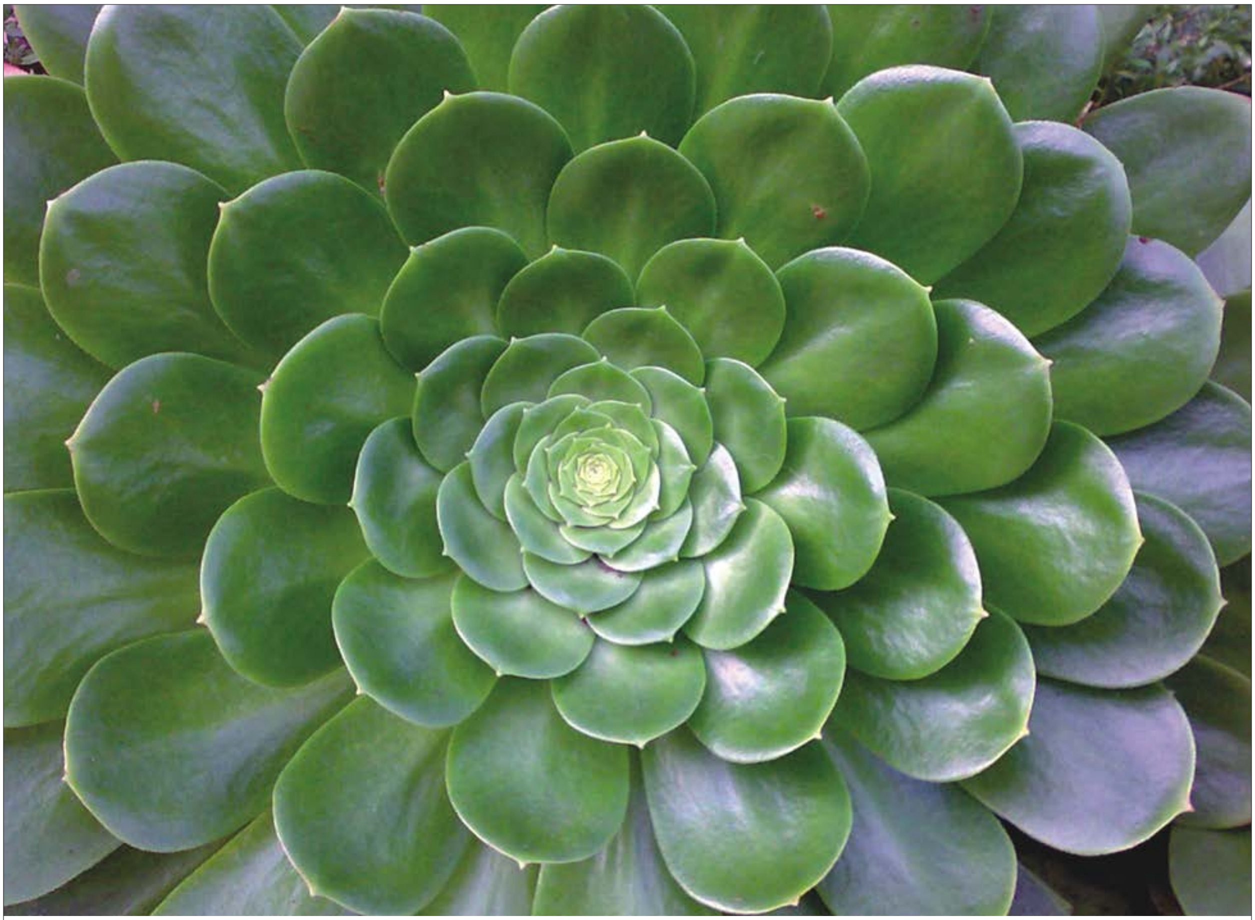

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Research Article
Appropriate Compost/Soil Ratios for Sustainable Production of Garlic (*Allium sativum* L.) under Mycorrhization in Pots Experiment

[1]Albert Ngakou, [1]Steve Takoukam Toukam, [2]Laurette Ngo Nkot, [3]Richard Tobolbaï and [1]Inna Maryamou

[1]Department of Biological Science, Faculty of Sciences, University of Ngaoundere, P.O. Box 454, Cameroon
[2]Department of Plant Biology, Faculty of Science, University of Douala, P.O. Box 24157, Douala, Cameroon
[3]Department of Microbiology, Faculty of Science, University of Yaoundé 1, P.O. Box 812, Yaounde, Cameroon

Abstract
Background and Objective: Garlic are highly dependent on AMF but little is known about the appropriate compost/soil ratio that can boost crop growth and development under AMF inoculation. The present work was carried out in pots experiment at Dang-Ngaoundere to assess the effect of different compost/soil ratios inoculated with Arbuscular Mycorrhiza Fungi (AMF) on *Allium sativum* L. production. **Materials and Methods:** The experimental design was a randomized complete block comprising seven treatments, each of which was replicated thrice: T_0: control soil without compost or AMF, T_1: 1/2 (compost/soil) ratio +30 g AMF, T_2: 1/4 (compost/soil) ratio +30 g AMF, T_3: 1/3(compost/soil) ratio +30 g AMF, T_4: 2/3 (compost/soil) ratio +30 g AMF, T_5: Compost alone, T_6: Compost alone +30 g AMF. The assessed parameters were the emergency rate, the frequency and intensity of mycorrhization, the plant length, the number of leaves/plant, the stem diameter, the bulb diameter and bulb weight/plant, the number of cloves/bulb and total bulb yield. **Results:** Results indicate that treatment T_4 had a positive and significant ($p<0.0001$) influence on Emergency rate, mycorrhizal frequency and intensity, plant height, stem diameter, bulb weight, number of cloves/bulb and total bulb yield compared to other treatments. Compost alone as a substrate was too rich in organic components to sustain garlic growth. **Conclusion:** Hence, 2/3 (compost/soil) ratio was best suited and could be recommended for sustainable cultivation of *Allium sativum* inoculated with AMF under pot experiment.

Key words: Compost/soil ratios, AMF, garlic (*Allium sativum*), growth, yield, intensity of mycorrhization

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Corresponding Author: Ngakou Albert, Department of Biological Science, Faculty of Sciences, University of Ngaoundere, P.O. Box 454, Cameroon
Tel: (+237) 699854850/677909201

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Agriculture in Cameroon is the main activity for the rural population inhabiting the five agro-ecological zones. Fruits and vegetables such as watermelon, pineapple, tomatoes, onions and garlic are gradually grown on cultivated surfaces[1]. Among these, garlic (*Allium sativum*) occupies a nutraceutical important place due to its spice consumed and appreciated in most of the raw dishes, or in various decoctions by the population of all the regions in the country. In the economic point of view, this spice represents an income crop for many families. In Cameroon, garlic is produced mainly in the north-west, north and far-north regions but productivity remains low. This low production which ranges from 8.8-2.76 t ha^{-1} is due to low soil fertility[2]. Averagely 50% of the national demand is, therefore, strongly competed by the imported Chinese garlic in the market. It is thus necessary to improve the soil fertility or extend the cultivated areas to increase the garlic production in the country. To achieve this, many tropical countries rely on chemical fertilizers, which have potentially revealed to be a pollutant to human health and environment[3]. These pollution effects can be circumvented by ecological application of biological inputs such as biofertilizers (i.e., mycorrhiza) and/or organic fertilizers (i.e., compost) as alternative strategies which have been reported to maintain the soil fertility[4,5]. With the understanding that most of the cultivated plants establish a mutualistic relationship with arbuscular mycorrhiza fungi (AMF)[6,7], this type of association could be exploited since it can further improve the soil structure[8], the resistance of plants to stresses[9], reduce insect pests[10], as well as plant pathogens and diseases[11,12]. On the other hand, organic fertilizers are becoming an important element in sustainable agriculture[13-15] and have shown to improve the physicochemical properties of soils[16]. Organic substrates such as farmyard manure, poultry manure, green manures and compost do not only supply the organic matters but also, increase the fertility status of soil[17].

Previous works on mycorrhizal inoculation and organic amendment in Cameroon have revealed enhanced plant growth and yield[18] and control of plant diseases[19]. Elsewhere, two mycorrhiza species and nitroxin have been tested as a sustainable strategy to increase garlic production[20]. Apart from a recent research conducted in the North-west on garlic on acid oxisols amended with basalt dust and *Tithonia diversifolia* powder[2], to the best of our knowledge, no research has yet been conducted to assess the effect of mycorrhiza and compost on garlic production in Cameroon. Compost is rich in organic matter and mineral nutrients but too many minerals particularly phosphorus decrease mycorrhizal development[21]. The substrate with compost may be adequate for mycorrhizal plants[22] if the quality of compost is sufficient[23]. According to Sainz *et al.*[24], compost addition may reduce the activity of AMF. Thus, the compost/soil ratio complementary to AMF inoculation for a particular plant has to be monitored. The question derived thereof is to know which appropriate compost/soil ratio under mycorrhization could boost the garlic production in pots experiment. In this context, the main objective of this study was to find out the best compost/soil ratio that could enable sustainable production of AMF-inoculated *Allium sativum*. The effects of compost and mycorrhiza (AMF) association on emergency rate, mycorrhization rate, growth and yield parameters are further discussed.

MATERIALS AND METHODS

Study sites: The study was conducted at Dang locality, Ngaoundere III subdivision Adamawa Region of Cameroon during the cropping season-extending January 2017 to February 2018. This region is located between the 6th and 8th degrees of latitude North and between the 11th and 15th degree of longitude East. It covers around 62000 km^2 and belongs to the high-altitude Guinean Savannah agro-ecological zone. The climate is characterized by a rainy season (April to October) and a dry season (November to March). The annual rainfall varies from 1227.9-1675.8 mm. The vegetation is represented by crops, ornamental plants, hedge plants, native savannah plants and gallery forests[25].

Biological materia: Garlic (*Allium sativum*) mature pink cloves were purchased in a phytosanitary store in Ngaoundere town. The growing cycle varies from 60-75 days at maturity, from which flowers are pink in colour, while harvested cloves are pink (Fig. 1).

Fertilizers used: The organic amendment used during this study was a compost produced from chicken manures (Fig. 2a) based on the composting method described by Menge[6].

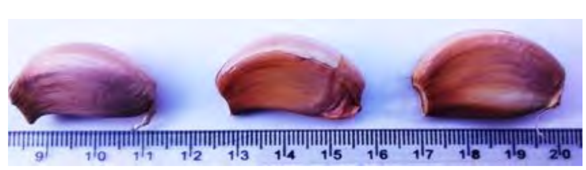

Fig. 1: Mature garlic cloves used in the study

Fig. 2(a-b): (a) Chicken manure compost and (b) Mycorrhizal inoculum (AMF) used in the study

Mycorrhiza as biological fertilizer Mycorrhizal inoculant (Fig. 2b) was made up of the genus *Glomus*, produced in the microbiology laboratory of the Institute of Agricultural Research for Development (IRAD) Ngaoundere. It was a mixture of soil, root fragments and spores of the genus *Glomus* (10 à 25 spores/1 g of soil).

Experimental design and treatments: Trials were conducted on flat on a 159 m^2 surface area, on which experimental pots were established. A woody fence was set up around the experimental site to protect plants from the devastating effect of cattle, usually abandoned to feed in natural environment in the region. The experimental design was a Randomized Complete Block (RCB) with seven treatments, each of which was repeated three times. The seven treatments were: T_0: Control soil without compost or AMF, T_1: 1/2 (compost/soil) ratio +30 g AMF, T_2: 1/4 (compost/soil) ratio +30 g AMF, T_3: 1/3(compost/soil) ratio +30 g AMF, T_4: 2/3 (compost/soil) ratio +30 g AMF, T_5: Compost alone, T_6: Compost alone +30 g AMF. Each treatment comprises 30 pots distributed on 3

Fig. 3: Partial view of the pot experiment showing one of the most successful treatment (T_3) at 42 DAS

experimental units of 2.2 m^2 surface (replicates), each containing 10 experimental pots separated 20 cm apart. Pots were 2 kg (20 cm diameter×40 cm height) black plastics, bought from a phytosanitary store at a local market. Experimental soils were sampled from 12 m depth wells soil, known to be poor in organic matter.

Physico-chemical analysis of soil and compost: Composite soil samples and compost were homogenized separately in three replicates of 1 kg each. These sub-samples were sun-dried, stored in 1kg sterile plastic bags, labeled and sent to the Engineering Laboratory of the Ngaoundere Institute of Technology for physicochemical analysis following the methods recognized and recommended by, Youseef *et al.*[26].

Mycorrhizal inoculation and sowing: The inoculation process was adopted from the method described by Abdel-Razzak and Elshakawy[27]. It consists of making a 3 cm depth hole on the substrate inside a pot, layering it with 30 g of mycorrhiza inoculum, placing a garlic clove on it before covering the sowing hole with the substrate. This was applied only for mycorrhizal treated pots. Each garlic clove was cut of on the apex with a laser blade, before sowing to stimulate germination. Two cloves were sown per pot. Plants were watered at the rate of 250 mL pot^{-1} daily. Figure 3 represents a partial view of the experimental setup.

Data collection: After germination, plants were thinned to 1/pot to avoid competition and were followed up from growth to harvest. The Emergency rate, mycorrhization rate, growth and yield parameters were assessed.

Emergency and Mycorrhization rates: The germination rate was evaluated by counting daily cloves that emerged from a pot at 20 days after sowing. The germination rate (%) was expressed as a ration of the number of cloves that emerged over the total number of cloves sown per treatment, based on the following formula as described by Scott *et al.*[28]. Tg = (NGC/NGS) $\times$ 100, where NGC is the number of cloves germinated and NGS is the number of cloves sown.

To determine the rate of mycorrhization, *Allium sativum* L. roots were harvested three weeks after germination. For this, six plants were randomly chosen in each treatment with two plants per replicate. The assessment of the mycorrhization rate consisted of staining the roots by discoloring all the cells, preserving their walls and then coloring the cell wall of the fungus with the blue cotton dye[29].

Infection frequency and intensity: The infection frequency is the number of fragments (1 cm) containing mycorrhizal structures on roots mounted between a slide and cover slide[30]. It was expressed by the formula[31].

$$F (\%) = 100 \times (N-N_0)/N$$

where, N = total number of observed fragments and N_0 total number of non-infect fragments.

Referred to as the percentage of surface colonized by the fungus in each of roots fragments mounted on the slide covered with the slide cover[32], the infection intensity was expressed by following equation[31]:

$$I (\%) = 95\ n5+70\ n4+30\ n3+5\ n2+n1/N$$

where, n mycorrhizal root fragments noted 5, 4, 3, 2, 1 and N the number of observed fragments.

Growth and yield attributes: The morphological characteristics such as the number of leaves per plant, plant height, stem diameters were evaluated at 42 days after sowing (DAS) on 21 plants per treatment using when necessary a graduated ruler (cm).

The yield was assessed by evaluating from 15 plants per treatment, the bulb diameter, the number of cloves per bulb and bulb weight using a Sartorius balance at 0.001 g sensibility. Bulb yield expressed in kg/ha was obtained by multiplying the bulb weight from a 2.2 m^2 plot of each treatment by the surface of a hectare (10000 m^2).

Statistical analysis: Data collected were subjected to analysis of variance (ANOVA) using the Stat Graphics plus software program. Treatment means were compared using the Duncan Multiple Range Test at 5% level. Correlations between variables were determined using the statistical package for social science (SPSS) software program. The correlation coefficient of Pearson used to check out the relationship between related parameters.

RESULTS

Physico-chemical composition of the soil and compost: The experimental soil and compost had a very low nitrogen and phosphorus contents, whereas their ash contents were very high. The pH values were closed to neutrality for both soil and compost, although it failed to weakly acid and neutral, respectively for soil and compost. Compost was rich in organic matter than soil (Table 1).

Estimation of the emergence rate of *Alium sativum* L.: Figure 4 illustrates the effects of treatments on the germination rate of *Allium sativum* at 20 days after sowing (DAS). It can be observed that treatment T_4 (2/3compost/soil +30 g AMF) expresses the best germination rate with a high significant difference (p<0.0001) in relation to other treatments. In contrast, the poorest germination rate was found in treatment T_5, made up of only compost (1500 g). Values obtained from treatment without compost nor AMF (T_0) and treatment T_6 comprising inoculated compost +30 g AMF were similar and less than those of treatments T_1, T_2 and T_3. Compost solely inoculated with AMF (T_6) or not (T_5) recorded the lowest germination rate compared to other treatments.

Table 1: Physico-chemical properties of the experimental soil and compost

	Average	
Physico-chemical parameters	Soil	Compost
Ash content (%)	87.78	74.20
Organic matter content (%)	9.13	20.78
Nitrogen content (mg g^{-1})	7.11	6.76
P_2O_5 content (mg g^{-1})	2.86	3.46
pH	5.21	7.11
Electrical conductivity (µs cm^{-1})	70.50	73.20

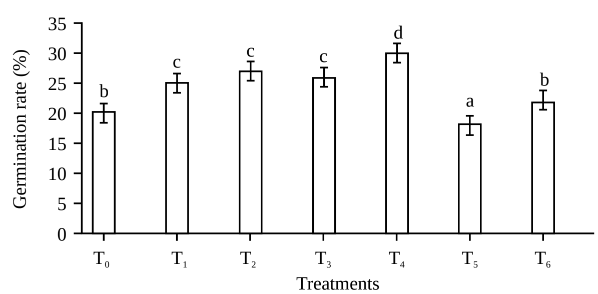

Fig. 4: The germination rate of *Allium sativum* for 20 days after sowing (DAS)

Bars affected with the same letters are not significantly different at the indicated level of significance. T_0 (control without compost or AMF), T_1: 1/2 (compost/soil) ratio +30 g AMF, T_2: 1/4 (compost/soil) ratio +30 g AMF, T_3: 1/3(compost/soil) ratio +30 g AMF, T_4: 2/3 (compost/soil) ratio +30 g AMF, T_5: Compost alone, T_6: Compost alone +30 g AMF.

Estimation of the mycorrhization rate in the root of *Allium sativum* L.: Table 2 illustrates the impact of treatments on the frequency and intensity of mycorrhization at 50% flowering. The mycorrhization rate in *Allium sativum* roots was recorded in all treatments including the un-inoculated plants (treatment T_0). The frequency of mycorrhization was significantly higher in treatment T_4 compared to the lowest values in treatment $T_5$and T_6. However, no significant difference was observed in the mycorrhization rate values between treatments T_0 and T_1, although it was lower than that of treatment T_3.

Concerning the intensity of mycorrhization, the highest value (81.1%) was recorded in treatment T_4, the lowest (1.5%) accounting for treatmentT_5 (compost only). However, values obtained from treatments T_0 or soil only (14.4%) and T6 or compost+mycorrhiza (3%) were lower but less than those obtained from treatmentsT_1 (16.5%); T_2 (16%) and T_3 (20.4%). A positive and significant correlation was observed between the mycorrhization intensity and frequency (r = 0.90; p<0.0001).

Table 2: Frequency and intensity of mycorrhization at 50% of flowering

	Parameters	
Treatments	Mycorrhizal frequency (%)	Mycorrhizal intensity (%)
T_0	8.33±2^b	14.4±0.016^b
T_1	8.66±2.33^b	16.5±0.017c^d
T_2	7.33±2^b	16.0±0.073^c
T_3	14.66±2.33^c	20.4±0.096^d
T_4	26.33±4^d	81.1±0.08^e
T_5	3.00±1^a	1.5±0.002^a
T_6	4.66±1.33^a	3.0±0.012^b
p-value	0.0001	<0.0001

In a column and for each and for each parameter, values affected with the same letters are not significantly different between treatments at the indicated level of significance. T_0 (control without compost or AMF), T_1: 1/2 (compost/soil) ratio +30 g AMF, T_2: 1/4 (compost/soil) ratio +30 g AMF, T_3: 1/3(compost/soil) ratio +30 g AMF, T_4: 2/3 (compost/soil) ratio +30 g AMF, T_5: Compost alone, T_6: Compost alone +30 g AMF

Variation of growth parameters between treatments in *Allium sativum* L. at 42 days after sowing: Table 3 presents the effects of treatments on the growth parameters of *Allium sativum* L. at 42 DAS. The number of leaves per plant, the plant height, the stem plant diameter was significantly improved by compost alone and all compost/soil ratios associated to AMF, with respectively p<0.0007, p<0.0001, p<0.0001, when compared to the same parameters growing on soil without compost and/or AMF. As for plant height, the most important improvements were obtained from treatments 1/3(compost/soil) ratio +30 g AMF (T_3), 2/3 (compost/soil) ratio +30 g AMF (T_4). Values obtained from treatments from 1/4 (compost/soil) ratio +30 g AMF (T_2) and compost alone +30 g AMF (T_6) were similar on one hand, between treatment control without compost or AMF (T_0) and compost alone (T_5) on the other. The best noticeable improvement for all these parameters was from treatment 2/3 (compost/soil) ratio +30 g AMF (T_4).

Variation of *Allium sativum* bulb diameter between treatments: Compost alone and all compost/soil ratios associated or not with AMF significantly enhanced the *Allium sativum* bulb diameter more than the control treatment for which no compost or AMF was used (Fig. 5). The effects of treatments T_1 and T_5 on one hand, treatments T_2, T_3, T_4, T_6 on the other were similar but remained higher than that of treatment control (T_0).

Table 3: Growth parameters of *Allium sativum* L. at 42 days after sowing

	Assessed parameters		
Treatments	Leaves/plant	Plant height (cm)	Stem diameter (cm)
T_0	4.36±0.32^a	4.43±0.45^a	2.42±0.03^a
T_1	7.30±0.12^{bc}	9.60±0.15^{bcd}	10.12±0.14^{bc}
T_2	8.00±1.12^c	9.37±0.48^{bc}	9.83±1.38^{bc}
T_3	8.30±1.00^c	10.44±0.98^{cd}	9.02±1.38^b
T_4	7.90±1.12^c	10.71±0.33^d	10.72±0.30^c
T_5	6.20±1.33^b	9.10±0.47^b	9.01±0.74^b
T_6	6.40±0.01^b	9.28±1^{bc}	9.84±0.71^{bc}
p-value	0.0007	<0.0001	0.0001

In a column and for each and for each parameter, values affected with the same letters are not significantly different between treatments at the indicated level of significance. T_0 (control without compost or AMF), T_1: 1/2 (compost/soil) ratio +30 g AMF, T_2: 1/4 (compost/soil) ratio +30 g AMF, T_3: 1/3(compost/soil) ratio +30 g AMF, T_4: 2/3 (compost/soil) ratio +30 g AMF, T_5: Compost alone; T_6: Compost alone +30 g AMF

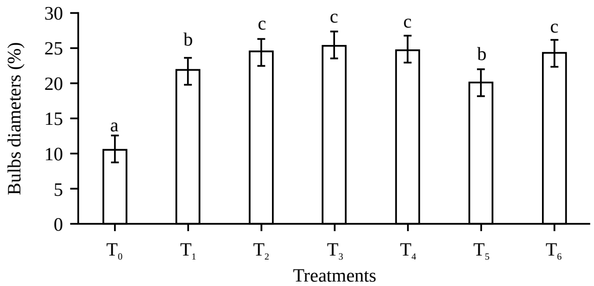

Fig. 5: Different bulb diameter of *Allium sativum* per treatment
Bars affected with the same letters are not significantly different at the indicated level of significance. T_0 (control without compost or AMF), T_1: 1/2 (compost/soil) ratio +30 g AMF, T_2: 1/4 (compost/soil) ratio +30 g AMF, T_3: 1/3(compost/soil) ratio +30 g AMF, T_4: 2/3 (compost/soil) ratio +30 g AMF, T_5: Compost alone, T_6: Compost alone +30 g AMF

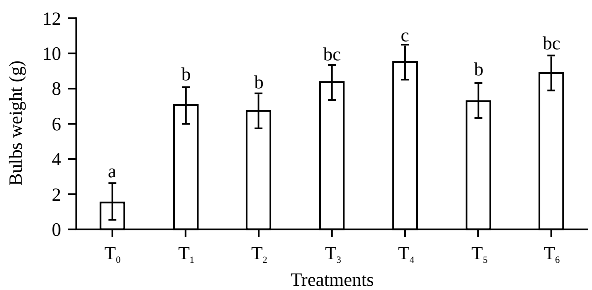

Fig. 6: Different bulb weight of *Allium sativum* between treatments
Bars affected with the same letters are not significantly different at the indicated level of significance. T_0 (control without compost or AMF), T_1: 1/2 (compost/soil) ratio +30 g AMF, T_2: 1/4 (compost/soil) ratio +30 g AMF, T_3: 1/3(compost/soil) ratio +30 g AMF, T_4: 2/3 (compost/soil) ratio +30 g AMF, T_5: Compost alone, T_6: Compost alone +30 g AMF

Changes in *Allium sativum* bulb weight between treatments: Figure 6 illustrates the effects of treatments on the weight of the bulbs. The bulbs weight from treatments T_4 was the highest ($p<0.0011$) compared to that of other treatments, particularly that of the control T_0 being the lowest al all.

No significant difference was noticed on *Allium sativum* bulb weight between treatments 1/2, 1/4 (compost/soil) ratio+AMF and compost alone. Similarly, the *Allium sativum* bulb weight from treatments 1/3 (compost/soil) ratio+AMF and compost alone+AMF did not differ significantly from each other.

Differences in *Allium sativum* cloves/bulb between treatments: Figure 7 illustrates the effects of treatments on the number of cloves per bulb. Plants amended with 1/2 (compost/soil) ratio +30 g AMF (T_1), 1/3 (compost/soil) ratio +30 g AMF (T_3), 2/3 (compost/soil) ratio +30 g AMF (T_4) and

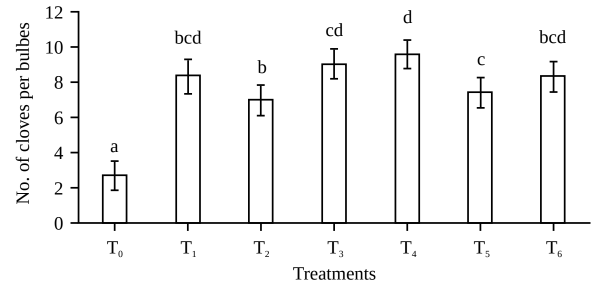

Fig. 7: Different *Allium sativum* cloves/bulb per treatment
Bars affected with the same letters are not significantly different at the indicated level of significance.T_0 (control without compost or AMF), T_1: 1/2 (compost/soil) ratio +30 g AMF; T_2: 1/4 (compost/soil) ratio +30 g AMF, T_3: 1/3(compost/soil)ratio +30 g AMF; T_4: 2/3 (compost/soil) ratio +30 g AMF, T_5: Compost alone, T_6: Compost alone +30 g AMF

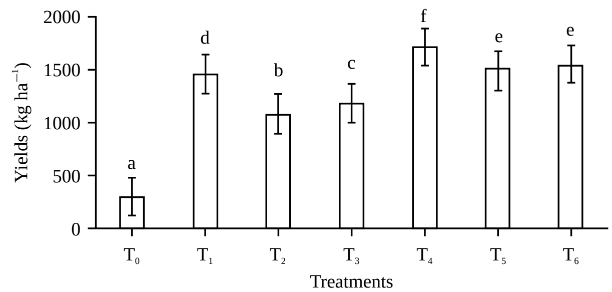

Fig. 8: *Allium sativum* bulb yield (kg ha^{-1}) per treatment
Bars affected with the same letters are not significantly different at the indicated level of significance. T_0 (control without compost or AMF), T_1: 1/2 (compost/soil) ratio +30 g AMF, T_2: 1/4 (compost/soil) ratio +30 g AMF, T_3: 1/3(compost/soil) ratio +30 g AMF, T_4: 2/3 (compost/soil) ratio +30 g AMF, T_5: Compost alone, T_6: Compost alone +30 g AMF

compost alone +30 g AMF(T_6) showed the number of cloves significantly higher ($p<0.0001$) than that of other treatments. The highest number of cloves per bulb was recorded in plants from treatment T_4 (9 cloves), while the lowest (3 cloves) was attributed to control plants that were neither amended with, nor inoculated with AMF (treatment T_0).

Variation of *Allium sativum* bulb yield (kg/ha) between treatments: Figure 8 presents differences in garlic bulb yield (kg ha^{-1}) as influenced by various compost/soil ratios. As AMF dependent crop, garlic responded well to 2:3 compost/soil ratio+AMF, referred to as treatment T_4 (1711.33 kg ha^{-1}), as compared to the 5 fold lower yield value (290 kg ha^{-1}) from plants growing on only soil without compost nor AMF supplement (T_0).

Positive and significant correlations were found between the number of cloves/bulbs and the bulb diameter ($r = 0.74$; $p<0.0001$), the number of cloves/bulbs and the bulbs weight ($r = 0.63$; $p<0.0001$), as well as between the bulb diameter and the bulbs weight ($r = 0.72$; $p<0.0001$). In other words, the more cloves are produced the greatest are the diameter of bulbs, than enhance their weight and thus the yield. These criteria were all fulfilled by treatment 4 and accounted for garlic plants growing in pot with 2/3(compost/soil) ratio and inoculated with AMF.

DISCUSSION

The physicochemical analysis has revealed the soil richness in ash and its poorest in available nutrients. In this research, compost and AMF were provided for the growth of garlic plants. Organic matter in compost is known to buffer the soil against major swings in pH by either taking up or releasing H^+ into the soil solution, making the concentration of soil solution H^+more constant[33]. The pH value of compost was 7.11, while the soil had a weakly acidic pH (5.21). In fact, the ideal pH for *Allium sativum* development has been reported to range between[34] 6 and 7. Analysis of the showed that the Compost and AMF were favorable to the germination rate of garlic cloves, except when compost was the substrate in pots. Too much organic matter in the compost, as the sole substrate may have negatively affected the seeds germination, as has been previously reported that high application of compost exhibited toxicity to plants by slowing down germination[35,36]. The frequency and intensity of mycorrhization were reduced by compost, indicating that excessive organic fertilization in soil negatively affects mycorrhization. These results confirm those of Marx *et al.*[37], who demonstrated that the more available the nitrogen and phosphorus in the soil, the less the roots mycorrhization. The mycorrhizal colonization under un-inoculated plants (treatment T_0) was also low, confirming the ubiquitous inefficient native of fungi occurring naturally in most agricultural soils[38,39]. However, appropriate compost/soil ratio+AMF mycorrhiza increased the growth parameters of *Allium sativum*, in conformity with increased vegetative growth of *Allium* (plant height, number of leaves and other) following application of compost extract+biofertilizers[40]. These results conform with those obtained by Bolandnazar *et al.*[41], who indicated improved AMF-onion growth and development in comparison to non-AMF plants. Mycorrhiza acts by extending and expanding the reach of plant roots for nutrient absorption, resulting in increase in plant nutrient uptake and growth[42]. These findings are also in agreement with the dependency of garlic to mycorrhiza demonstrated by Al-Karaki[43], or stimulation of *Lycopersicon esculentum* growth[13], *Solanum tuberosum* development[19] after a reasonable application of compost and/or compost tea. The application of mycorrhiza in the soil has been revealed to increase the mineral absorption favoring the plant growth[44]. The increase in the plant height and stem diameter of *Allium sativum* by treatment 2/3 (compost/soil)+AUMF could be ascribed to increase nutrient uptake by plants and their optimum assimilation for plant growth and development. Similar results were obtained by Shuab *et al.*[45], who pointed out that the onion plant is highly responsive to several AMF, which tend to associate with onion roots leading to improved plant growth and nutrient uptake. However, after maximum growth, the effects of treatment may have reduced, in line with results of Olfati *et al.*[46], who stated that the number of leaves per plant and other growth parameters in garlic reached their maximum values three weeks before harvesting stage and then decreased.

Plants growing on soils that have received compost and/or mycorrhiza had the greatest bulb diameter compared to those of developing on soil without compost or mycorrhiza. This finding lines with an increase in bulb diameter as the response to the dissolution of soil nutrients available for absorption by the root system[47-49]. Another reason might be more accumulation of carbohydrates released by mycorrhiza, which increased the diameter of bulb[17]. The weight of garlic bulbs from compost and or mycorrhizal treatments was higher than that of bulbs from the soil that did not receive compost or mycorrhiza. This may be assigned to the fact that compost and mycorrhiza improved nitrogen supply, which increases the metabolism rate through carbohydrate synthesis and increased bulb weight and total yield. These results agree with enhanced total root yield (fresh and dry weight of bulb) of garlic plants as reported by Mengeshe and Tesfaye[16], or significantly increased in AMF inoculated plants than non-inoculated ones pointed out by other investigations[50]. The number of cloves formed by the bulb of garlic plants from compost only and /or mycorrhiza treatments was higher than that of bulbs from the soil that did not receive compost and mycorrhiza. These observations may be due to enough proportion of compost amended in this treatment. Compost releases nutrient for plant growth and mycorrhiza help the plant to take up nutrients by extending the rhizospheric zone where plant roots usually reach. These results are similar to those of Hargreaves *et al.*[51], Marzauk *et al.*[52], Kumar *et al.*[53], who showed the beneficial effect of biofertilizers application on cloves formation/bulb, as well as the average clove weight of garlic plants. The positive effect of compost manure fertilizer on physical properties and the number of cloves formed by *Allium sativum* was also reported[17]. The yield of garlic bulbs in kg ha^{-1} demonstrated that compost and or mycorrhizal treatments had higher yields than that of the control treatment. These results lines with those of Tawaraya *et al.*[54], who demonstrated that AMF-inoculation can achieve a marketable yield of *Allium fistulosum*, while Usman *et al.*[49] stated that the application of organic fertilizers positively enhanced garlic growth and productivity. However, further studies still need to be carried out to provide the net receipt to farmers who intend to apply this ratio at a large scale in the field.

CONCLUSION

Our results have indicated that inoculating garlic plants with AMF at sowing can substantially improve the growth of this crop under a suitable compost/soil ratio supplement. The 2/3 (compost/soil) ratio inoculated with 30 g mycorrhiza (treatment T_4) had a positive and significant effect on plant emergency and mycorrhization rates, plant height, stem diameter, fresh bulb weight, number of cloves/bulb and total bulb yields/hectare (1.711 t ha^{-1}) compared to other treatments. Hence, this treatment could be recommended to advertise garlic growers in boosting their production in the context of research sustainability.

SIGNIFICANCE STATEMENT

This study discovered that 2/3(compost/soil) is the best substrate ratio that, if inoculated with 30 g of AMF can enhance the growth and yield parameters of *Allium sativum* in potted experiment. This research will help garlic growers to monitor the compost/soil concentration requested for more income generation and the improvement of their living standards.

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