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karima Ghebbi
Faculty of Biological Sciences and Agronomic Sciences, Mouloud Mammeri University of Tizi-Ouzou, 15000, Algeria., kghebbi@gmail.com

Mohamed Meziane Bellal
National Higher School of Agronomy, El Harrach 16130 Algiers, Algeria

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Cover Page Footnote

Mr TAMEN, responsible of Technical Institute of Vegetables (ITMAS) is acknowledged for his assistance.

IMPACT OF MINERAL FERTILIZATION, HOME COMPOST AND FARM MANURE ON YIELD COMPONENTS AND NUTRITIONAL PARAMETERS OF TOMATO FRUIT

KARIMA GHEBBI[1*] AND MOHAMED MEZIANE BELLAL[2]

[1]*Faculty of Biological Sciences and Agronomic Sciences, Mouloud Mammeri University of Tizi-Ouzou, 15000, Algeria.*
[2]*National Higher School of Agronomy, El Harrach 16130 Algiers, Algeria.*

*Corresponding author's email: kghebbi@gmail.com

ABSTRACT

Mineral fertilization, home compost and farm manure were tested on tomato hybrid variety cultivated in open field (*Lycopersicon esculentum* Mill.) evaluating the effect on growth, yield components and nutritional parameters of fruit. Tomato variety was grown on clay-loam soil poor in potassium and nitrogen but rich in phosphor and fairly well provided with organic matter. The test was carried out in a randomized complete block design with four replications. Results showed that supply by home compost revealed to be better on most of parameters measured compared with farm manure and mineral fertilization. Fruit yield was positively affected by home compost whereas the values of lycopene content, vitamin C, refractive index of fruit juice and final height of tomato were higher with farm manure than by mineral fertilization and home compost. The variance analysis showed at least a significant effect of home compost on numerous parameters. Home compost followed by farm manure promotes soil enrichment in mineral elements, improves fruit yield, and their quality, in addition, it guarantees sustainable agriculture through the preservation of soil structure and keep clean our environmental soils nape.

Key words: Farm manure, home compost, mineral fertilization, fruit yield, lycopene.

INTRODUCTION

The world's population is growing at around 7 billion people and could reach 9.6 billion by the year 2050. According to the FAO (2009) food production must be increased by 70 % to feed 2,3 billion additional people. According to Mougeot and Moustier (2004) this demographic growth poses many challenges when food production will have to double and waste will be quadrupled in cities. FAO (2016) promotes the transition to sustainable and climate resilient agricultural policies. In fact, the population explosion results in intensification through the extensive uses of mineral fertilization which tend in excessive agricultural degradation of soils, a decrease in arable land and increasing demand of water uses. Water use is limited by the expansion of urban and industrial sectors (FAO, 2004). Nowadays, it's necessary to increase production without harming our environment with keeping quality of human food health. So, the protection of our environment and the economic use of natural resources will be indispensable. Regarding to Temgoua et al., (2015) farmers use an important quantity of pests and mineral fertilizers to better yields, but residues released are set on fruits and become dangerous for human health and the concentration of fertilizers in soil causes physiological damage. An adequate program must be put in place to safeguard our planet and human health. According to Naika (2005) home compost and farm manure improve soil fertility and its structure reducing the need of elements like phosphor (P), nitrogen (N) and potassium (K). According to Decoupman (2013) humus is still considered to be a basic of soil fertility because organic matter bound improves water retention. The rate of organic matter influences positively structural stability and limits the phenomenon of surface bending. Kuepper (2003) found that organic manure is essential in biological and sustainable management of soils, by its nature and reactivity which makes it a unique component and a major player in the carbon cycle (Baudin et al., 2017). When soil is worked the mineralization of humus tends to increase. In fact, no tillage techniques activates mineralization by oxygenation, resulting in better conservation of humus in soils worked superficially (Hubert et al., 2011).With conventional tillage, in temperate regions 1 to 3 % of stable humus can be lost annually, but with no-tillage less than 0.5 % is lost (Rosell, 1993 in Huber, 2011). Organic matter uses produce better results when combined with other renewable practices, such as crop rotation, crop enhancement, and green manure. So, soil structure will change gradually to achieve a continuous cultural profile after few years. Nowadays, yield is so important as well as fruit quality. the purpose of this work is to evaluate in open field the effect of home compost and farm manure on tomato plant growth, yield and fruit quality parameters.

MATERIALS AND METHODS

The experiment was conducted at the Technical Institute for vegetables and Mountain Crops (ITMA) of Boukhalfa located at 200-300 m of altitude in Tizi-Ouzou town (Algeria) (Fig.1).Tomato plants (*Lycopersicon esculentum* Mill.) were grown in open field with a clay soil (40 %), fairly well provided with organic matter (2.75 %) and phosphorus (184ppm P), low in potassium (0.50 ppm K^+) and nitrogen (0.075 %).

Figure 1: Satellite image of the experimental parcel (Google Earth, 2018)

The study focused on one tomato hybrid variety (Baghera F1). The requirements of the tomato in major mineral elements for a ton of fruit are 4 to 5 kg of N, 1 to 1.5 kg of P_2O_5 and 5 to 8 kg of K_2O. The variety selection criteria were based on plant characteristics such as type of fruit, good plant shape, and resistance to pests as *Tuta absoluta* and diseases as alternariasis. This cultivar has a high production potential under local conditions (50 tons ha- 1). The previous crop was wheat without major impact on the health status of tomato plant. In fact, Wheat is less demanding in mineral fertilizers like tomato and as they are from different families therefore less risk for soil diseases. Manual planting of bare roots of plant was undertaken on 13/05/2018. Harvesting was carried out on 26 July 2018, spread on four harvests with ten-day intervals. In the field, the distance between plants in the row was 0.4m and the distance between rows was 1m, giving plant density of 25000 plants/ha. The area of the basic plot was 7.6 m^2. The input of nitrogen fertilizer concerned all the tests. The spreading of nitrogen on the whole plot will have a rapid recovery effect of the plants from the nursery, it is to push the plants at start-up. But potassium and phosphorus concerned only mineral plots. Nitrogen input (120Uha^{-1}) was urea (46 %) which was fractioned in two inputs: one at planting stage (13/05/2018) and the second at early flowering stage (26/06/2018). Potassium (250 kg ha^{-1} K2O) with K2SO4 and Phosphor (80 kg ha^{-1}) as Super phosphate (46 % P2O5) supplies is carried on at planting (15/05/2018).

Experimental Design

Plots with farm manure and home compost (fruit and vegetable peelings) haven't received potassium and phosphorus. Plots with farm manure received 40t ha^{-1} every ten days corresponding to 200 g per plant of organic matter from plantation until harvest. Chemical composition of both farm manure and home compost were fairly stable (Table 1). In a block there are three plots, one with mineral fertilization, this is the control, one plot with farmyard manure and the third with compost.

Table 1: Chemical composition (%) in fertilizers of home compost and farm manure

Chemical Composition	Home Compost	Farm Manure
pH	6	6
C/N	10	12
N	0.99	0.99
P_2O_5	0.44	0.56
K_2O	0.73	0.56

Manual weeding was carried out several times during the cycle as well as protective treatments, especially application of insecticides (organophosphorus).

The experimental setup was in a complete randomized block design with four replications. At each block, three plots were performed: farm manure, home compost and mineral fertilization. The planting distance was 0.4m between plants and 1m between rows. Per block there were 36 plants leading to a surface area of 14.4 m^2 per block. Flowers set on after one month after plantation. In each plot, three tomato plants were labeled vegetative and reproductive parameters measurement. At maturation stage three tomato fruits were taken for technological characteristics. Plantation of tomato was observed on 13/05/2018 after one month of sowing. Duration of tomato production cycle was five months and the last date of harvest was at 30/09/2018. The statistical analysis was performed by variance analysis using software STAT-BOX with significance level at 5 %.

During the experiment, the highest temperature was registered in July and August with an average of 28.05 °C (Table 2) corresponding to the moisture content ranging from 50.4 to 52.1 % respectively. Water deficit was compensated by manual irrigation, leading to 4l of water per plant per day spread over the cycle covering all physiological stages of plant development (growth, flowering, fruit set and fruit growing) for two hours in the morning (9AM) and two hours in the afternoon (4 PM).

Numerous variables were measured such as final height of the main stem, total number of flowers, total number of clusters, total weight of fruit, mean fruit weight per plant and mineral content of fruit (calcium and potassium measured by atomic absorption; phosphorus measured by spectrophotometer UV visible Unicam). The technological parameters were the pH, measured by using a pH-meter (Inolab level1, Germany) and the refractive index (°brix) of fruit juice, measured using a refractometer (ORA 10BA- KERN French). The lycopene content was measured by UV visible spectrophotometer, using the method reported by Lime et al., (1957). Observations were carried out at two different wavelengths (450 and 503 nm) using the formula:

Cl (mg/l) = 3.956 DO503 - 6.806 DO451

Cl is the concentration of lycopene.

Table 2: Temperature, humidity and average monthly rainfall during plant development stage during 2018 (Boukhalfa ITMA, 2018) (ONM, Tizi Ouzou, 2018).

Months	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**
T^0C mean	23.74	20.58	14.84	12.21	10.22	10.42	13.29	15.98	19.38	24.45	28.05	28.05
H % mean	60.2	69	75.8	79.5	79.6	76.6	72.5	70.5	69	58.2	52.1	50.4
P(mm)	39.47	74.74	120.1	115.1	116.7	116.7	98.8	98.8	71.5	12.12	2.9	6.39

P: precipitations; T: temperature, H %: Relative humidity, Months (September, October, December, January, February, April, May, July, August).

RESULTS AND DISCUSSION

Agronomic Parameters

The various analysis showed at least a significant effect of fertilization type used on final height of tomato plant (*P= 0.02*), total number of trusses (*P= 0.0002*), flowers (*P= 0.0002*) and fruits (*P= 0.01*) per plant; the same observation concern also the mean fruit weight (P= 0.0001) and total fruit weight (*P= 0.0001*) per plant and yield (Table 3).

The final main height of stem was positively affected ($P \leq 0.05$) by using farm manure and mineral fertilization which were better than home compost (Table3). About total number of trusses per plant, the various analysis showed a very high significant effect of fertilization type (*P= 0. 000*). So, home compost registered the highest value of total number of trusses (*P=0.0001*), total number of fruits (*P= 0.01*) and total number of flowers per plant (*0.0001*) (Table 3). As showed in table 3, about size of fruit per plant, the variance analysis registered a very high effect with using home compost (*P= 0.000*) compared with other fertilization types. Also, for average weight of fruit per plant, variance analysis showed a very high significant difference (*P= 0.000*) of both home compost and farm manure which registered the highest value (table 3). Finally, an increase in total fruit yield per hectare was observed with using home compost where the highest yield remains in favor of home compost (449.33qtx / ha) compared to the other types of fertilization. The quality of home compost is better in particular, with its good maturation (Table1). Regarding to the total fruit weight per plant, the variance analysis showed a very high significant difference (*P= 0.0001*) and home compost registered the greatest value of total fruit weight per plant compared to mineral fertilization and farm manure (Table 3).

Nutritional Parameters of Fruit Juice

The variance analysis showed a high significant effect of farm manure (*P= 0.009*), home compost and mineral fertilization, respectively, on refractive index of fruit juice. For total sugar content, home compost registered better level, followed by farm manure and mineral fertilization (*P= 0.01*). Same results are obtained for vitamin C and lycopene content (Table 3). About fruit juice pH, results showed that home compost and farm manure registered low values (*P= 0.004*) than using mineral fertilization. With mineral fertilization, we obtained better minerals accumulation in tomato fruit like potassium and phosphor; however, calcium accumulation was higher with using home compost (Table 4).

Table 3 - Effect of type of fertilization on vegetative and production parameters

Fertilization Variables	Home compost	Farm manure	Synthetic fertilizers	Significance
Main stem height (cm)	0.87±0.047 (B)	0.95±0.079 (A)	0.94±0.068 (A)	S
Collar diameter (cm)	0.99±0.14	0.94±0.06	0.81±0.068	NS
Total number of trusses/plant	26.75±0.73 (A)	25.5±0.89 (B)	24.33±0.88 (C)	VHS
Total number of flowers/plant	160.5±4.41 (A)	153±5.38 (B)	146±5.28 (C)	VHS
Total number of fruits/plant	57±0.82 (A)	55.83±1.12 (B)	55.33±1.44 (B)	S
Size of fruit (cm)	8.06±0.45 (A)	7.66±0.48 (A)	6.51±0.49 (B)	VHS
Mean fruit weight (g)	275.08±9.59 (A)	274.08±10.72 (A)	204.5±10.47	VHS
Total weight of fruit/plant (Kg)	15.68±0.64 (A)	15.28±0.79 (A)	11.31±0.68 (B)	S
Yield (Qtx/ha)	449.33±72.6 (A)	346.3±31.42 (B)	362.7±39.34 (B)	S

S: significant level at ≤5 %; HS: Highly significant ≤0.001; VHS: very highly significant; A, B, C: homogeneous groups of Newman and Keuls test.

Table 4: Mean values of technological and minerals parameters content in fruit according to fertilization types

Fertilisation Variables	Home compost	Farm manure	Synthetic fertiliser	Signifiance
Rerfractive index	6.66±0.05 (A)	7±0.06 (A)	4.33±0.07 (B)	HS
Sugar content %	1.94±0.05 (A)	1.90±0.05 (A)	1.78±0.01(B)	S
Vitamin C %	14.1±0.52 (A)	16.6±0.72 (B)	13.76±0.4 (B)	HS
pH	4.26±0.06 (B)	4.33±0.15 (B)	4.75±0.09 (A)	HS
Lycopene content (mg/kg FM)	7.77±0.06 (B)	8.58±0.12 (A)	4.93±0.05 (C)	VHS
K	218.66±6.65 (B)	215.66±6.65 (B)	288.33±7.09 (A)	VHS
Ca	9.75±0.1 (A)	8.93±0.15 (B)	9.62±10.22 (A)	HS
P	13.33±0.45 (C)	14.09±0.2 (B)	16.2±0.68 (B)	VHS

S: significant level at ≤5 %; HS: Highly significant ≤0.001; VHS: very highly significant; A, B, C: homogeneous groups of Newman and Keuls test

The results showed that different type of fertilization on production and quality parameters of tomato hybrid variety with supply, particularly with home compost for most variables measured, in particular on total fruit yield per hectare, total number of fruits, average fruit weight, total number of trusses and flowers per plant. About technological parameters and mineral fruit content, we obtained highest values in sugar content, lowest values in pH and calcium fruit content with home compost. In other hand, the use of farm manure has a positive effect on fruit juice lycopene and vitamin C of fruit juice. Our results are in concordance with those of Amadou et al., (2010), which indicated that the contribution of organic matter has a positive effect on the increase in tomato production. Otherwise, there is a decrease in pH of tomato fruit juice by using farm manure, in particular with home compost. In fact, low pH value is very important in fruit conservation during tomato processing. About phosphor and potassium, they were accumulated in fruit with mineral fertilization due to their easier availability in soil. Moreover, Hamilton and Bernier (1975) reported on three market gardening crops (celery, onion and carrot) that organic matter supply influences their biochemical qualities. Indeed, these authors explain that decomposition of organic matter releases nutrients available to the plant, which promotes a good rooting and make take easily the nutrients that plant needs.

Worthington (1998) signaled of about 27 % in organic matter supplied results in the elevation of 30.8 % Ca, 24.4 % Mg and 0.66 % P. The contribution of organic matter would largely lead to an improvement in the mineral quality of the crops.

According to Andrews and Reganold (2006), yields of tomato fruit were 76 % higher in conventional plots, but organically grown fruits were better than conventional fruits: their sharper color, sugars content and their dry matter content are superior, and have better organoleptics properties. Fruits grown under biological control deteriorate less rapidly during marketing simulations and exhibit better conservation properties.

Similarly, Hajslova et al., *(*2005) reported that organic supply is correlated with fruit firmness, their better storage and high ascorbic acid (vitamin C) content. Our results are in line with those of Lairon (2009) on potato, who registered a higher dry matter content in organic potatoes, which were higher comparatively with those conducted on mineral fertilization. It’s the same response for the antioxidant content, like vitamin C.

Also, our results confirm those of Hogstad et al., (1997), on carrot cultivar, where sugar content is higher under biological manure and Reganold et al., (2001) on apples that are sweeter and less acidic, than fruits obtained in conventional treatment. The biological manure enhance the earthworms activity, their galleries allowed the percolation of water at depth and limits surface runoff. According to Labreuche and Bodet (2001) they played a very important role in degradation and migration of organic matter; since the drainage through the galleries and the maintenance of a structural state are favorable to the development of plants.

Decoupman (2013) reports that mature compost loses easily degradable and fermentable carbon and causes a rapid and short action on the biological and physical properties of the soil, having a favorable impact on quality fruits. On the other hand, Kuepper (2003) reported that bad raw manure deteriorates the quality of vegetables such as potatoes, cucumbers and squash. By decomposing in the soil, the manure releases compounds like skatole, in dole and other phenols. Absorbed by plants, these compounds can give an abnormal flavor or undesirable odor to vegetables.

Ultimately, the practice of organic fertilization improves the agro-mineral status of soil. So, farm manure and home compost increase mineral content of soil which becomes light in the texture. Our results are consistent with those of Maltas et al., (2012) where soils receiving regular organic fertilizers have a higher biomass and microbial activity than soils receiving only mineral fertilizers. The composition of this biomass appears to be affected by these inputs. According to Maltas et al., (2013) the use of farm manure is considered to be an effective way of increasing soil organic carbon (SOC) sequestration and supplying micronutrients to crops in comparison with using mineral fertilizers only.

According to Oliveira et al., (2013) organic matter and home compost improved fruit firmness, probably due to the presence of different growth promoting substances released by the compost. The effects of organic fertilizers are remarkable on soil protection, water economic and microbiological activity, in addition a definite impact on yield and quality of production.

Some researchers found that organic tomatoes are tender and have a better taste, flavor, texture and juiciness. However, conventional tomatoes are perceived as less ripe, dry and less fragrant (Mc Collum et al., 2005). Our results confirm those of Caris-Veyrat et al., (2004) where tomatoes grown in organic crops have a higher carotenoid content and vitamin C compared to the conventional crop.

CONCLUSION AND PESRPECTIVES

The quality and yield of tomato which cultivated both with farm manure and home compost was better when compared to conventional treatment under mineral fertilization. It is advisable to usually use organic matter or home compost depending with their availability to preserve agricultural soil and good quality of our diet, which will be rich in micronutrients important for health without polluting water underground. It will be judicious to carry on deeply chemical analysis on the chemicals released by the organic matter and home compost which could be responsible for many organically qualities in fruit.

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CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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