Research Article Open Access

# Soil Fertility and Pepper Yield in Response to Different Sources of Nutrients in Arid Conditions of Southern Morocco

K. Aouass[1,*], L. Kenny[1], Y. Hachim[1], A. Ouchen[2], H. Hajji[2], M. Bakki[2]

[1]Department of Horticulture, Agronomy and veterinary Institute HassanII , Rabat, Morocco
[2]Department of Biology, University of Ibn Zohr, Agadir, Morocco

**Edited by:**
**Khuram Ziaf,**
University of Agriculture, Faisalabad, Pakistan
**Reviewed by:**
**Muhammad Imran,**
Nanjing Agricultural University, Nanjing, China
**Azhar Hussain**,
Islamia University, Bahawalpur, Pakistan
**Noosheen Zahid,**
University of Poonch, Rawlakot, Azad Kashmir, Pakistan
**Received**
December28, 2017
**Accepted**
March17, 2018
**Published Online**
June 20, 2018

**Abstract:** A greenhouse research was conducted in order to determine the effect of different sources of commercial organic fertilizers (COF) as compared to compost on soil fertility, growth and yield of pepper in the Souss Massa area in south of Morocco. Pepper were transplanted to sandy-loamy soils under greenhouse prior to adding 300kg/ha of N, 150 kg/ha of P and 350 kg/ha of K either as compost (Tc; 2.5:3:2.5, N:$P_2O_5$: $K_2O$), a triple source COF ($T_{NPK}$, 7:4:7), a mixture of double source COF ($T_{NP+K}$, 8-12-0) and single source COF (0:0:30) or a mixture of three single source COFs ($T_{N+P+K}$, 10:0:0 + 0:18:0 + 0:0:30). The highest yields (58 t $ha^{-1}$) were obtained with compost and the ternary COF (57 t $ha^{-1}$). As for soil fertility parameters, a clear effect of organic inputs was registered on soil organic matter, electric conductivity and pH. Based on these findings, recommendations on how to build an organic fertilization program pepper crop are discussed.

**Keywords:** Organic fertilizer, pepper, Soil fertility, Compost, arid conditions.

***Corresponding author:** Aouass Kaoutar, E-mail:,aouass.kaoutar@gmail.com

**Cite this article as:** Aousass, K., L. Kenny, Y. Hashim, A. Ouchen, H. Hajji and M. Bakki. 2018. **Soil fertility and pepper yield in response to different sources of nutrients in arid conditions of Southern Morocco**. Journal of Environmental and Agricultural Sciences. 15: 43-50.



## 1 Introduction

Peppers are among the important vegetable crops in the arid regions (Smith, 2015). They are grown in the field as well as in the protective environments including greenhouses and hydroponics (Dhaliwal et al., 2017; Serret et al., 2018). It is a high nutrient demanding crop (Rekani et al., 2017). More attention has been paid to secure high yield and good quality of sweet pepper affecting its productivity. One of the main problems faced by the pepper farmers is the high cost of production due to the use of inorganic fertilizers.

Plant growth and development are dependent on supply of nutrient, availability of nitrogen and phosphorous are among the major limitations for crop production (Murphy et al., 2017; Weider et al., 2015), which is aggravated under environmental stresses, mainly water stress (Jin et al., 2017; Wang et al., 2017 ). Crop production, in arid and semi-arid regions, to attain highest productivity; usually requires supplementation with the excessive amounts of fertilizers. Excessive use of fertilizer can result in soil degradation (Ata-Ul-Karim et al., 2016; Clune et al., 2017; Valentin et al., 2017). Studies have demonstrated that wide variety of organic fertilizer that may be used to amend soils, such as compost (Scotti et al., 2016), urban refuse, sewage sludge and peat (Jarousseau et al., 2016; Kchaou et al., 2018). Different types of organic fertilizer will differ in their availability of nutrient in soil and subsequently plant growth and yield (Dotaniya and Meena, 2015; Olmo et al., 2016; Zechmeister-Boltenstern et al., 2015). This also depends upon previous history of soil in term of crop and nutrient management (Gutser et al., 2005; Jin et al., 2017; Miao et al., 2011).

Many investigators found that about sweet pepper, addition of organic fertilizers had a major effect on vegetative growth characters of sweet pepper (Rekani et al., 2017), total yield (Huez et al.,2011) and quality of sweet pepper plants (Szafirowska and Krystyna, 2009). Islam et al. (2017) reported that organic and inorganic fertilizers had significant impact on soil properties and the growth, yield and quality of tomato.

Timing and amount of mineralization often do not coincide with crop need, making in-season fertilization necessary (Ata-Ul-Karim et al., 2017; Pang and Letey, 2000). This lack of synchrony between N mineralized from organic matter and crop N uptake is a major challenge for fertility management in organic systems (Gaskell et al., 2007). Applying right amount of N fertilizer to ensure optimum crop yield and quality makes sound economic sense and help to reduce the levels of potentially leachable N in the soil.

Unfortunately, in Morocco, limited data is available on crop nutrient management for intensive vegetable production with vegetables. Higher rates of fertilizer often reported incidents of pests and diseases attack (Dordas, 2008). The practice of organic agriculture is gaining attention of vegetable growers in Morocco. (Alaoui, 2009). The most important sites for organic vegetables production in Morocco is Souss Massa. This is characterized with a very good climate with moderate temperature degree (19°c) in winter, and moderate relative humidity (40%). Such climate is suitable for indoor vegetable production throughout the year. In this context, we aim to investigate the effect of compost and commercial organic fertilizer on soil fertility, growth and yield of pepper grown under greenhouse condition in Souss Massa area, Morocco.

## 2. Materials and Methods

### 2.1.Experimental Design

The research was conducted at Villatelimoune farm, 40 km from Agadir city, capital of Souss-Massa region, Morocco, from October 2013 to March 2014. Arid climate with low precipitation (250 mm, average of last 20 years) and sunny days (>300 sunny days a year) are main climatic characteristics of experimental site (Abahous et al., 2018; Schulz et al., 2008). Rainfall mainly occurs during Nov-March. Average temperature varied from 10-16 °C (January) to 20-29 °C (July) in 2014. Soil type was loamy with a pH of 8.13 and EC 0.27 $dSm^{-1}$. Experimental soil was moderately rich in organic matter (1.6%), field capacity relative humidity (FCRH) was 30%, and the permanent wilting point humidity (PWPRH) was 15%. Experiment was laid in completely randomized design with 4 treatments and 4 repetitions. This experiment included four treatments which were as follows: C: compost, $COF_{NPK}$: commercial fertilizer NPK, $COF_{NP+K}$: commercial fertilizer NP and fertilizer with K, $COF_{N+P+K}$: commercial fertilizer N combined with commercial fertilizer P and K. Feeding programs for the main crop were based on compost and three commercial organic fertilizers used as granule form. The products are widely used by local farmers for organic vegetable growing. The main characteristics of these products are presented in (Table 1). In this experiment, the quantity of compost and commercial fertilizer applied were based on crop N requirement and for a potential yield of 90 t $ha^{-1}$ of pepper and need the following nutritional needs 300 kg of N, 150 kg of P and 350 kg of K (Elattir et al., 2003) (Table 2).

Experimental soil was sandy in texture, with fairly alkaline pH and poor in organic matter and N status (Table 3). Pepper variety Wassila was used as plant material. Total 70 plants were planted in the main plot at a distance of 0.4m each with a planting density of 20,000 plants $ha^{-1}$. The experimental field was prepared by ploughing with a tractor driven 3-disc plough. During the second half of September raised seedbeds were formed manually. Fertilizers were calculated according to crop needs of N, the fertilizer content and soil content of N. Fertilizers were applied on 2nd September 2013 before transplanting the pepper seedlings.

### 2.2. Soil and Plant Analysis

Soil texture, mechanical analysis was carried out using the pipette method. Soil pH, was measured in 20g: 50ml (soil: water) suspension using a glass electrode. Electrical conductivity (EC) was measured in the supernatant extraction of 20g: 100ml (soil: water). Organic matter content: was determined using the modified Walkley Black method. Total N: was determined using a Kjeldahl method (Black, 1965). Total phosphorous: measured by using Olsen method, by colorimetric method.

**Table 1. Characteristics of the compost and organic fertilizer used in the experiment**

| | OM % | N% | $P_2O_5$% | $K_2O$ % | CaO % | MgO% |
|---|---|---|---|---|---|---|
| Compost | 30 | 2.5 | 3 | 2.5 | 6.5 | 1.5 |
| NPK fertilizer | 49 | 7 | 4 | 7 | - | 2 |
| NP fertilizer | 55 | 8 | 12 | 0 | 10 | - |
| N fertilizer | - | 10 | 0 | 0 | - | - |
| P fertilizer | 0 | 0 | 18 | 0 | - | - |
| K fertilizer | 0 | 0 | 0 | 30 | - | 10 |

**Table 2. Pepper Nutritional Requirements (Elattir et al., 2003)**

| Crop Growth Stage | Days | N (kg $ha^{-1}$) | P (kg $ha^{-1}$) | K (kg $ha^{-1}$) |
|---|---|---|---|---|
| Planting | 37 | 60 | 87 | 49 |
| First fruit | 45 | 108 | 45 | 80,5 |
| Harvesting | 92 | 132 | 18 | 220,5 |
| Total | 174 | 300 | 150 | 350 |

Micronutrients (Fe, Zn, Mn and Cu) were extracted by DTPA (Lindsay and Norvell, 1978) and measured by atomic absorption spectrophotometer (GBC model 300). Macronutrients (Mg, K, Ca and Na) were determined by the flame photometer method (Jackson, 1967). Plant samples were taken after harvest at the 5thleaf from the upper level, total N, total P, other macro and microelements (K, Ca, Na, Mg, Fe, Cu, Mn and Zn) were measured. Leaf samples were oven dried (6-7 hours at 80°C) after washing with distills water. The samples crushed into small pieces. Subsequently crushed material (0.5 g) was oven dried (500 °C, 6 h), after cooling the crushed material empted in the Erlenmeyer of 100 ml, by adding HCl (2N). Nutrients were dissolved in water through sand heating. The quantity of the solution remained after evaporation, was added to tubes and full with distilled water to form mother solution, which diluted 10 and 100 times for further chemical analysis.

### 2.4. Statistical Analysis

The SPSS Version 23.0 was used for statistical evaluations. The results were subjected to one-way analyses of variance (ANOVA) with the significance of the means tested with a Duncan-test at p< =0.05.

## 3. Results and Discussion

### 3.1. Soil Properties

Results regarding the main chemical characteristics and Soil major nutrient content in crop cycle are presented in Table 4. Soil pH varied significantly with the treatments and it decreased with organic fertilizer application. This reduction in pH can be explained by the formation of organic acids during organic matter degradation (Franco-Oteroet al., 2012). The largest decrease was recorded for treatments $COF_{NP+K}$ and $COF_{NPK}$ with 7.73 and 7.68 respectively at 92 DAP. Organic fertilizers contribute to the increase of organic matter content in soil. Soil organic matter was increased significantly with all types of organic application and that was recorded the highest with compost application with 2.19%. The high soil temperature that favors the mineralization process especially in sandy soils can explain the increased in this percentage (Griffin et al, 2002).

**Table 3 Soil Chemical Analysis**

| | Elements | Unit | Value | Observations |
|---|---|---|---|---|
| Soil properties | Organic matter | % | 1.36 | Low |
| | Total carbonates | % | 52.78 | High |
| | Active lime | % | 8.82 | Low |
| | pH | - | 8.60 | Alkaline |
| | EC | m mhos/cm | 0.33 | Medium |
| | C/N | - | 12 | Medium |
| Macronutrients | $NO_3^-$ | ppm | 151.7 | High |
| | $P_2O_5$ | % | 0.194 | High |
| | K | Meq/100g | 0.603 | Normal |
| | Ca | Meq/100g | 2.040 | Normal |
| | Mg | Meq/100g | 1.576 | High |
| | Na | Meq/100g | 0.247 | Medium |
| Micronutrients | Manganese | Meq/100g | 1.576 | Very low |
| | Iron | ppm | 0.100 | low |
| | Copper | ppm | 2.0 | Normal |
| | Mn | ppm | 33.4 | High |
| | Zinc | ppm | 13.8 | High |

**Table 4.Chemical characteristics and Soil major nutrient content in pepper crop cycle.**

| | **pH** | | | **EC m mhos/cm** | | | **M.O %** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **DAP** | | | **DAP** | | | **DAP** | | |
| | **35** | **45** | **92** | **35** | **45** | **92** | **35** | **45** | **92** |
| $T_C$ | 8.230 a | 8.238ab | 7.683b | 0.246 a | 0.422a | 1.293a | 1.934a | 1.828b | 2.190a |
| $T_{NPK}$ | 8.465 a | 8.170 b | 7.783a | 0.218 a | 0.390a | 0.418b | 1.663b | 1.777c | 1.663b |
| $T_{NP+K}$ | 8.335 a | 8.253a | 7.730b | 0.217 a | 0.476a | 0.563b | 1.774a | 1.897b | 1.775b |
| $T_{N+P+K}$ | 8.310 a | 8.273a | 7.803a | 0.254 a | 0.394a | 0.950b | 1.793a | 1.916a | 1.793a b |
| | N % | | | $P_2O_5$ % | | | $K_2O$(meq/100g) | | |
| $T_C$ | 0.16a | 0.17a | 0.18a | 0.280 a | 0.200a | 0.323a | 0.189b | 0.832a | 3.485b |
| $T_{NPK}$ | 0.12b | 0.12b | 0.14b | 0.193c | 0.246a | 0.298b | 0.168b | 0.715b | 3.857a |
| $T_{NP+K}$ | 0.15a | 0.17a | 0.13b | 0.240ab | 0.255a | 0.303b | 0.247a | 0.721b | 3.729a |
| $T_{N+P+K}$ | 0.14a | 0.14b | 0.13b | 0.205bc | 0.206a | 0.275b | 0.198a | 0.694b | 3.282b |
| | Ca (meq/100g) | | | Mg (meq/100g) | | | Fe (ppm) | | |
| $T_C$ | 1.391a | 1.209a | 1.911a | 1.117a | 0.296a | 1.260a | 13.671a | 8.080a | 21.930a |
| $T_{NPK}$ | 1.752a | 1.381a | 1.566ab | 1.165a | 0.371a | 1.159ab | 14.648a | 7.968a | 21.640a |
| $T_{NP+K}$ | 1.984a | 1.323a | 1.128ab | 1.043a | 0.428a | 0.978ab | 16.280a | 8.750a | 24.530a |
| $T_{N+P+K}$ | 1.674a | 1.152a | 1.034b | 1.043a | 0.465a | 0.690b | 17.900a | 9.651a | 21.930a |

DAP, days after plantation; N, Total N%.

The electrical conductivity of the soil increased from 0.33-1.29 m mhos/cm with compost application. This increase can be explained by the accumulation of minerals in the ground at 45 DAP (Eghball et al., 2004). The treatment $COF_{N+P+K}$ is the lowest (0.42 mmhos/ cm). As for statistical analysis, it showed no significant difference between treatments. A significant difference in N parentage, which ranged between (0.126%- 0.169%), was observed. Highest value of N parentage was recorded when adding compost (0.175%), and the lowest value of N was observed in the $COF_{NPK}$ (0.126%). It might be due to the direct addition of N from the decomposition of organic matter leads to mineralization of organic fertilizers. This result was in agreement with Baishya et al. (2015) who observed that organic nitrogen content in soil was directly correlated to the organic matter application.

An increase of soil available P was recorded during the crop cycle. As for the compost, this level decreased between the 30 and 45 DAP and increased to the higher value (0.32 ‰) at the 92 DAP. We can explain this increase by changing the amount of P in each fertilizer by the needs of culture that differ from one crop stage to another. As for statistical analysis, it did not detect any significant difference between treatments. In accordance to the statement of Gupta et al. (2004); it's likely due to the effect of alkaline soil pH that caused the formation of more stable (less soluble) minerals through reactions with calcium (Ca). In case of soil exchangeable K, there is no significant difference among treatments, in general evolution of soil exchangeable K followed the same tendency in all treatments. Addition of compost was demonstrated to increase soil available P and K (Zhong et al., 2007; Saleem et al, 2017). This finding is in accordance with the report published by Ann (2012) which states that the pepper crop only requires 265 kg/ha of K in order to sustain the growth and production of pepper.

According to statistical analysis there is a significant difference between treatments in terms of soil exchangeable Ca at the third crop stage and all treatments followed the same tendency over crop cycle. An increase of soil exchangeable Ca was observed at the second stage due to high amount released by compost and commercial fertilizer over crop cycle. The high amount of soil exchangeable Ca recorded during all crop cycle and in different treatments can have different explanation, either by the decrease of pH which made Ca in soil more available (Lim et al., 2015) or the high amount of Ca in compost (7.38%) and commercial fertilizer COF N + P + K (7.15%) used.

**Table 5.Effect of organic fertilizer on foliar pepper nutriment at end of the crop cycle**

| **Treatments** | **N (%)** | **P (%)** | **K (%)** | **Ca (%)** | **Mg (ppm)** | **Zn (ppm)** |
|---|---|---|---|---|---|---|
| $T_c$ | 4.73 ab | 0.50 a | 3.51 a | 2.55 a | 0.18 a | 22.34a |
| $T_{NPK}$ | 4.66 b | 0.49 a | 3.11 a | 2.52 a | 0.17 a | 21.47 a |
| $T_{NP+K}$ | 4.76ab | 0.51 a | 3.22 a | 2.46 a | 0.18 a | 26.54 a |
| $T_{N+P+K}$ | 4.84 a | 0.49 a | 3.06 a | 2.47 a | 0.16 a | 18.00 a |

N, total nitrogen; P, available phosphors; K, potassium; Na, sodium; Zn, zinc; Ca, calcium; Mg, magnesium

**Table 6. Number of fruits of peppers plant-1 under different fertilizer treatments**

| Treatment | 60 DAP | 80DAP | 100 DAP | 120 DAP |
|---|---|---|---|---|
| $T_c$ | 4.82ab | 9.55b | 9.05ab | 6.70a |
| $T_{NPK}$ | 3.95b | 5.40c | 5.70c | 3.90b |
| $T_{NP+K}$ | 4.32ab | 6.60c | 7.60c | 6.45a |
| $T_{N+P+K}$ | 5.10a | 10.88a | 9.18a | 7.20a |

DAP, days after planting.

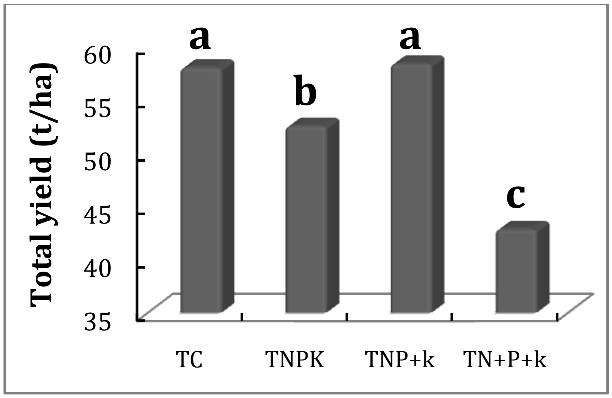


**Fig. 1. Pepper yield under different fertilizer treatments.**

The evolution of soil exchangeable Mg follows the same tendency in all treatments. The amounts of exchangeable Mg recorded over crop cycle in all treatments were between 1.57 to 0.38 meq $100g^{-1}$. At the second stage compost (1.26 meq $100g^{-1}$) is significantly higher than the COF $_{N+P+K}$ with 0.68 meq $100g^{-1}$. This high content of exchangeable Mg in the soil can be linked to the antagonism effect of high content of P soil which blocks Mg absorption by plants.

### 3.2. Foliage Nutrient Contents

The foliar analyses were done to confirm soil analysis results, and according to foliar analysis results and field observation we did not record any deficiency in terms of N and P in all treatments higher than the norms recommended by Reuter and Robinson (1995). According to statistical analysis there is no significant difference between treatments in terms of total N and P content in leaves at harvesting period. Total P content in plant leaves was high in all treatments and this can be explained by the high absorption of P by plant. In case of K content in plant leaves, no significant difference between treatments was recorded, the same remark for total Ca content in leaves (Table 5).

### 3.3. Yield Quality

All measured parameters gave highly significant differences ($P\leq 0.01$) between treatments. Pepper yield was positively affected by organic fertilizers application (Abul-Soud et al., 2014). Compost and COF $_{NP+K}$ gave the highest yield parameters compared to other treatments. COF $_{N+P+K}$ gave the highest values of number of fruits/plant (30 fruits; Table 6), and the compost gave the highest value of fruits yield (58 ton $ha^{-1}$).

The performance of conventional pepper was 80 t $ha^{-1}$ (Elattir et al, 2003) so 30% more than compost. Compost increased fruits yield by (26%) as compared to the $T_{NP+K}$. The lowest values of pepper yield parameters were obtained with the $T_{NP+K}$ (42 $tonha^{-1}$; Fig. 1). The established results are in good agreement with which states that the yield of pepper when fertilized with compost can reach 60 ton $ha^{-1}$.

Significant difference was recorded between the average heights of pepper under different treatments. Plant height in the treatment $COF_{NP+K}$ was highest (87.67 cm), and significantly higher than the other treatments (compost, $COF_{NPK}$ and $COF_{N+P+k}$). At 80 DAP, the difference between $COF_{NP+K}$ and $COF_{N+P+K}$ becomes insignificant. After 120 DAP, plants supplemented with $COF_{NP+K}$ gave the highest value of height plants (113 cm) compared with the other treatments. The compost gave the lowest value (105 cm; Table 7).

**Table 7. Temporal changes in plant height of peppers under different fertilizer treatments**

| Treatment | 60 DAP | 80DAP | 100 DAP | 120 DAP |
|---|---|---|---|---|
| $T_c$ | 79.20b | 95.55a | 105.83a | 110.47a |
| $T_{NPK}$ | 77.83b | 90.90b | 99.63b | 105.85b |
| $T_{NP+K}$ | 78.60b | 92.85ab | 100.13b | 110.08ab |
| $T_{N+P+K}$ | 87.67a | 95.60a | 106.35a | 113.38a |

DAP, days after planting

## 4. Conclusion

Based on obtained results about the effect of compost and commercial organic fertilizer on soil fertility, growth and yield of pepper grown under greenhouse in Souss Massa we concluded that the soil pH was improved significantly under treatment $T_C$, due to high amount of compost applied in this treatment. Application of compost lead to significant increase in soil organic matter content, and this will improve long term soil fertility. Soil P and K contents increased in all treatments with significant differences among the treatments. The highest yield (58 $tha^{-1}$) of pepper was recorded under treatment where compost was applied, followed by treatment $COF_{NP+K}$ (57 $tha^{-1}$) than $COF_{NPK}$(52 $tha^{-1}$), whereas the lowest yield was recorded under $COF_{N+P+K}$ (42 $tha^{-1}$).Although difference between treatments in terms of available Mg and Ca remained non-significant, however, this might have long term implication. Concerning fruit quality, non-significant difference was recorded between treatments in the studied year.

**List of Abbreviations:** COF, commercial organic fertilizer; DAP, days after planting; EC, electrical conductivity.

**Acknowledgements:** Authors wish to acknowledge efforts of reviewers and editor for their valuable comments to improve the manuscript.

**Conflict of Interest:** The authors have declared no conflicts of interests

**Authors Contribution:** All the authors have contributed significantly and equally in preparation of this manuscript.

## References

Abahous, H., J. Ronchail, A. Sifeddine, L. Kenny and L. Bouchaou. 2018. Trend and change point analyses of annual precipitation in the Souss-Massa Region in Morocco during 1932–2010. Theor. Appl. Climatol. https://doi.org/10.1007/s00704-017-2325-0.

Abul-Soud, M., **M. A.** Abdrabbo, A.A Farag. 2014. Increasing Soil Organic Matter Content as a Key Factor for Sustainable Production of Sweet Pepper. Int. J. PlantSoilSci. 3 (6): 707-723.

Alaoui, S.B. 2009. Organic farming in the world, and case study of Morocco.In: Symposium international Gestion intégrée des ressources en eau et en sol et durabilité des systèmes de culture en sone Méditerranée (AGDUMED), Rabat 14-16 May, 2009, p. 311-313.

Ann, Y.C. 2012. Impact of different fertilization methods on the soil, yield and growth performance of black pepper (*Piper nigrum* L.). Malaysian J. Soil Sci.16: 69-84.

Ata-Ul-Karim, S.T., Q. Cao, Y. Zhu, L. Tang, M.I.A. Rehmani and W. Cao. 2016. Non-destructive assessment of plant nitrogen parameters using leaf chlorophyll measurements in rice. Front. Plant Sci. 7(1829).

Ata-Ul-Karim, S.T., Y. Zhu, Q. Cao, M.I.A. Rehmani, W. Cao and L. Tang. 2017. In-season assessment of grain protein and amylose content in rice using critical nitrogen dilution curve. Europ. J. Agron. 90: 139-151.

Baishya, k. 2015.Impact of agrochemicals application on soil quality degradation—a review. Int. J. Sci. Technol. Manag. 4 (1) 220-228.

Black, C.A. 1965. Methods of Soil Analysis: Part I, Physical and Mineralogical Properties. Soc.Of Agron. Madison, Wisconsin, U.S.A.1149 p.

Clune, S., E. Crossin and K. Verghese. 2017. Systematic review of greenhouse gas emissions for 409 different fresh food categories. J. Clean Prod.140: 766-783.

Dhaliwal, M.S., S.P. Sharma, S.K. Jindal, L.K. Dhaliwal and A.K. Gaikwad. 2017. Growth and yield of bell pepper as influenced by growing environment, mulch, and planting date. J. Crop Improv. 31(6): 830-846.

Dordas, C. 2008. Role of nutrients in controlling plant diseases in sustainable agriculture. A review. Agron. Sustain. Develop. 28(1): 33-46.

Dotaniya, M.L. and V.D. Meena. 2015. Rhizosphere Effect on Nutrient Availability in Soil and Its Uptake by Plants: A Review. Proc. Nat. Acad. Sci. India Section B: Biol. Sci. 85(1): 1-12.

Eghball, B., D. Ginting and J.E. Gilley. 2004. Residual effects of manure and compost applications on corn production and soil properties joint contribution of USDA-ARS and University of Nebraska. Agron J. 96:442-447.

Elattir, H., A. Skiredj and A. Elfadl. 2003. Transfert de technologie en agriculture, Fiche technique 5: la tomate, l'aubergine, le poivron, le gombo. Bulletin mensuel d'information et de liaison du PNTTA. Ministère de l'Agriculture et du développement rural.

Franco-Otero, V.G., P.Soler-Rovira, D. Hernández et al., 2012. Short-term effects of organic municipal wastes on wheat yield, microbial biomass, microbial activity, and chemical properties of soil. Biol. Fert. Soils. 48(2): 205-216.

Gaskell, M., R.J. Smith, S.Mitchell, T. Koike, C.Fouche, T. Hartz, W. Horwath and L. Jackson. 2007. Soil fertility management for organic crops. University of California Davis Publication. 7249. DOI: https://doi.org/10.3733/ucanr.7249

Griffin ,T., C. Honeycutt and Z. He.2002. Effects of temperature, soil water status, and soil type on swine slurry nitrogen transformations. Biol. Fert. Soils. 36:442–446

Gupta, A., R. Antil and R. Narwal. 2004 .Utilization of deoiled castor cake for crop production. Arch. Agron. Soil Sci. 50(7):389-395.

Gutser, R., T. Ebertseder, A. Weber, M. Schraml and U. Schmidhalter. 2005. Short-term and residual availability of nitrogen after long-term application of organic fertilizers on arable land. J. Plant Nutr. Soil Sci. 168(4): 439-446.

Huez, M., A. Ulery, Z. Samani, G. Picchioni and R. Flynn. 2011. Response of chile pepper (*Capsicum annuum* L.) to salt stress and organic and inorganic nitrogen sources: I. growth and yield. Tropical Subtropical Agroecosyst. 14: 137-147.

Islam,M., S. Islam, A. Akter, M.H. Rahman and D. Nandwani. 2017. Effect of organic and inorganic fertilizers on soil properties and the growth, yield and quality of tomato in Mymensingh, Bangladesh. Agriculture. 7: 18.

Jackson, M.L. 1958. Soil Chemicals Analysis. Prentice-Hall, Inc. Englewood Cliffs, NJ. p. 498

Jarousseau, H., T. Wassenaar,B. Sallote and J.M.Paillat. 2016. Waste recycling and social dynamics in the transition from rural to the peri-urban in Reunion Island. Cah. Agric. 25(6): 65002. (In French with English Abstract).

Jin, K., P.J. White, W.R. Whalley, J. Shen and L. Shi. 2017. Shaping an optimal soil by root–soil interaction. Trends Plant Sci. 22(10): 823-829.

Kchaou, R., R. Baccar, Y. Hidri, K. Harbaoui, J.Bouzid and S. Rejeb. 2018. Growth and Yield of Triticale Plants Amended with Sewage Sludge Under Sub-humid Mediterranean Conditions. In: Kallel A., Ksibi M., Ben Dhia H., Khélifi N. (eds) Recent Advances in Environmental Science from the Euro-Mediterranean and Surrounding Regions. EMCEI 2017.Advances in Science, Technology & Innovation (IEREK Interdisciplinary Series for Sustainable Development). Springer, Cham. DOI: https://doi.org/10.1007/978-3-319-70548-4_114

Lim, P.N., T.Y. Wu, C. Clarke and N.N.N. Daud. 2015. A potential bioconversion of empty fruit bunches into organic fertilizer using *Eudrilus eugeniae*. Int. J. Environ. Sci. Technol. 12:2533-2544.

Lindsay, W.L. and W.A. Norvell. 1978. Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil Sci. Soc. Am. Jl. 42: 421-428.

Miao, Y., B.A. Stewart and F. Zhang. 2011. Long-term experiments for sustainable nutrient management in China. A review. Agron. Sustain. Develop. 31(2): 397-414.

Murphy, C.J., E.M. Baggs, N. Morley, D.P. Wall and E. Paterson. 2017. Nitrogen availability alters rhizosphere processes mediating soil organic matter mineralisation. Plant Soil. 417(1): 499-510.

Olmo, M., R. Villar, P. Salazar and J.A. Alburquerque. 2016. Changes in soil nutrient availability explain biochar's impact on wheat root development. Plant Soil. 399(1): 333-343.

Pang, X.P., and J. Letey. 2000. Organic farming challenge of timing nitrogen availability to crop nitrogen requirements. Soil Sci. Soc. Am. J. 64:247-253.

Rekani, O., H.Ameen and S. Ahmed. 2017. Effect of different potting mixes on germination and vegetative growth of sweet pepper plant (*Capsicum annum* L.) under greenhouse conditions. Sci. J. Uni. Zakho. 4(2): 187-193.

Reuter, D. J. and J.B. Robinson. 1995. Plant Analysis: an Interpretation Manual. 2 Ed. Australian Soil and Plant analysis council (ASPAC), Melbourne.

Saleem, A., M. Irshad, H. Amjad, M.Qaisar and A. Eneji. 2017. Extractability and bioavailability of phosphorus in soils amended with poultry manure co-composted with crop wastes. J. Soil Sci. Plant Nutr. 17 (3): 609-623.

Schulz, O., H. Busche and A. Benbouziane. 2008. Decadal Precipitation Variances and Reservoir Inflow in the Semi-Arid Upper Drâa Basin (South-Eastern Morocco). In: Zereini, F., Hötzl, H. (Eds.), Climatic Changes and Water Resources in the Middle East and North Africa. Springer Berlin Heidelberg, Berlin, Heidelberg, p. 165-178.

Scotti, R., C. Pane, R. Spaccini, A.M. Palese, A. Piccolo, G. Celano and M.Zaccardelli. 2016. On-farm compost: a useful tool to improve soil quality under intensive farming systems. Appl. Soil Ecol. 107: 13–23.

Serret, M.D., S. Yousfi, R. Vicente, M.C. Piñero, G. Otálora-Alcón, F.M. del Amor and J.L. Araus. 2018. Interactive Effects of $CO_2$ concentration and water regime on stable isotope signatures, nitrogen assimilation and growth in sweet pepper. Front. Plant Sci. 8:2180.

Smith, S.H. 2015. In the shadow of a pepper-centric historiography: Understanding the global diffusion of capsicums in the sixteenth and seventeenth centuries. J. Ethnopharmacol. 167: 64-77.

Szafirowska, A. and E. Krystyna. 2009. Yielding and fruit quality of three sweet pepper cultivars from organic and conventional cultivation. Veg. Crop. Res. Bull. 69: 135-143.

Valentin, C., P.Bacal, and B. lurie .2017.The pressure of natural and anthropogenic factors on the status of soil from central development region. Present Environ. Sust. Develop. 11(1): 163-171.

Wang, Y., C.R. Jensen and F. Liu. 2017. Nutritional responses to soil drying and rewetting cycles under partial root-zone drying irrigation. Agric. Water Manage. 179: 254-259.

Wieder, W.R., C.C. Cleveland, W.K. Smith and K. Todd-Brown. 2015. Future productivity and carbon storage limited by terrestrial nutrient availability. Nature Geoscience. 8: 441.

Zechmeister-Boltenstern, S., K.M. Keiblinger, M. Mooshammer, J. Peñuelas, A. Richter, J. Sardans and W. Wanek. 2015. The application of ecological stoichiometry to plant–microbial–soil organic matter transformations. Ecol. Monogr. 85(2): 133-155.

Zhong, W. H., Z. C. Cai and H. Zhang. 2007. Effects of long-term application of inorganic fertilizers on biochemical properties of a rice-planting red soil. Pedosphere. 17(4): 419–428..