Original research Articles

Response of maize to the integrated use of date palm compost and mineral-N fertilizer

ABSTRACT

The study aimed to assess the effect-combined use different of date palm composts amended with ligno-cellulolytic fungi and mineral-N on growth and N, P and K-uptake of maize plants in sandy calcareous soil. Each type of compost was applied either in organic form in dose equivalent to 100% of N fertilization (285 kg ha^{-1}) or in organic form in combination with mineral-N (50% for each). The experiment was constructed in a complete randomized block design (CRBD). Results showed that plant height and dry weight of shoot and root of maize significantly increased as a result of the combined use of compost with mineral-N (1:1, w:w). All types of composts combined with half-dose of mineral-N was effective, however, compost that contained with *Aspergillus niger* + *A. subsessilis* + *Trichoderma lanuginosus* + *Bacillus* sp. was the best. This type of fertilization increased N-uptake shoot and root of maize more than mineral N-fertilizer by 39.73%-49%. In addition, the P-uptake by shoot and root of maize increased by 58.82%-156%. The addition of compost treatments to the soil increased the total N, P and K after harvesting. Regression analysis showed positive and significant linear correlation between the application rate of compost and the availability of P and K in soil.

Keywords: Maize, compost, fertilizer, sandy calcareous soil, fungi, *Aspergillus*

1. INTRODUCTION

Reclamation of new lands is a strategic choice for many governments to fill the gap of food production resulting from the steady increase in population. However, the new reclaimed soil, especially, sandy calcareous soil is usually deficient in organic matter such as nitrogen, phosphorus and micronutrients [1]. Therefore, the chemical fertilizers were intensively used; however, they increased the pollution of soil, water and food.

Using the agricultural wastes as soil amendments on farmland instead of burning them is an attractive alternative because it allows for some cost recovery, improves soil physical properties and recycles the carbon into the soil [2]. The natural way to recycle the agricultural wastes is so-called composting [3]. Addition of compost enhances soil fertility and quality that brings about increasing the productivity, improving biodiversity, reduction the ecological risks and a better environment [4,5]. In addition to its providing with organic matter, compost decreases bulk density and erosion of the soil. It increases aggregate stability, aeration, water infiltration and retention [6,7]. It increases concentrations and availability of micro and macro nutrients [8,9], providing a wider range of nutrients than inorganic fertilizers, with less nitrate leaching and water contamination [10, 11].

Abundance of the raw agricultural waste that is ready to make compost is an important factor that makes the composting process is sustainable and economic. Egypt is famous for a huge number of date palm trees. There is more than seven million of date palm trees distributed allover Egyptian latitude. Large quantity of date palm residues (DPR) comprises a great problem that leads to different environmental pollution. Disposal of such quantities could solve potential pollution problems and result in loss of relatively valuable resources, suitable for meeting a variety of national needs. Compost is considered as a suitable mean for disposal and recycling such large quantities of wastes.

Adding microorganisms to speed up composting and increase the nitrogen content in the waste to improve the degradation process was reported [12,13]. Many studies focused on a single nutritional indicator such as total nitrogen or total phosphorus, however, few studies investigated the effects of microbes on the composting waste with a complete evaluation of nutrient status and the availability of total nitrogen, phosphorus and potassium [14]. Microorganisms such as bacteria, fungi and actinomycetes involve in composting process require carbon for growth and energy, and nitrogen for protein synthesis. Thus, C/N ratio is considered the most important aspects of composting [15,16]. Enrichment of compost with biofertilizers (microorganisms) and organic amendments that accelerate the composting process is very important. Requena et al. [17] found that the incubation of turnip compost with ligno-cellulolytic microorganisms (*Trichoderma viride* or *Bacillus* sp.) increased the degree of humification of organic matter and improve its quality as soil amendments. Tengerdy and Szakacs [18] reported that enrichment of the process of ligno-cellulose composting with *Aspergillus* and *Trichoderma* strains greatly increased the availability of different nutrients as compared with control (non inoculated treatment).

Therefore, the aim of this study was to investigate the effect of the combined use of four types of date palm composts amended with lingo-cellulolytic fungi and mineral-N on growth and NPK-uptake of maize plants grown on sandy calcareous soil.

2. MATERIALS AND METHODS

2.1 Preparation of compost

2.1.1. Microorganisms

Aspergillus niger (AUSB-27401), *Aspergillus subsessilis* (AUSB-27402) and *Thermomyces lanuginosus* (AUSB-27103) were isolated from date palm residues on potato dextrose agar medium (PDA) at 28˚C, 45˚C and 45˚C, respectively. *Bacillus* sp. (AUSB-27104) was isolated from the same material on nutrient agar at 45˚C.

2.1.2. Preparation of the inocula

The inocula of *A. niger, A. subsessilis* and *Thermomyces lanuginosus* were prepared by inoculation of sterilized wheat bran with 3-days old cultures of these fungi, separately, under aseptic condition. The inoculated wheat bran was incubated at 28˚C in case of *A. niger* and at 45˚C in case of *A. subsessilis* and *Thermomyces lanuginosus* for 5 days. Inoculum of *Bacillus* sp. was prepared by inoculation of sterilized nutrient broth for 48 hours at 45˚C under aseptic condition.

2.1.3. Preparation of composted heaps

Raw shredded date palm residues (DPR) was enriched with water before formulating the heaps and arranged in composting beds (1 m^2). Each heap weighed 210 kg. DPR was mixed with chicken manure (CM) and farm yard manure (FYM) in a ratio of 1:1:4 (w:w:w). Inoculum potential of *A. niger, A. subsessilis* and *Thermomyces lanuginosus* was 10^4 cfu/g and was 10^6 cfu/g in case of *Bacillus* sp. Primarily screening to select the appropriate inocula to carry out composting process was designed. A combination between raw materials and microorganisms were constructed. During composting, materials were manually mixed every week throughout the composting period for air circulation and temperature homogeneity. Three composite samples of each heap were taken every 15 days to determine the chemical properties. The moisture levels of the heaps were measured gravimetrically every week and appropriate amount of water was sprinkled onto the heap to increase the moisture content to 60%.

2.2. Pot experiment

The pot experiment was carried out in greenhouse of Assiut Agricultural Research Station. The experiment was set using four composts as the following:

Compost A: DPR + CM + FYM + *A. niger* + *A. subsessilis* + *T. lanuginosus* + *Bacillus* sp.

Compost B: DPR + CM + FYM + *A. subsessilis* + *T. lanuginosus*.

Compost C: DPR + CM + FYM + *A. niger* +*T. lanuginosus* + *Bacillus* sp.

Compost D: DPR + CM + FYM + *A. subsessilis* + *Bacillus* sp.

The selected composts were applied in two forms: 1) complete organic form, in which the dose was estimated to be equivalent to 100% of N fertilization (285 kg ha^{-1}), and 2) mixed form, in which the compost was mixed with mineral N in 1:1 (w:w). Sandy calcareous soil was soil was used in all experiments. The pot experiment was designed with 9 treatments in a complete randomized block design (CRBD). It is applied 10 replicates. Treatments were as the following:

T1: Recommended dose of N (285 kg ha^{-1})

T2: (compost-A) 100% N

T3: (compost-A) 50% N + 50% (mineral-N)

T4: (compost-B) 100% N

T5: (compost-B) 50% N + 50% (mineral- N)

T6: (compost-C) 100% N

T7: (compost-C) 50% N + 50% (mineral- N)

T8: (compost-D) 100% N

T9: (compost-D) 50% N + 50% (mineral- N)

Maize (*Zea maize*) was used as a test plant in summer season to study the effect of the prepared composts on plant growth and nutrient uptake as well as nutrient content in the soil after harvesting. Soils were dried and placed in plastic bags (5 kg soil). The selected composts were mixed carefully with the soil. Ammonium sulphate (205 g N kg^{-1}) was used as a source of mineral-N after 15 days from sowing. Five seeds of maize were sown in each pot. Plants were then irrigated to the field capacity. Plant samples were taken after 60 days from planting. Fresh and dry weights were determined. Then, plants were properly dried at 70˚c for 72 hours, ground and prepared for analysis as described by Jackson [19].

2.3. Compost analysis

Compost samples were dried at 70˚C to constant weight ground. Values of pH were determined in (1:10) [compost: water] suspension using glass electrode pH meter. Electrical conductivity (EC) (dSm^{-1}) was determined in 1:10 [compost: water] extract as described by Jackson [19]. The organic matter (OM.) content of the compost was analyzed by weight loss on ignition at 430˚C for 24h and total organic carbon (TOC) was calculated from (OM) to the following equations by Navarro [20].

$$OM = [(W_{105} – W_{430}) / W_{105}] \times 100$$

W_{105} = oven dry weight of mass at 105˚C

W_{430} = furnace dry weight of mass at 430˚C

$$\% TOC = 0.51 \times \% O.M + 0.48$$, where

W_{105} = oven dry weight of mass at 105˚c

W_{430} = furnace dry weight of mass at 430˚C

Compost samples were digested using mixture of H_2O_2 and H_2SO_4. Total nitrogen was determined using the micro-kjeldahl procedure by Jackson [19]. Total phosphorus and Potassium was measured by methods of Page [21].

2.4. Soil analysis

Soil texture was mechanical analyzed as described by Piper [22]. Field capacity was determined using the method of Klute [23]. Water saturation capacity of the studied soil samples, soil pH, total calcium carbonate, organic matter content, total soluble salts according to Jackson [19]. Available phosphorus and potassium was extracted and measured [19]. Total nitrogen in soil was determined using micro Kjeldahl method [24].

2.5. Plant tissue analysis

Dried plant samples were accurately weighed and placed in a beaker for subsequent digestion. The wet ashing method using a mixture of sulphuric acid and hydrogen peroxide was followed [24]. Total nitrogen in the plant was determined using micro Kjeldahl method. Total phosphorus in plant was determined spectrometrically using the colorstannous phosphomolybdic acid method in a sulphuric acid system. Total potassium in the plant was determined by the flame photometer method [19]. Nutrient uptake by roots and shoots were calculated as:

~~Nutrient uptake root to shoot= % Nutrient (roots or shoots) / 100 × Dry (root or shoot) weight~~

Nutrient uptake in root or shoot, mg pot^{-1}= Dry weight of root or root(g) × Nutrient concentration in root or shoot (%) × 10

2.6. Statistical analysis

The obtained data were subjected to analysis of variance and LSD test was used to compare the treatment means according to the procedures outlined by Snedecor and Cochran [25].

3. RESULTS

The physical and chemical characteristics of the four types of composts are summarized in Table 1. The used soil represents sandy calcareous soil of the new reclaimed desert in east side from the River Nile. Physical and chemical characteristics of the used soil are shown in Table 2.

3.1. Parameters of plant growth

Table 3 shows the effect of different fertilization strategies on maize plants after 60 days from planting in sandy calcareous soil. The plant height and dry weight of shoots and roots significantly increased because of the combined application of compost with mineral-N. Plant height fluctuated between 56.01 cm and 80.50 cm. The minimum value of the plant height (56.10 cm) was obtained in case of applying the recommended dose of N fertilizer in organic form (T8). While, the maximum value (80.50 cm) was obtained because of applying the recommended dose of N fertilizer in both mineral and organic form (T3). The combined application of N in both organic and mineral forms increased all parameter than when the recommended dose of N was applied either in mineral form or as compost. Application of any type of compost with half recommended dose of mineral-N increased the maize shoot and root fresh and dry weights than using mineral-N fertilization or compost alone. However, using of compost as a sole source of fertilization involved in inhibition of growth of maize compared with the mineral-N fertilization. Fresh weight of the shoot increased by 96.30%, 80.46%, 30.42% and 51.28% when the mineral-N fertilizer was used in T3, T5, T7 and T9, respectively. The dry weight of shoot increased by 86.56%, 82.41%, 20.85% and 50.38%, respectively in the same treatments. Fresh weight of the root increased by 74.34%, 51.79%, 39.80% and 36.54%, respectively as a result of application of the same treatments, however, the dry weight of root increased by 77.21%, 67.95%, 13.39% and 31.91%, respectively. These results indicate that using 50% of N as compost combined with 50% of recommended dose of mineral-N resulted is preferred by the plants than single fertilization either in organic or in the mineral form.

3.2. Nutrient uptake

Concerning the total N content, the obtained data approved a significant increase in N-uptake by both shoots and roots (Table 4). The uptake ranged between 0.060 to 0.149 g pot^{-1} and 0.051 to 0.102 g pot^{-1} of shoots and roots, respectively. Using of any type of compost combined with half-dose of mineral-N achieved better results than those obtained by using the recommended dose of N-fertilizer (285 kg ha^{-1} either in mineral or organic form). The N-uptake by shoot increased over the mineral N-fertilizer by 49%, 16%, 15% and 28% in T3, T5, T7 and T9, respectively. While the N-uptake by root increased by 39.73%, 24.66%, 2.74% and 5.48% in the same treatments, respectively. The results indicated that using of any type of compost combined with half-dose of N-fertilizer significantly increased the N-uptake by shoots and roots of maize compared with either mineral-N fertilizer or compost alone.

Concerning to the total uptake of phosphorus (P), data in Table 4 show that almost similar trend that was mentioned in N-uptake by shoots and roots. Data show a significant increase in P-uptake in both shoots and roots of maize. Application of compost or compost combined with half-dose of mineral-N induced the P-uptake more than that treated with the recommended dose of mineral-N (285 kg ha^{-1}). P-uptake by shoots and roots fluctuated between 0.025 to 0.064 g pot^{-1} and 0.016 to 0.027 g pot^{-1}, respectively. Application of T3, T5, T7 and T9 increased P-uptake in shoot by 156%, 88%, 68% and 64% compared with the mineral-N fertilizer, respectively. The increase in P-uptake by the root was 58.82%, 41.18%, 11.77% and 29.41 % compared with the mineral-N fertilizer, respectively.

K-uptake accomplished a similar manner as in the total N and P-uptake (Table 4). K-uptake in shoots and roots ranged between 0.17 to 0.38 g pot^{-1} and 0.07 to 0.125 g pot^{-1}, respectively. It is clear that the addition of any compost alone or combined with half-dose of mineral-N increased the K-uptake more than application of recommended dose of mineral-N (285 kg ha^{-1}). The up taken K in shoots were 0.35, 0.38, 0.29 and 0.37 g pot^{-1} when, respectively. While in roots, the up taken K in T3, T5, T7 and T9 was 0.125, 0.121, 0.102 and 0.107 g pot^{-1}, respectively.

Analyzing the relationship between the amount of N, P and K taken up by the maize plants and the application rate of compost types using the regression analysis showed that quadratic equations were best fitted the obtained results (Fig. 1). The relationship between the rate of application of compost A, B, C and D and the amounts of N, P and K taken up by maize plants were significant ($P < 0.05$).

3.3. N, P and K-content in soil after harvest

Table 5 shows that the addition of different compost types to the soil increased the total N, available P and available K after harvesting maize plants. The total nitrogen increased by using any type of compost or compost combined with half-dose of mineral-N more than application of full recommended dose of mineral-N, however difference among the treatment was not significant. The total-N ranged between 370 to 460 mg kg^{-1}. Concerning the available P and K, results show a significant increase in the availability of both elements due to the addition of any type of compost compared with the mineral-N only. Application of compost alone in T2, T4, T6 and T8 significantly increased the available of P and K compared with application of compost combined with half-dose of mineral-N and full recommended dose of mineral-N. Available P recorded 17.57, 17.25, 18.50 and 18.72 mg kg^{-1} in T2, T4, T6 and T8, respectively. While, available K recorded 89.7, 85.8, 93.6 and 89.7 mg kg^{-1} soil in the same treatments, respectively.

Regression analysis was used to study the relationship between the applied amount of compost A, B, C and D and total N in soil. Fig. 2 shows that linear regression was the best equation fitting the relationship between the amount of compost and total N in soil ($P<0.05$), except compost A and B. The correlation coefficient for C and D was 0.619 and 0.5797, respectively. The slop of the regression lines were 16.438 and 19.459 for C and D, respectively. This means that the amounts of compost C and D required to increase the total N in soil by one unit were drastically differ within four types of compost. There was a positive linear relationship between the application rate of compost types and available P in soil (Fig. 3) when $P< 0.01$. Correlation coefficient for compost A, B, C and D was 0.8501, 0.8694, 0.9113 and 0.9380, respectively. Available K in soil increased linearly ($P<0.01$) by increasing the application rate of compost (Fig. 4). The correlation coefficient for the relationship between application rate of compost and available K was 0.7471, 0.7934, 0.8853 and 0.7962 for T3, T5, T7 and T9, respectively.

4. DISCUSSION

The significant increase in plant height and growth of maize plants as the result of application the recommended dose of N as a combined form (compost + mineral-N) could be because the compost has a high content of nutrients and biologically active enzymes as well as hormone-like substances. These substances enhance the root growth and increase the ability of root systems to explore a large volume of soil and consequently increase the amount of nutrients taken up by plant [26, 27]. Substitution of half-dose of N-fertilization by any compost increased the fresh and dry weight of the root. We assume that the superiority of compost "A" is because it contains a consortium of the four microorganisms (*A. niger* + *A. subsessilis* + *T. lanuginosus* + *Bacillus* sp.), which improved compost quality. In agreement with our results, Toumpeli [3] reported the increase in growth of maize plants because of application of organic and mineral-N fertilizers mixture. Other authors [28, 29, 30] found that the application of organic materials in combination with N-fertilizer significantly increased plant height of oil seed rape and wheat plants as compared with the untreated crops. Our results confirmed that the addition of compost in combination with half-dose of N-fertilizer to sandy calcareous soil significantly increased both fresh and dry weight of maize. These results were supported by similar findings obtained by Desoki [30] and Abdel-Wahab [31].

The results of N-uptake by maize plants, determined in shoots and roots of maize plants, reflected the vital role of organic materials to increase the nutrient uptake compared with the mineral-N fertilization. Addition of organic materials such as corn stalks, soybean straw and plant residues compost in combination with half-dose of N-fertilizer to sandy calcareous soils increased the N-uptake by wheat plants than the inorganic-N fertilizer only [29, 30, 31]. Improved nutrient uptake (especially N and K) might have increased the photosynthetic capacity of the plant [32], consequently leading to increased biomass production [33].

The results of P-uptake by shoots and roots of maize plants indicated that the treatments of compost enriched with biofertilizers (ligno-cellulolytic microorganisms) increased the P-uptake more than those receiving the recommended dose of mineral-N. The results were in agreement with those obtained by Badran [34] and Badawi [29], who pointed that the decomposition of organic materials in soil had a positive effect in solubilizing of phosphate by producing organic acids which decrease pH and increase the dissolution of bound forms of phosphate. In addition, some of hydroxy acids may chelate calcium and iron resulting in effective solubilization and utilization of phosphates. During the decomposition of the organic constituents of the compost, a lot of soluble organic acids and humic substances are released, which enhance the growth of roots and facilitate the turnover of unavailable P pools to available ones resulting in increasing the P uptake by the growing plants.

K-uptake by shoots and roots of maize plants was improved by addition of compost to the sandy calcareous soil. Our finding is supported by many others, who observed that the application of organic materials either alone or in combination with mineral-N fertilizer to soils, particularly newly reclaimed sandy soils, significantly increased the availability of nutrients (NPK) to plants that consequently increased their uptake by plants. The increases in the availability of nutrients by application of organic matter is attributed to the improved water holding capacity and cation exchange of soil [29, 30, 33]. Remarkable amount of organic acids released during the decomposition of organic fertilizer may result in desorbing the mineral-bound insoluble potassium rendering it more available for plant uptake [35, 36].

The amount of total N in soil after plant harvesting could be resulted by many processes taking place during the growth period of plants. Firstly, the decomposition of organic fertilizers has a substantially effect on increasing the amount of N in soil [37, 38]. Secondly, the high amount of total N in soil treated with organic fertilizer could be due to the enhancement of the activity of soil microorganisms that fix the atmospheric N [39].

The increased available-P could be due to the increasing in soil water holding capacity that encourages the solubility and available of nutrient as well as the retention of K by organic colloids [30]. Also, the effect of organic residues on lowering the fixation of phosphate through several mechanisms such as chelation and formation of organic compounds. These results are similar to those obtained by some authors [34, 35], who found that the addition of different kinds of organic materials to sandy calcareous and clay soils significantly increased the soil moisture retention and availability of phosphorus and potassium. They explained the increase of available-P by the production of CO_2 and thus the formation of H_2CO_3 during organic matter decomposition, which lead to phosphate solubility.

5. CONCLUSION

Our results could conclude that maize plants grown in sandy calcareous soil amended with the mixture of compost inoculated with microorganisms and mineral-N showed a significant increase in plant height, fresh and dry weights, and NPK uptake compared with those amended with mineral-N only. We assume that the improved plant growth was due to the enhancement of the physical, chemical and biological properties of the soil because of addition of compost and microorganisms. This stimulative effect may be related to good equilibrium of nutrients and water around the root medium or to the beneficial effect of bacteria on vital enzymes and hormones that induced the plant growth. We recommend using such combination of the compost containing different benefit microbes and low doses of mineral-N to enhance the plant growth and soil properties. Application of such strategy will lead to the reduction of chemical input in the biosphere and establishing the equilibrium in soil characteristic.

REFERENCES

01. Sarhadi-Sardoui J, Ronaghi A, Maftoun M, Karimian N. Growth and Chemical Composition of Corn in Three Calcareous Sandy Soils of Iran as Affected by Applied Phosphorus and Manure. J. Agric. Sci. Technol. 2003; 5: 77-84.

02. Abdel-Motaal HM. Production of organic fertilizer enriched with phosphorus from some agriculture wastes mixed with Rock phosphate. Ph.D. Thesis. Fac. Agric. Minia University 2004.

03. Toumpeli A, Pavlatou AK-V, Kostopoulou SK, Mamolos AP, Siomos AS, Kalburtji KL. Composting *Phragmites australis* Cav. plant material and compost effects on soil and tomato (*Lycopersicon esculentum* Mill.) growth. Journal of Environmental Management 2014; 128: 243-251.

04. Paradelo R, Moldes AB, Barral MT. Evolution of organic matter during the mesophilic composting of lignocellulosic winery wastes. J. Environ. Manage 2013; 116: 18-26.

05. Roca-Pérez L, Martínez C, Marcilla P, Boluda R. Composting rice straw with sewage sludge and compost effects on the soil plant system. Chemosphere 2009; 75: 781-787.

06. Serra-Wittling C, Houot S, Barriuso E. Modification of soil water retention and biological properties by municipal solid waste compost. Compost Sci. Util. 1996; 4: 44-52.

07. Ros M, Garcia C, Hernandez T. The use of urban organic wastes in the control of erosion in a semiarid Mediterranean soil. Soil Use Manage 2001; 17: 292-293.

08. Guerrero C, Gomez I, Moral R, Mataix-Solera J, Mataix-Beneyto J, Hernandez T. Reclamation of a burned forest soil with municipal waste compost: macronutrient dynamic and improved vegetation cover recovery. Bioresour. Technol. 2001; 76: 221-226.

09. Martínez F, Cuevas G, Calvo R,Walter I. Biowaste effects on soil and native plants in a semiarid ecosystem. J. Environ. Qual 2003; 32: 472-479.

10. Gagnon B, Simard RR, Robitaille R, Goulet M, Rioux R. Effect of composts and inorganic fertilizers on spring wheat growth and N uptake. Can. J. Soil Sci. 1997; 77: 487-495.

11. Mamo M, Molina JAE, Rosen CJ, Halbach TR. Nitrogen and carbon mineralization in soil amended with municipal solid waste compost. Can. J. Soil Sci.1999; 79: 535-542.

12. Vargas-Garcia MC, Suarez-Estrella F, Lopez MJ, Moreno J. Effect of inoculation in composting processes: Modification in lignocellulosic fraction. Waste Manage 2007; 27: 1099-1107.

13. He J, Jiang T, Wang D, Li J, Lv B. Effect of feeding efficient microbial community on aerobic composting of municipal waste and excrement. Int. J. Biotechnolo 2008; 10: 93-103.

14. Li LM, Ding XL, Qian KY, Ding Y, Yin ZJ. Effect of Microbial Consortia on the Composting of Pig Manure. Journal of Animal and Veterinary Advances**,** 2011; 10: 1738-1742.

15. Parr JF, Willson GB, Colacicco D. Improving soil with organic wastes municipal sludge composts. FAO Soils Bulletin, 1982; 45: 52-65.

16. Dalzell HW, Bidlestone AG, Gary KR, Thurairajan K. “Soil Management”: Compost Production and Use in Tropical and Subtropical Environments” FAO, Soil Bulletin 1987; 49.

17. Requena N, Baca TM, Azcon R. Evolution of humic substances from unripe compost during inocubation with lignolytic or cellulolytic microorganisms and effects on the lettuce growth promotion mediated by *Azotobacter chroococcum*. Biol. Fertil. Soils 1997; 24: 59-65.

18. Tengerdy RP, Szakacs G. Bioconversion of lignocellulose in solid substrate fermentation. Biochem. Eng. J. 2003; 13: 169-179.

19. Jackson ML. “Soil Chemical Analysis” Prentice-Hall of India Private Limited, New Delhi 1973.

20. Navarro AF, Cegarra J, Roig A and Garcia D. Relationships between organic matter and carbon contents of organic waste. Biore. Techn. 1993; 44: 203-207.

21. Page AL, Miller RH and keeney DR. "Methods of Soil Analysis". Π Chemical and Microbiological Properties. Amer. Soc. Agron. Inc. Bull., Madison, Wisconsin., USA. 1982.

22. Piper CS. "Soil and Plant Analysis". 1st Ed. Inter science Publishers. Inc, New York, pp. 1950; 30-229.

23. Klute A. Methods of soil analysis. Part-1. Physical and mineralogical methods. 2nd Edition American Society of Agronomy, Madison, Wisconsin, USA 1986.

24. Black CA, Evans DD, Ensminger LE, white JL, Clark FE, Dinauer RC. "Methods of Soil Analysis". Π Chemical and Microbiological Properties. Amer. Soc. Agron. Inc. Bull., Madison, Wisconsin., USA 1965.

25. Snedecor GW, Cochran WG. "Statistical Methods" 7th Ed., Iowa State Univ. Press, Amr., USA, pp. 1980; 255-269.

26. Quasi AM, Akram M, Ahmad N, Artiola JF, Tuller M. 2009. Economical and environmental implications of solid waste compost applications to agricultural fields in Punjab, Pakistan. Waste Manage 29: 2437–2445.

27. Weber J, Kocowicz A, Bekier J, Jamroz E, Tyszka R, Debicka M, Parylak D, Kordas L. The effect of a sandy soil amendment with municipal solid waste (MSW) compost on nitrogen uptake efficiency by plants. Europ. J. Agronomy 2014; 54: 54– 60.

28. Abdalla FM, Antoun GG, Attia SAM. Effect of type and rate of fertilizer and inoculation with *Azotobacter chroococcum* on growth and seed yield of rape plants. Egypt. J. Agric. Res. 1992; 70: 9-17.

29. Badawi FSF. Studies on bio-organic fertilization of wheat under newly reclaimed soils. Ph.D. Thesis, Fac. Agric., Cairo Univ., Egypt 2003.

30. Desoki AH. Recycling of some agricultural wastes and their utilization in bio-organic agriculture. Ph.D. Thesis, Dept. of Agric. Sci., Institute of Environmental Studies & Research, Ain Shams Univ., Egypt 2004.

31. Abdel-Wahab AFM. Iron-zinc-organic wastes interactions and their effects on biological nitrogen fixation in newly reclaimed soils. Ph.D. Thesis, Fac. Of Agric., Ain Shams Univ., Egypt 1999.

32. Condon AG, Richards RA, Rebetzke GJ, Farquhar GD. Improving intrinsic water-use efficiency and crop yield. Crop Science 2002; 42: 122–131.

33. Adamtey N, Cofie O, Ofosu-Budu KG, Ofosu-Anim J, Laryea KB, Forster D. Effect of N-enriched co-compost on transpiration efficiency and water-use efficiency of maize (*Zea mays* L.) under controlled irrigation. Agricultural Water Management 2010; 97: 995–1005.

34. Badran NM, Khalil MEA, El-Emam MAA. Availability of N, P and K in sandy and clay soils as affected by the addition of organic materials. Egypt. J. Soil Sci. 2000; 40: 265-283.

35. Mekail MM, Zanouny I. Evaluation of some natural organic wastes as amendments for virgin coarse textured soils. II. Residual effect of filtermud (Pressmud) and nitrogen application on some soil properties and yield of fodder maize. J. Agric. Sci., Mansoura Univ. 1998; 23: 6295-6307.

36. Elsharawy MAO, Aziz MA, Ali LKM. Effect of the application of plant residues composts on some soil properties and yield of wheat and corn plants. Egypt. J. Soil. Sci. 2003; 43: 421-434.

37. El-Etr WT, Laila KM, El-Khatib EI. Comparative effects of bio-compost and compost on growth yield and nutrients content of pea and wheat plants grown on sandy soils. Egypt. J. Agric. Res. 2004; 82: 73-94.

38. Mohamed WH, Hussein, MA. Effect of some organic fertilizers and sulphur application on root yield and nutrient uptake of sugar beet in relation to some soil tests. J. Adv. Agric. Res. (Fac. Agric. Saba Basha) 2005; 25: 3541-3558.

39. Elbordiny MM, Taha TA, El-Sebaay AS. Evaluating nitrogen fertilizer sources and scheduling for cotton. Egypt. J. Soil. Sci. 2003; 43: 435-445.

Table 1. ~~Physical~~ [A1]~~and c~~Chemical characteristics of the four used composts

Compost type	pH	EC (dsm^{-1})	% O.C	% O.M	% Total-N	C/N ratio	% Total-P	% Total-K
Compost A	9.54	8.88	18.23	34.81	1.51	12.11	0.453	1.95
Compost B	9.15	8.38	18.65	35.63	1.36	13.68	0.678	2.06
Compost C	8.82	9.91	22.89	43.96	1.60	14.31	0.489	2.47
Compost D	8.76	8.99	20.35	38.96	1.46	14.05	0.470	2.19

Table 2. Physical and chemical characteristics of used soil.

Soil Properties	Values
Particle size distribution	
Sand (%)	89.9
Silt (%)	7.1
Clay (%)	3.0
Soil texture	Sandy
Field capacity (%)	10.9
Total $CaCO_3$ (g kg^{-1})	300
EC, mmhos/cm soil water extract, 1 : 1	1.6
pH (1:1 water suspension)	8.46
Organic matter (g kg^{-1} soil)	2.4
Soluble cations ($mmol_c$ L^{-1})	
Ca^{++}	3.4
Mg^{++}	2.54
Na^{+}	9.1
K^{+}	0.96
Soluble anions ($mmol_c$ L^{-1})	
CO_3^{-} HCO_3^{-}	8.7
Cl^{-}	6.1
SO_4^{-}	1.2
Total nitrogen (mg kg^{-1})	130
Available Phosphorus (mg kg^{-1})	10.75
Available potassium (mg kg^{-1})	54.6

Table 3. Effect of different compost types on plant height, fresh weight and dry weight of roots and shoots of maize plants.

Treat-ment No.	Treatment content	Plant height (cm)	Fresh weight (g/pot)		Dry weight (g/pot)	
			Root	Shoot	Root	Shoot
T1	Recommended dose of N (285 kg ha^{-1})	67.86	42.94	44.01	7.02	7.96
T2	Compost-A (100% N)	60.90	33.47	32.44	5.89	5.55
T3	Compost-A (50% N) + (50% mineral-N)	80.50	74.86	86.39	12.44	14.85
T4	Compost-B (100% N)	61.60	38.29	34.47	6.21	6.09
T5	Compost-B (50% N) + (50% mineral-N)	76.90	65.18	79.42	11.79	14.52
T6	Compost-C (100% N)	60.80	41.58	35.24	5.95	5.77
T7	Compost-C (50% N) + (50% mineral-N)	65.10	60.03	57.40	7.96	9.62
T8	Compost-D (100% N)	56.10	52.55	37.82	7.21	6.50
T9	Compost-D (50% N) + (50% mineral-N)	61.90	58.63	66.58	9.26	11.97
	L.S.D.0.05	12.33	10.80	8.25	1.71	1.58

Compost -A= (DPR + CM + FYM + *A. niger* + *A. subsessilis* + *T. lanuginosus* + *Bacillus* sp.)

Compost -B= (DPR + CM + FYM + *A. subsessilis* + *T. lanuginosus*)

Compost- C= (DPR + CM + FYM + *A. niger* +*T. lanuginosus* + *Bacillus* sp.)

Compost -D= (DPR + CM + FYM + *A. subsessilis* + *Bacillus* sp.)

Table 4. Effect of different compost types on nutrient uptake of roots and shoots of maize plants after harvesting (60 days)

Treatment	Treatment content	Nutrient uptake (g/pot) of root			Nutrient uptake (g/pot) of shoot		
		N	P	K	N	P	K
T1	Recommended dose of N (285 kg ha^{-1})	0.073	0.017	0.070	0.10	0.025	0.17
T2	Compost-A (100% N)	0.053	0.016	0.088	0.060	0.027	0.18
T3	Compost-A (50% N) + (50% mineral-N)	0.102	0.027	0.125	0.149	0.064	0.35
T4	Compost-B (100% N)	0.054	0.018	0.091	0.062	0.032	0.20
T5	Compost-B (50% N) + (50% mineral- N)	0.091	0.024	0.121	0.116	0.047	0.38
T6	Compost-C (100% N)	0.051	0.016	0.089	0.064	0.044	0.20
T7	Compost-C (50% N) + (50% mineral- N)	0.075	0.019	0.102	0.115	0.042	0.29
T8	Compost-D (100% N)	0.062	0.018	0.099	0.073	0.047	0.22
T9	Compost-D (50% N) + (50% mineral- N)	0.077	0.022	0.107	0.128	0.041	0.37
	L.S.D.0.05	0.015	0.005	0.02	0.021	0.009	0.06 [A2]

See foot note in Table 3

Table 5. Effect of different compost types on N, P and K contents in the soil after harvesting (60 days).

Treatment	Treatment content	Nutrient concentrations in soils		
		N (mg kg^{-1})	P (mg kg^{-1})	K (mg kg^{-1})
T1	Recommended dose of N (285 kg ha^{-1})	370	4.31	39
T2	Compost-A (100% N)	460	17.57	89.7
T3	Compost-A (50% N) + (50% mineral-N)	440	11.34	50.7
T4	Compost-B (100% N)	450	17.25	85.8
T5	Compost-B (50% N) + (50% mineral- N)	420	11.16	46.8
T6	Compost-C (100% N)	450	18.50	93.6
T7	Compost-C (50% N) + (50% mineral- N)	430	10.41	54.6
T8	Compost-D (100% N)	460	18.72	89.7
T9	Compost-D (50% N) + (50% mineral- N)	440	11.04	46.8
	L.S.D. (P < 0.05)	NS*	2.72	12.09

See foot note in Table 3

*Not significant

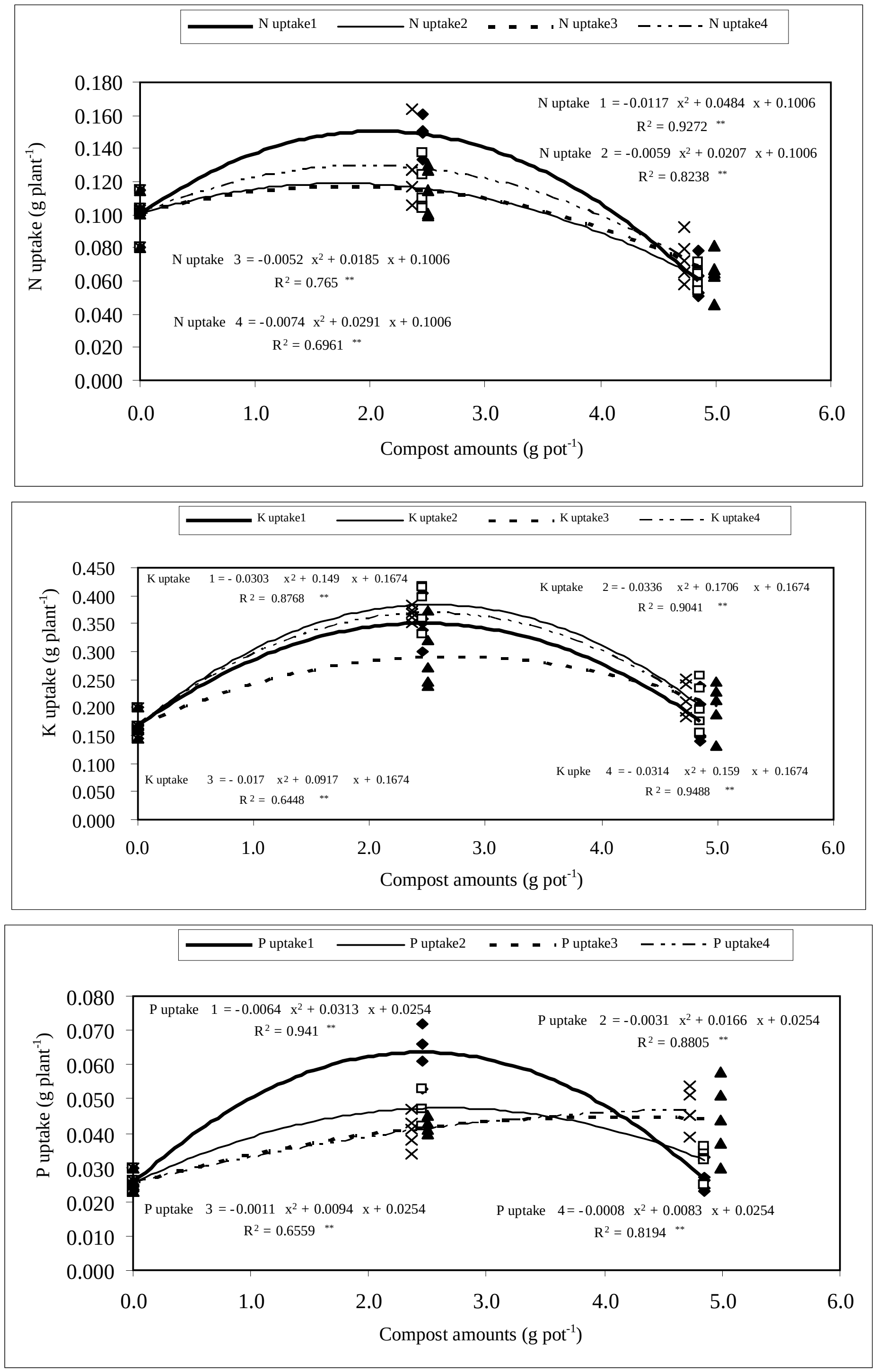

Fig. 1. Quadratic regression analysis of amount of organic fertilizers and N, P and K uptake of maize plants.

Uptake1= uptake the element in case of Compost A (DPR + CM + FYM + *A. niger* + *A. subsessilis* + *T. lanuginosus* + *Bacillus* sp.)
Uptake2= uptake the element in case of Compost B (DPR + CM + FYM + *A. subsessilis* + *T. lanuginosus*)
Uptake3= uptake the element in case of Compost C (DPR + CM + FYM + *A. niger* +*T. lanuginosus* + *Bacillus* sp.)
Uptake4= uptake the element in case of Compost D (DPR + CM + FYM + A. subsessilis + Bacillus sp.)

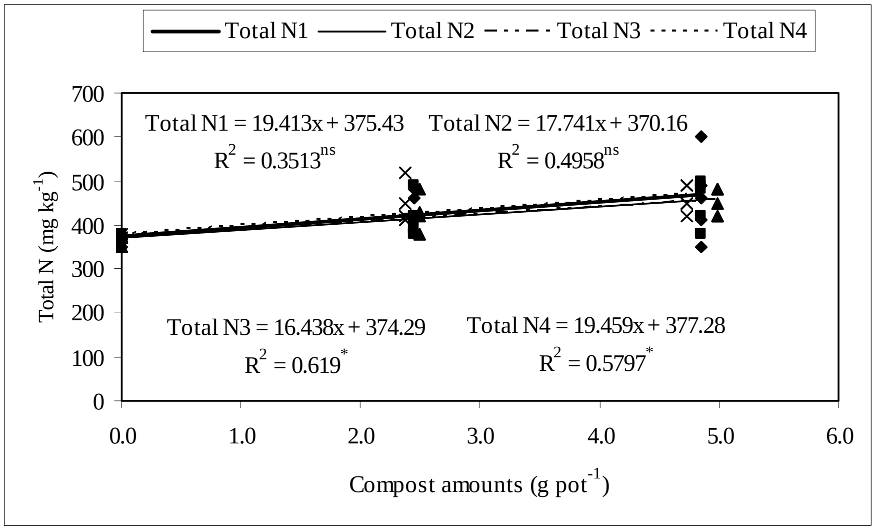

Fig. 2. Linear regression analysis of amount of organic fertilizers and total N content in soil.

Total N1= total N in case of Compost A (DPR + CM + FYM + *A. niger* + *A. subsessilis* + *T. lanuginosus* + *Bacillus* sp.)

Total N2= total N in case of Compost B (DPR + CM + FYM + *A. subsessilis* + *T. lanuginosus*)

Total N3= total N in case of Compost C (DPR + CM + FYM + *A. niger* +*T. lanuginosus* + *Bacillus* sp.)

Total N4= total N in case of Compost D (DPR + CM + FYM + A. subsessilis + Bacillus sp.)

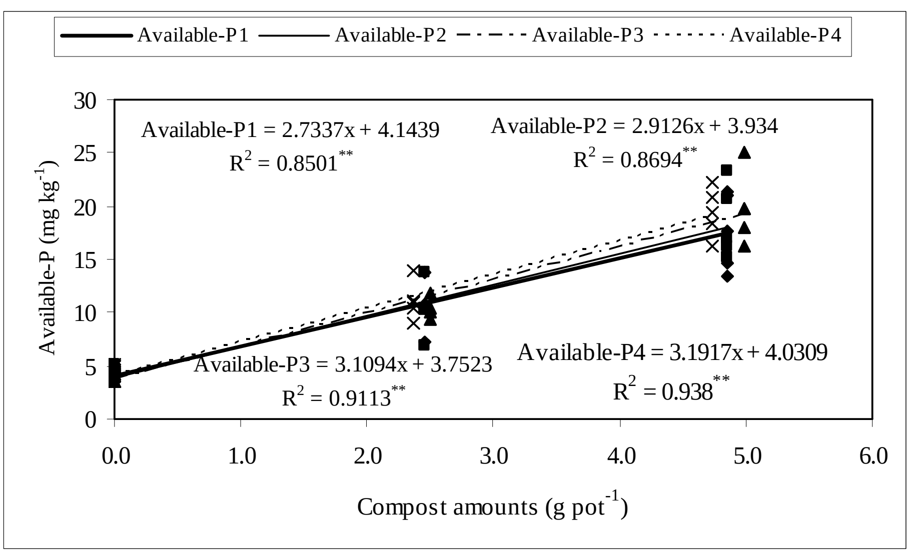

Fig. 3. Linear regression analysis of amount of organic fertilizers and available P in soil.

Available- P1= Available- P1 in case of Compost A (DPR + CM + FYM + *A. niger* + *A. subsessilis* + *T. lanuginosus* + *Bacillus* sp.)

Available- P2= Available- P2 in case of Compost B (DPR + CM + FYM + *A. subsessilis* + *T. lanuginosus*)

Available -P3= Available- P3 in case of Compost C (DPR + CM + FYM + *A. niger* +*T. lanuginosus* + *Bacillus* sp.)

Available- P4= Available -P4 in case of Compost D (DPR + CM + FYM + *A. subsessilis* + *Bacillus* sp.)

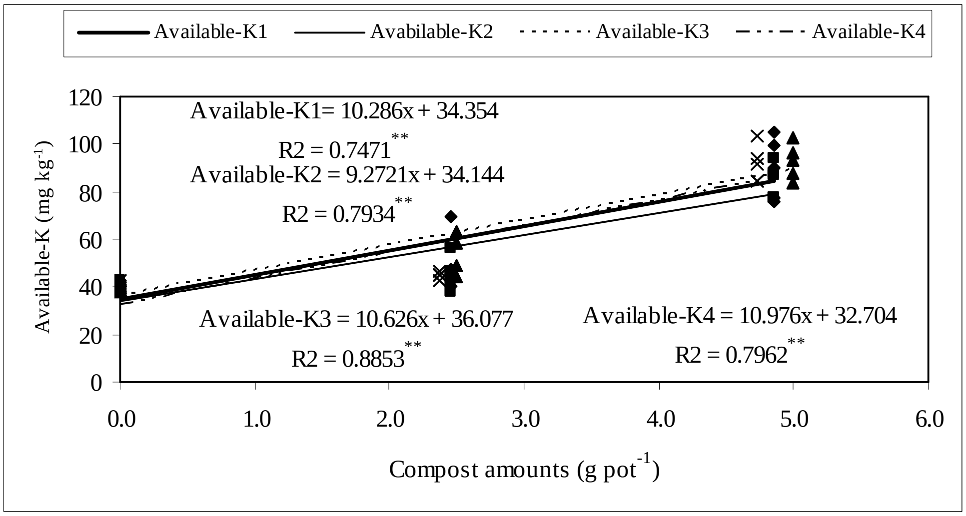

Fig. 4. Linear regression analysis of amount of organic fertilizers and available K in soil.

Available -K1= Available -K1 in case of Compost A (DPR + CM + FYM + *A. niger* + *A. subsessilis* + *T. lanuginosus* + *Bacillus* sp.)

Available -K2= Available -K2 in case of Compost B (DPR + CM + FYM + *A. subsessilis* + *T. lanuginosus*)

Available -K3= Available- K3 in case of Compost C (DPR + CM + FYM + *A. niger* +*T. lanuginosus* + *Bacillus* sp.)

Available- K4= Available- K4 in case of Compost D (DPR + CM + FYM + *A. subsessilis* + *Bacillus* sp.)