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Successive Application Impact of Some Organic Amendments Combined with Acid Producing Bacteria on Soil Properties, NPK Availability and Uptake by Some Plants

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A B S T R A C T

Three pot experiments were conducted during three successive seasons (winter 2010/2011, summer season 2011 and winter 2011/2012) in the screen house of Agricultural Experimental Farm of Department of Soils and Water, Faculty of Agricultural, South Valley University, Qena governorate, Egypt to investigate the effects of successive seasonal applications of two organic amendments (filter mud cake FYM and farmyard manure FYM) at a level of 10 ton/fed, in a combination with adding acid producing bacteria (APB) and molasses on sandy soil properties and NPK, availability, as well as growth and NPK uptakes of wheat and sorghum plants along three successive seasons. The results showed that, the successive additions of FMC and FYM to the soil combined with molasses and APB exhibited improvements in of soil chemical properties and fertility status which an increase in the soil nutrient (NPK) power supply of the soil occurred with the available N, P and K in the soil. Thus, increase in the plants dry matter yield as well as N, P and K uptakes of the wheat plants were fulfilled in the third season compared to those of the first season. More studies are needed to investigate the long term effect of successive additions of such organic treatments on soil properties and available nutrients as well as plant growth and nutrients uptake under field conditions.

Keywords

Organic amendments, Molasses, Acid producing bacteria, NPK plant uptakes.

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Introduction

The new cultivated desert soils in Egypt are very poor in their fertility due to low organic matter content. Applying an adequate amount of different fertilizers to soil is an important cultivation practice for the yield and quality of crops, environmental protection and soil sustainability (Chaney 1990; Oenema *et al.*, 2009). On the basis of sustainability, it is important to apply organic matter to the new cultivated soils because soil cultivation enhances the rate of soil degradation and decomposition of soil organic matter (Chen *et al.*, 2009; Domínguez *et al.*, 2010; Liang *et al.*, 2012).

Organic amendments improve the physical, chemical and biological properties of the soils as well as their fertility. The addition of organic wastes to these soils is a current environmental and agricultural practice for maintaining soil quality. It has a greatest effect on organic matter content and nutrient values, as well as improves the structure, water and air balance and microbiological activities of soils (Candemir and Gulser, 2007; Chaturvedi *et al.*, 2008). Therefore, the application of organic wastes to these soils that are used for crop production is of great importance for soil productivity due to their nutritional input and low costs; (Cogger *et al.,* 2004; Mantovi *et al.,* 2005; Sigua *et al.,* 2005. As the soil organic matter increases, nitrogen (N) and phosphorus (P) availability in the soil increases (Ewulo *et al.,* 2008). The organic wastes include animal manures, crop residues and industries organic wastes that are applied to soil as amendments which are important in increasing the productivity of agricultural soils of low levels of organic carbon (Adani *et al.,* 1998; Fernández Escobar *et al.,* 1996).

The microbial decomposition of the organic matter also releases organic acids and acidic products which not only lower the soil pH but also dissolve the calcium carbonate of calcareous soils (Westerman and Bicudo, 2005). Phosphate dissolving bacteria play a key role in soils through producing organic acids which convert the unavailable P form to an available one (Han and Lee, 2005).

Molasses, a byproduct of sugarcane industry, contain different nutrients that are suitable for microorganism nutrition. Molasses have been used extensively as a carbon source for the commercial production of baker's yeast (Peppler, 1979). Cane molasses also contain trace elements and vitamins, such as thiamine, riboflavin, pyridoxine, and niacinamide that they essential for plants Crueger and Crueger, (1984). Also, Shteinberg *et al.,* (1982) and Shteinberg and Datsyuk (1985) reported that the molasses contain natural growth factors for stimulating cobalamin genesis in *Achromobacter cobalamini*. So, cane molasses could be a source of growth factors at appropriate concentrations.

Lourenzi *et al.,* (2012) reported that, successive applications of pig slurry to soils can increase the nutrient levels in the uppermost soil layers and promote the migration of total N and P down to 30 cm and the translocation of the available P and K to the deepest layer. Ceretta *et al.,* (2003) found that increases in the levels of available soil P in the upper 10 cm layer as a result of application pig slurry for 48 months.

The objective of this study is to investigate the impacts of successive applications of different organic fertilizer treatments in combination with applying acid producing bacteria with and without adding molasses to a sandy soil on soil properties and nutrient availability as well as, growth, nutrient uptake of various grown plants.

Materials and Methods

Three pot experiments were carried out in the screen house of Agricultural Experimental Farm of Department of Soils and Water, Faculty of Agriculture, South Valley University, Qena, Egypt, during three successive growth seasons(winter 2010/2011, followed by summer 2011 and winter of 2011/2012) to study the effects of the successive seasonal applications of two types of organic amendments (filter mud cake and farmyard manure) at a level of 10 ton/fed, combined with applying of acid producing bacteria and molasses on the soil properties, nutrient availability of a sandy soil as well as, growth, nutrient uptake of different crop plants. Wheat (Giza 168 variety) plants were grown in the winter of the first and third seasons (2010/2011 and 2011/2012, respectively) and sorghum (*Sorghum Vulgar*) (cv. Dorado) plants were in the summer of the second season (2011).

Some physical and chemical characteristics of an experimental soil sample that was collected from the experimental farm are present in table 1.

Applied organic amendments and bacterial strains

Filter mud cake (FMC): was obtained from Quos sugarcane factory, Qena governorate, Egypt.

Farmyard manure (FYM) was taken from the Animal Production Farm, Faculty of Agriculture, South Valley University.

The chemical analysis of the farm yard manure and filter mud cake is presented in Table 2.

Molasses: were brought from Quos sugarcane factory, Qena governorate, Egypt which had pH of 5.2 and contain total Sugars 36.0 %; Nitrogen Free Extract, 4.3%; Calcium, 0.68 %, Phosphorus, 0.076 %; Potassium, 2.2 %; Sodium, 0.19 %, Sulfur, 0.47; Copper, 38 mg/kg; Iron, 163 mg/kg; Manganese, 29 mg/kg and Zinc, 16 mg/kg.

Bacterial strains

Acid producing bacteria (APB), (*Paenibacillus polymyxa*; previously *Bacillus polymyxa*) were locally isolated from Sebeya phosphate mine, Aswan governorate, Egypt (Abo-Baker, 2003).

Experimental design and treatments

The pot experiments were arranged in a completely randomized design using plastic pots of 35 cm in diameter and 40 cm in height and with a drainage hole in the bottom; each one was filled with 6 kg of the investigated soil. The different treatments that were used in these experiments are shown in table (3).

Table.1 Some physical and chemical properties of a representative sample of the studied soil

Property	Value
Sand (%)	85
Silt (%)	9
clay (%)	6
Texture	Sand
pH (1:1)	8.03
ECe(dSm^{-1})	2.2
Calcium carbonate (%)	7.52
Organic matter (%)	0.26
Total nitrogen (%)	0.013
Available P (mg kg^{-1})	6.14
Available K (mg kg^{-1})	141.5

Table.2 Chemical analysis on the dry weigh basis of the filter mud cake and farm yard manure used in the experiments

Property	Filter mud cake	Farmyard manure
pH (1:10)	6.7	7.6
EC (1:10), (dS/m)	5.6	8.6
Organic matter (%)	65.34	42.20
Organic carbon (%)	37.90	24.40
Total nitrogen (%)	2.31	1.43
C/N ratio	16.41	17.06
Total P (%)	2.51	1.33
Total K (%)	0.32	1.05

Table.3 Different treatments used in the experiments

Treatment No.	Treatment content
T0	Control
T1	Molasses
T2	APD
T3	Molasses + APD
T4	F.M.C
T5	F.M.C+ Molasses
T6	F.M.C APD
T7	F.M.C+Molasses+ APD
T8	FYM
T9	FYM + Molasses
T10	FYM + APD
T11	FYM +Molasses + APD

APB =Acid producing bacteria, (Paenibacilluspolymyxa; previously Bacillus polymyxa), FMC = Filter mud cake,andFYM = farmyard manure

Experiments

First season (winter 2010/2011)

Air - dried organic amendments of (FMCor FYM) were used at a level of 10 ton/fed (119.1 g/pot). The soil sample in each pot was thoroughly mixed with the investigated amendment and then 10 seeds of wheat were son in each pot. Twenty mL of a liquid inoculum of APB ($4x10^{7}$ cells ml^{-1}) were diluted in 1 liter of water, and then 8.5 ml of the diluted inoculum were added to the pots of APB treatments. Also, 10 ml of diluted molasses solution (50 g / L) were applied to the pots that have molasses treatments and then the pots were irrigated directly. The control treatment was done without applying any amendments. Each treatment was replicated three times. The added amount of irrigated water was adjusted to reach the field capacity using fresh water during the experiment time. All pots were thinned to 6 plants after germination. Superphosphate fertilizer (15.5% P_2O_5), was added at a level of 200 kg/fed (2.4g / pot) at the time of planting. However, Potassium sulphate 48% K_2O at a level of 50 kg/fed (0.6 g of / pot) and ammonium nitrate 33.5 % were added at a level of 364 kg/fed (4.3 g / pot) after two weeks from planting.

Second season (summer 2011)

The same pots of the previous season were retreated with the same different treatments that used in of the first season. In addition, ten seeds of sorghum (*Sorghum Vulgar*) (cv. Dorado) were sown in each pot and thinned to 6 plants after germination. The soil moisture in each pot was maintained at the field capacity during the experiment time using fresh water. Superphosphate fertilizer (15.5% P_2O_5), was added at a level of 200 kg/fed (2.4g / pot) at the time of planting. However, Potassium sulphate 48% K_2O at a level of 50 kg/fed (0.6 g of / pot) and ammonium nitrate 33.5 % were added at a level of 303 kg/fed (3.6 g / pot) after two weeks from planting.

Third season (Winter2011/2012)

All experimental treatments that were applied at the first and second seasons were also carried out for wheat planting in the third season. Ten seeds of wheat (Giza 168 variety) were planted in each pot and thinned to 6 plants per pot after germination**.** All agricultural practices that were applied in the first season were also used for wheat plants in this season. For each experiment (each season), the plants were harvested after 50 days from planting. The plants of each pot were washed using deionized water, oven-dried at 70^o C, the plant dry weight was recorded. Then, a plant sample, of each pot was mill ground and prepared for chemical analysis. Nitrogen (N), Phosphorus (P), and Potassium (K) contents of the plants samples were determined.

Soil samples were collected from the pots after harvesting the plants of each season and air-dried, passed through a 2 mm sieve and kept for soil chemical analysis. The pH, electrical conductivity (EC), organic matter content (OM%), calcium carbonate content ($CaCO_3$), N, P and K were estimated in these soil samples.

Analysis methods

Soil analysis

The particle-sizedistribution of the soil samples was carried out using the pipette method according to Jackson (1973). The organic carbon in the soil and organic wastes samples were determined using the Walkley-Black wet combustion method (Jackson, 1973) and then the soil organic matter was calculated. The calcium carbonate content of the soil samples was estimated using a collins volumetric calcimeter (Jakson, 1973). The soil pH was measured in water suspension of 1:1 soil to water ratio using a glass electrode. The electrical conductivity of the soil samples was measured in the water suspension of 1:5 soil to water ratio. The pH and EC of organic wastes were measured in water suspensions and extracts of 1:10 ratio (Schlichting *et al.*, 1995). The a ailable P in the soil samples was extracted using the $NaHCO_3$ method buffered at pH 8.5 according to Olsen *et al.*, (1954) and it was measured using the chlorostannus - phosphomolybdic acid method by spectrophotometer (Jackson, 1973). The available potassium in the soil samples was extracted using 1 N ammonium acetate at pH 7.0 and determined by flame photometer (Jackson, 1973). The total N of the soil samples was estimated using the microkjeldahl method as described by Jackson (1973). Moreover, the available nitrogen was extracted by 1% K_2SO_4 method and determined using the microkjeldahl method as described by Jackson (1973).

Plant and organic wastes analysis

Sample of 0.2 g of dried plant materials or organic wastes were digested using a 7 : 3 mixture of sulfuric to perchloric acids and then analyzed for K using the flame photometry method Jackson (1973). Phosphorous of plant samples and organic wastes digests was determined using the chlorostannous-phosphomolybdic acid (Jackson (1973). The total N of the plant samples and organic wastes was determined using the microkjeldahl method as described by Jackson (1967).

Statistical analyses

All data obtained were analyzed using MSTAT-C (Russell, 1994) and one-way analysis of variance was applied. The differences between means of the different treatments were compared using the least significant difference (L.S.D.) at 5% and 1% probability.

Results and Discussion

Effects of successive soil applications of filter mud cake (FMC) and farm yard manure (FYM) in combined with molasses or acid producing bacteria (APB) on soil properties, nutrient availability, plant growth and nutrient uptake by the tested crops. The plants along three successive seasons differently varied according to the investigated treatments.

Soil properties

The changes in the soil organic matter (OM%) content, PH, calcium carbonate ($CaCO_3$%) content and salinity (EC) induced by the investigated treatments in the three successive seasons are presented in table 4.

Organic Matter (OM %) content

The results of the first, second and third seasons showed that the sole application of FMC or FYM or in combination with molasses or APB and their mixture significantly increased the soil organic matter content compared to the control treatment (Table 4). After the first season, the soil OM% increases reached 240.1, 284.3, 362.5, 308.1, 161.7, 193.2, 318.8 and 345.0 % for T4, T5, T6, T7, T8, T9, T10 andT11treatments, respectively compared to the control (T0). However, after the second season, they were 639.57, 713.53, 839.25, 935.40, 420.53, 553.78, 524.63 and 628.74 %, respectively. Moreover, these respective treatments exhibited highly significant soil OM% increases of 1135.2, 1332.9, 1382.3, 1415.6, 977.3, 1085.2, 1223.2 and 1361.3% compared to the control after the third season.

In general, applying the investigated treatments to the soil was associated with gradual increases in the soil OM content and reached the maximum value in the third season. The OM content of the soil amended with FMC + Molasses + APB (T7) and FYM + Molasses + APB (T11) was 2.152 and 2.075% after the third season, while applying each of FMC and FYM alone recorded the lower OM values of 1.754 and 1.530 % (Fig. 1). However, the lowest values of OM content were found with the control treatment. Also, the successive application of molasses, APB individually and their mixture as well as the control (T1, T2, T3, and T4, treatments, respectively) exhibited gradual decreases in the soil O M content along three growth seasons (Fig 1).

Several investigators reported that the application of organic matter to different soils significantly increased their organic matter contents and improved the soil physical and chemical properties (Fresquez *et al.,* 1990; Rehan *et al.,* 2004; Youssef, 2011; Hadad *et al.,* 2015). Also, Rashid *et al.*, 2004 reported that, all phosphate solubilizing microorganisms (PSM) strains utilize carbon sources for production of organic acids

Soil pH

The results in table 4 clearly showed that, after harvesting wheat plants in the first season, applying all studied treatments to the soil resulted in significant decreases in the soil pH compared to both control treatment and the original soil pH (Table 1) leading to lowest soil pH values of 7.52, 7.57, 7.57 and 7.57 with FMC + APB (T6), FMC + molasses + APB (T7), FYM + APB (T10) and FYM + molasses + APB (T11), respectively. However, after harvesting sorghum plants in the second season, increases in soil pH were recorded with all treatments compared to those of the first season giving pH values of 7.95, 7.97, 7.82 and 7.97 for T6, T7, T10 and T11, respectively. On the other hand, the soil pH values of all treatments returned to decrease again after the third season under the growth of wheat plants. These reductions in the soil pH in the first and third season were more pronounced under FMC and FYM applications either alone or in combination with molasses, APB or their mixture, while the control treatment exhibited higher values (Fig. 2).

These results show that an initial reduction in the soil pH occurred after50 days of applying organic amendments and with the growing wheat of the first season. In this study, the reduction in soil pH induced by organic amendments might be attributed to increasing the partial pressure of CO2 of the soil due to the microbial activity and root exudates. Ali and Soha (2009) indicated that the soil application of bio-organic fertilizers significantly decreased the soil pH. The obtained results are also in accordance with those reported by Hassan and Mohey El-Din (2002), El-Sharawy *et al.* (2003), Rehan *et al.*, (2004), Rifaat and Negm (2004), Ewulo (2005) and Youssef (2006). However, after the second season when sorghum plants were grown the soil pH ascended in spite of reapplication of organic amendments (10 ton/fed) either alone or in associated with molasses and APB or their mixture. The increase in soil pH could be explained by the production of CO_2 and other organic acid during organic matter decomposition which react with calcium carbonate of the soil and release calcium into soil solution causing soil pH rise (Singh, *et al.,* 1981).

After the third season under growing wheat plants, the pH of soil decreased again as a result of all treatments re additions specially FMC and FYM and their combination with molasses and APB (Fig. 2). The lowest pH values (7.44 and 7.45) after the third season were recorded for FMC + molasses + APB (T7) and FYM+ molasses + APB (T11) respectively. These decreases may be due to the cumulative effect of organic acids, produced from organic matter decomposition by microorganisms. These results are in a close agreement with those found by Rehan *et al.*, (2004), Kannan *et al.*, (2005) and Okur *et al.*, (2008).

Soil calcium carbonate ($CaCO_3$) content

The successive applications of all examined different treatments resulted in significant decreases in the soil $CaCO_3$ content compared to the control in the three growth seasons (Table 4 and Fig. 3). After the first season, the decrease in the $CaCO_3$ content was from 7.52 % in the soil before wheat planting to 6.32 %

and 6.24 % in the soil amended with T7 and T11, respectively. Moreover, the decrease in the soil $CaCO_3$ content continued after the second and third season due to the investigated treatments. However, the, $CaCO_3$ reduction after the second season was greater than the third season. Thus the soil $CaCO_3$ content decreased after the second season to 5.68 % and 5.68 % for the respective T8 and T11 treatments. The application of these respective treatments after the third season exhibited more reduction of $CaCO_3$ in the soil and recorded values of 5.6 and 5.6 %.

The effect of organic amendments on the soil $CaCO_3$ is attributed mainly to the production of organic acids during the organic matter decomposition. These organic acids react with and dissolve calcium carbonate of the soil releasing calcium into soil solution (Singh *et al.,* 1981). Also, Westerman and Bicudo (2005) reported that the microbial decomposition of the organic matter also releases acidic products which not only lower the pH but also dissolve the calcium carbonate of calcareous soils.

Soil salinity

The electrical conductivity (EC) of the soil extract is considered as an indication of the soil salinity. The soil EC after the first season induced by the application of FMC (T4), FMC +Molasses (T5), FMC+APB (T6) and FMC + Molasses + APB (T7) was 1.65, 1.87, 1.81 and 1.53 ds/m, respectively. On the other hand, applying FYM (T8) FYM +Molasses (T9), FYM+APB (T10) and FYM + Molasses + APB (T11) displayed higher soil EC higher than of FMC treatments. These respective Ec values were 2.45, 2.68, 2.05 and 2.13 dS/m for the previous respective treatments, respectively. These highest values of EC in soil amended with FYM may due to the fact that FYM contains a higher EC value (8.6 ds/m) than FMC (5.6 dS/m) (Table 2). Moreover, both organic amendments (FMC and FYM) and their combinations had higher soil EC values than those when molasses, APB and Molasses + APB were solely added without using the organic amendments which recorded EC values of 1.153, 1.21 and 1.11, respectively.

Regarding, the soil EC after the second and third seasons, all treatments showed gradual decreases in the soil EC (Fig 4). That may be attributed to leaching of soluble salts with irrigation water. The produced organic acid from OM decomposition accelerates the loss of soluble salt.

Rahman *et al.*, (1996) achieved a substantially decreased EC of saline-sodic soils with the addition of different organic amendments.

However, the soil EC reached the lowest values after the third season. The soil EC values after the second season were 0.34, 0.32, 0.33, 0.41, 0.26, 0.28, 0.46 and 0.48dS/m for T4, T5, T6, T7, T8, T9, T10 and T11treatments, respectively. However, the after the third season the soil EC induced by these respective treatments were 0.23, 0.28, 0.28, 0.28, 0.25, 0.22, 0.30 and 0.29dS/m, respectively.

In this respect, the successive seasonal additions of these organic amendments and their combination treatments caused gradual decreases in the soil EC values which reached to the lowest values after the third season (Fig. 4).

Available Soil N, P and K contents

The effect of FMC and FYM materials either alone or incorporate with molasses or APB and their mixture on the available soil nitrogen, phosphorus and potassium after three successive growth seasons of wheat, sorghum and wheat plants, is in table 5.

Available soil nitrogen

The sole addition of FMC and FYM associated with molasses or APB and their mixture significantly increased the available soil N content after each growth season compared to its control treatment (Table 5). After the first season, the maximum available nitrogen values were found in soil amended with both FMC and FYM combined with molasses giving 303.97 and 288.1 mg/kg available N, respectively, compared to the control which recorded 9.3 mg /kg. However, applying FMC+molasses + APB (T7)and FYM + molasses + APB (T11)exhibited highest values of the available N of 330.4 and 323.8 mg / kg, respectively, after the second season compared to control treatment (11.01) mg/kg. Moreover, the results after third season revealed an almost similar trend as that previously obtained after the first season.

In general, the successive applications of the investigated treatments to the soil were associated with increases in the available soil N content which reached the maximum value after the second season. On the other side, a decrease in the available N content occurred after the third season (Fig 5) but the available soil nitrogen content induced by these treatments was still higher than that of the control or the added treatments without both organic amendments.

The combination impact of the organic amendment used in this investigation and molasses plus APB on the available soil N content could be due to the positive effect of this combination in improving soil physical, chemical and biological properties as a result of increasing the populations and activities of micro-organisms in the soil. Increases in the total N content of the soil were reported due to the application of organic fertilizers combined with bio-fertilizers (Maerere *et al.*, 2001; Kannan *et al.*, 2005; Das *et al.*, 2008; Sarwar *et al.,* 2008; Adeleye *et al.*,2010).

Available soil phosphorus

The available soil phosphorus significantly increased with applying type organic amendments (FMC and FYM) either alone or in combination with molasses and APB over the control (Table 4).

After the first season, the available-P in the soil amended with FMC (T4), FMC + molasses (T5), FMC +APB (T6) and FMC + molasses +APB (T7) increased from from10.07 for the control to 15.86, 19.29, 19.72 and 20.14 mg/kg, respectively and from 10.07 to19.21, 19.86, 19.86 and 20.07 mg/kg in the soil treated with FYM (T8), FYM + molasses (T9), FYM +APB (T10) and FYM + molasses +APB (T11), respectively.

A similar trend was recorded after the second season, that of the first season, which the available soil P significantly increased as a results of applying the different treatments compared to the control one (Table 5). However, the soil available P values were lower after the second season than those of the first one which they may be related to depletion of available P from the soil through its uptake by growing plants (sorghum) and its use by microorganisms and its precipitation by calcium ions released from the dissolution of $CaCO_3$ by organic acids produced from the decomposition of organic matter. Hadad *et al.*, (2015) reported that the available soil P had lowest values in the calcareous sandy soil in spite of the applied levels of some organic wastes which it may be attributed to the high fixation of the released P in the calcareous sandy soil. The soil chemical properties also play a major role for the phosphate fixation in the calcareous soil (Tekchand and Tomar, 1993).

The results after the third season showed the same trend for the available P as those obtained after the first and second ones, but soil available P increases occurred for all treatments that include FMC and FYM compared to those of the same treatments after the second season (Fig. 6).

The maximum values of available soil P of 20.36 and 22.29 mg/kg were found in the soil amended with FMC and FYM combined with molasses plus APB respectively (T7 and T11respectively). While control still displayed a lower values (7.07mg / kg).

The single treatments of molasses and APB as well as their mixture did not show significant in the available soil P among them after each growth season. However, the successive additions of FMC or FYM combined with molasses + APB improved and increased the available P resulted the highest values after the third seasons (20.36 and 22.29 mg/kg, respectively. In general, the available soil P after the three successive additions of FMC or FYM and its combinations was upper the critical level (9 mg/kg) that was recommended by Olsen and Sommers (1982).

It might be due to the released phosphorus from the organic matter decomposition as well as produced organic acids which maintain and increase the phosphorus availability in the soil. Maerere *et al.,* 2001 indicated that applications of poultry, goat and dairy cow manures significantly increased the available soil P levels. Adeleye *et al.,* (2010) also found that the poultry manure application exhibited an increase in the available soil P, content. The increases in the available soil P may be due to the better phosphorus dissolution as a result of the bacterial activity in the soil, and also to lowering soil the pH through yielding intermediate organic acids and finally humus materials. The obtained results coincided with those mentioned by Das *et al.,*(2008).

Available soil potassium

The available K in the soil after the three successive seasons significantly increased with the successive additions of each organic amendment either alone or associated with molasses or / and APB (Table 5). After the first season, the maximum increases in the available soil K were for FMC + molasses (T5) and FYM + molasses (T4) treatments which recorded 1027.8 and to 992.24mg/kg, respectively, compared to the control treatment (230.4 mg / kg).

A similar trend was obtained in the available soil K after the second season as after the first season, which the available K values of FMC or FYM combination treatments were significantly higher than control, sole molasses, sole APB or their mixture (Table 5). However, available soil potassium level were lower after the second season than after the first season which it may be related to depletion of available potassium from the soil by sorghum plant uptake or leaching with irrigation water. The available soil K after the third season returned to rise again and showed the same trend as that obtained in the first and second ones, but it was still lower than that obtained after the first season and higher than that of the second season (Fig 7). Increases in the available potassium of the soil was reported due to the application of organic fertilizers combined with biofertilizers (Kannan *et al.,* 2005; Kaur *et al.,* 2005; Das *et al.,* 2008; Dadhich *et al.,*2011).

It could be concluded that the successive seasonal applications of FMC + molasses (T5) and FYM + molasses (T9) treatments to the soil resulted in remarkable abundance in the available soil K. These increases in the available K could be attributed to potassium release to the soil from FMC and FYM as well as molasses that are applied to the soil (Ahmed. and Ali, 2005).

Dry matter yield of the grown plants

The dry matter of grown plants is taken as an indicator for the plant growth response to the successive seasonal applications of both organic amendments to the soil and their combination with molasses and acid bacteria (APB).

In the first season, the dry matter yield of wheat plants was significantly affected by applications of the investigated organic amendments either alone or associated with APB, molasses or application of FMC or FYM combined with APB, molasses or both of them (Table 6). Generally, application of FMC or FYM combined with APB and molasses gave significant increase in the dry matter yield of wheat plants compared to the control, molasses, APB or their mixture treatments. The highest increases in the dry matter yield of wheat plants were 421 and 397 % for the soil treated with filter mud cake combined with molasses and APB (T7) and farmyard manure combined with molasses and APB (T11) treatments, respectively compared to the control treatment. These may be attributed to the improving additions effect of these organic amendments on the physico-chemical and biological properties as well as fertility status of the soil.

The dry matter yield of sorghum plants grown in the second season displayed the same trends as that of the first season regarding the addition of organic amendments and their combination with molasses and APB (Table 6).

The highest increases in the dry matter yield of sorghum plants were obtained for T7 and T11which 335 % and 500 %, respectively compared to the control treatment. In this respect, Khalil *et al.,* (2004) found that the total dry biomass production of wheat plants increased as a result of applying organic materials (chicken manure and compost). Also, these results are in an agreement with those obtained by Hassan and Mohey El–Din (2002) and Yassen *et al.,* (2006). Javaid and Shah (2010) reported that the wheat dry biomass yield was significantly increased with phosphate dissolving bacteria (PDB) application to various organic manure treatments. Also, the application of the different organic materials combined with molasses resulted in high dry matter yield of wheat plants and the differences between the treatments in presence or absence of molasses were significant. Molasses contain different substrates considered as an important source of nutrients and energy for microorganisms and plants.

The dry matter yield of wheat plants grown in the third season was higher than that of wheat plant grown in the first season (Table 6). This increase in the dry matter yield could be due to the accumulation of the positive effects of the successively added treatments regarding the improvement of soil physical, chemical and biological properties as well as the soil fertility status and increasing the population and activity of micro-organisms in the soil. Highest increases the dry matter of wheat plants grown in the third season of 314 and 482 % were found in the soil treated with T6 and T11 treatments, respectively compared to the control treatment. Also, the increase of the soil exchange capacity due to the decomposed organic matter and maintains the released available nutrients in the soil resulting in stimulating the plant growth. Significant increases of some growth characters of wheat plants were reported with the application of organic manures (Atta Allah and Mohmed, 2003; Ibrahim *et al.,* 2008; Channabasanagowda *et al.,* 2008; Salem *et al.,* 1990).

Table.4 Successive application effects of filter mud cake (FMC), farm yard manure (FYM), molasses and acid producing bacteria (APB)treatments on the soil organic matter (OM%) content, pH, calcium carbonate ($CaCO_3$%) content and electrical conductivity (Ec) after three subsequent growth seasons

Treatment	Treatment No.	OM%			pH			$CaCO_3$ %			EC (ds/m)		
		Sesson1	Sesson2	Sesson3	Sesson1	Sesson2	Sesson3	Sesson1	Sesson2	Sesson3	Sesson1	Sesson2	Sesson3
Control	T0	0.299	0.201	0.142	7.97	8.24	7.95	7.04	6.88	6.72	1.82	0.89	0.28
Molasses	T1	0.381	0.261	0.189	7.55	8.24	7.95	7.04	6.88	6.72	1.15	0.27	0.27
APD	T2	0.371	0.241	0.171	7.58	8.35	7.95	6.72	6.56	6.40	1.21	0.28	0.25
Molasses + APD	T3	0.401	0.268	0.199	7.53	8.21	7.95	6.56	6.56	6.40	1.11	0.28	0.28
F.M.C	T4	1.017	1.487	1.754	7.65	7.94	7.5	6.32	6.16	6.00	1.65	0.34	0.23
F.M.C+ Molasses	T5	1.149	1.635	2.035	7.65	7.81	7.48	6.32	6.08	5.92	1.87	0.32	0.28
F.M.C APD	T6	1.383	1.888	2.105	7.52	7.95	7.45	6.32	6	5.84	1.81	0.33	0.28
F.M.C+Molasses+ APD	T7	1.220	2.081	2.152	7.57	7.97	7.44	6.32	5.68	5.60	1.53	0.41	0.28
FYM	T8	0.783	1.046	1.530	7.62	7.87	7.6	6.24	5.92	5.76	2.45	0.26	0.25
FYM + Molasses	T9	0.877	1.314	1.683	7.58	7.84	7.49	6.24	5.84	5.68	2.68	0.28	0.224
FYM + APD	T10	1.252	1.256	1.879	7.57	7.82	7.46	6.24	5.84	5.68	2.05	0.46	0.30
FYM +Molasses + APD	T11	1.330	1.465	2.075	7.57	7.97	7.45	6.24	5.68	5.60	2.13	0.48	0.29
LSD 0.05		0.1507	0.2132	0.4362	0.1305	0.1299	0.1301	0.1066	0.2064	0.1056	0.31	0.075	0.05
LSD 0.01		0.2043	0.2889	0.5911	0.1769	0.1869	0.1761	0.1444	0.2797	0.1441	0.42	0.102	0.07

Table.5 Successive application effects of filter mud cake (FMC), farm yard manure (FYM), molasses and acid producing bacteria (APB) treatments on available soil N, P and K contentafter three subsequence growth seasons

Treatment	Treatment No.	N (mg/kg)			P (mg/kg)			K (mg/kg)		
		Sesson1	S Sesson2	Sesson3	Sesson1	Sesson2	Sesson3	Sesson1	Sesson2	Sesson3
Control	T0	9.30	11.01	13.22	10.07	7.07	7.07	230.4	230.4	194.9
Molasses	T1	14.10	16.00	19.82	10.22	7.50	7.14	236.7	203.9	209.9
APD	T2	11.30	13.22	16.52	11.10	7.95	7.57	222	212.7	212.7
Molasses + APD	T3	12.90	19.82	29.74	11.10	8.43	7.43	277.9	265.8	219.0
F.M.C	T4	264.32	285.00	165.20	15.86	11.57	12.43	567.1	319	365.8
F.M.C+ Molasses	T5	303.97	317.18	198.20	19.29	11.79	13.07	1027.8	354.4	365.8
F.M.C APD	T6	185.02	195.00	165.20	19.72	14.57	17.93	713.9	336.7	425.3
F.M.C+Molasses+ APD	T7	231.28	330.40	198.20	20.14	17.60	20.36	708.9	301.3	620.3
FYM	T8	251.10	251.10	152.90	19.21	9.21	10.72	974.7	354.4	460.8
FYM + Molasses	T9	288.10	257.71	166.10	19.86	9.57	11.79	992.4	425.3	655.7
FYM + APD	T10	269.40	248.90	166.10	19.86	10.72	17.79	744.3	372.2	389.9
FYM +Molasses + APD	T11	249.56	323.79	133.10	20.07	11.57	22.29	726.6	372.2	620.3
LSD 0.05		35.47	38.47	23.39	2.851	1.93	2.355	115.6	53.83	71.9
LSD 0.01		48.06	52.13	31.69	3.863	2.62	3.191	156.6	72.95	97.5

Table.6 Successive addition effect of filter mud cake (FMC), farm yard manure (FYM), molasses and acid producing bacteria (APB) on the dry matter yield (g/pot) and the uptake of N,P and K (mg/pot) by different grown plants during the three successive seasons

Treatments	Treatment No.	Dry matter (g/pot)			N uptake (mg/pot)			P uptake (mg/pot)			K uptake (mg/pot)		
		Sesson1	Sesson2	Sesson3	Sesson1	S Sesson2	Sesson3	Sesson1	Sesson2	Sesson3	Sesson1	Sesson2	Sesson3
Control	T0	0.78	1.938	2.54	15.44	20.93	27.41	1.25	4.46	4.82	15.37	49.61	69.29
Molasses	T1	1.08	2.082	5.02	15.98	22.49	74.83	1.94	4.79	11.05	22.79	56.84	150.16
APD	T2	1.482	2.52	5.28	26.82	32.00	55.97	2.67	5.80	11.62	32.16	56.45	145.20
Molasses + APD	T3	1.398	2.742	6.06	27.68	34.82	98.78	2.52	5.48	13.33	32.29	61.97	126.65
F.M.C	T4	1.92	5.478	8.02	39.74	94.22	215.79	3.84	14.24	22.46	48.77	209.26	278.36
F.M.C+ Molasses	T5	2.922	7.218	8.88	70.13	150.13	288.60	5.84	23.10	24.86	75.10	324.81	301.03
F.M.C APD	T6	2.898	7.2	9.12	71.87	172.08	303.70	5.80	28.80	26.45	73.61	324.00	402.19
F.M.C+Molasses+ APD	T7	4.062	8.442	10.50	100.74	201.76	376.95	8.94	36.30	51.45	101.96	437.30	463.05
FYM	T8	1.722	5.538	7.56	39.78	146.76	225.29	4.31	16.61	21.17	43.22	197.15	256.28
FYM + Molasses	T9	2.562	6.738	11.34	61.49	203.49	340.20	6.41	24.26	31.75	64.31	326.12	500.09
FYM + APD	T10	2.538	8.58	11.52	60.91	262.55	347.90	7.61	31.75	46.08	65.48	429.00	566.78
FYM +Molasses + APD	T11	3.882	11.622	14.76	102.48	323.09	521.03	12.42	59.27	76.75	102.87	621.78	739.48
LSD 0.05		0.4584	1.101	1.515	10.13	28.42	47.23	1.33	4.453	5.838	10.61	52.71	65.14
LSD 0.01		0.6212	1.492	2.053	13.73	38.51	64.00	1.40	6.053	7.912	14.38	71.43	88.28

Fig.1 Soil organic matter (OM%) content induced by sequence additions of the tested treatmentsafter three successive growth seasons (S1, S2 and S3)

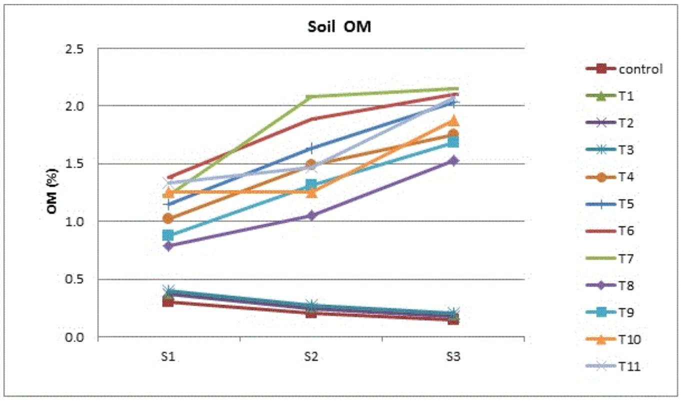


Fig.2 The soil pH affected by successive additions of the investigated treatments after three successive growth seasons(S1, S2 and S3)

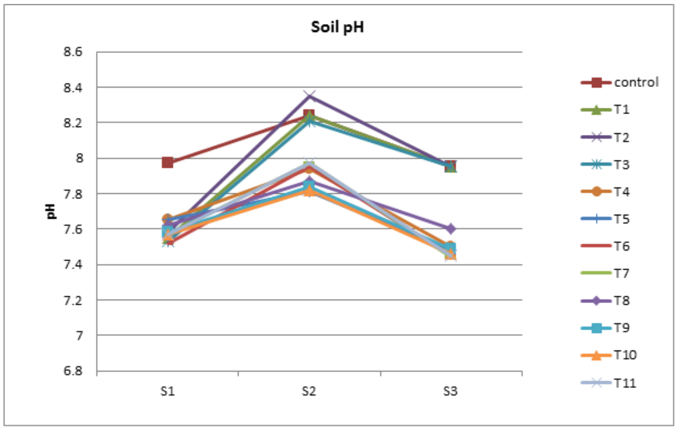


Fig.3 The soil total calcium carbonate content ($CaCO_3$%) affected by sequence additions of different treatments after three successive growth seasons(S1, S2 and S3)

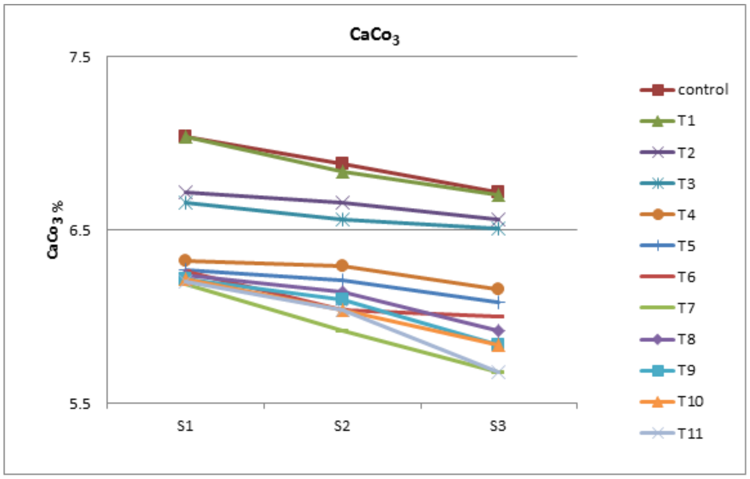


Fig.4 The soil EC (dS/m)induced by successive additions of the examined treatments after three successive growth seasons (S1, S2 and S3)

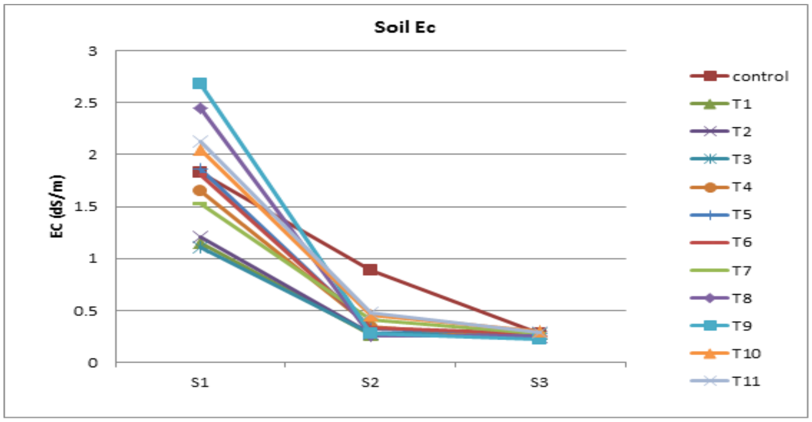


Fig.5 The available soil N content influenced by successive additions of the investigated treatments after three successive growth seasons (S1, S2 and S3)

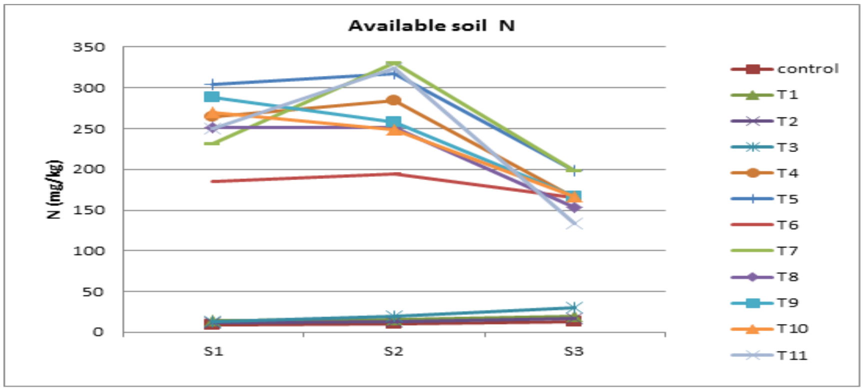


Fig.6 The available soil P content induced by the successive additions of the examined treatments after three successive growth seasons (S1, S2 and S3)

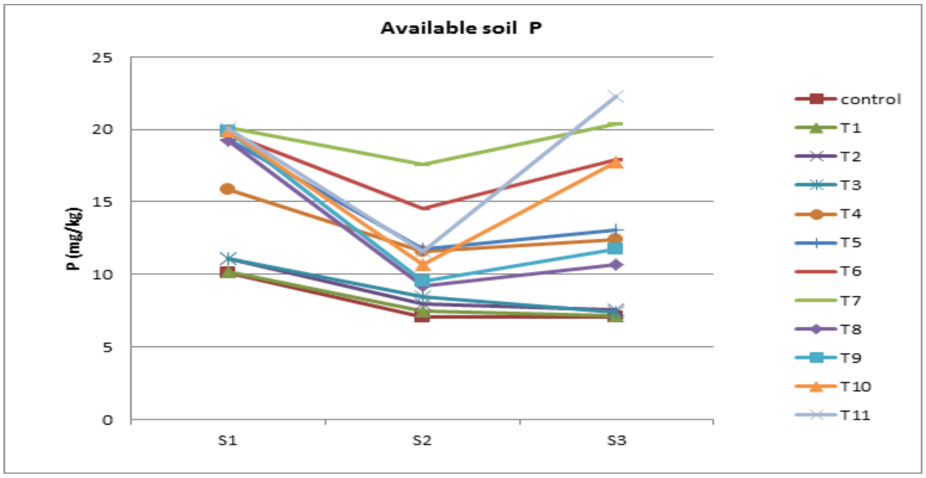
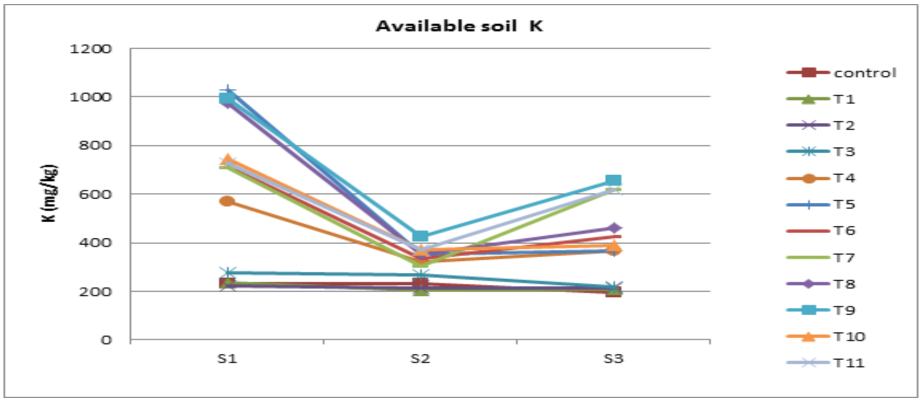


Fig.7 The available soil K content influenced by the sequence additions of the investigated treatments after three successive growth seasons (S1, S2 and S3)



Uptake of N, P and K by grown plants

Uptakes of N, P and K by investigated plants grown in the soil treated with organic amendments with or without molasses and APB during the three successive growth seasons were taken as an indication of the availability of these nutrients in the soils after organic matter decomposition.

The amount of N, P and K taken up by wheat plants grown in all growth seasons significantly increased as a result of applying FMC and FYM with or without molasses and APB additions compared to the control (Table 6). The highest uptake values of N, P and K by wheat plants grown in the first season were recorded FMC +Molasses + APB (T7) treatment which displayed 100.74, 8.94 and 101.96 mg / N, P and K / pot, respectively, and FYM +Molasses + APB (T11) treatment that exhibited 102.48, 12.42 and 102.87 mg N, P and K / pot, respectively. However, wheat plants grown in the second winter season showed a higher assimilation capacity for N, P and K uptake than the first season. The results also revealed that the highest uptake values of N, P and K by wheat plants grown in the second winter season were also obtained with T7 which recorded 376.95, 51.54 and 463.05 mg / N, P and K / pot, respectively and T11 treatment that had 521.03, 76.75 and 739.48 mg N, P and K / pot treatments, respectively.

The amounts of N, P and K taken up by sorghum plants in the summer season showed the same trend as that obtained with wheat plants in the first and second winter growth season which they were 201.76, 36.30 and 437.3 mg N, P and K/ pot, respectively, for T7 treatment and 323.09, 59.27 and 621.78 mg N, P and K / pot, respectively, for T11 treatments. These results are in accordance with those indicated by Ali (1999) who found a significant increase in the uptake of N, P and K by wheat plants grown in the sandy and calcareous sandy soils treated with composted sugar beet residues. The addition efficiency of these organic amendments markedly increased with using organic amendments incorporate with molasses and APB, compared with applying them alone (Table 6), where the response of NPK uptake by the grown plants was more pronounced with the application of organic these organic materials combined with molasses plus APB. These results harmonize with those obtained by Naseem (1994) and Kabesh *et al.*, (2009) who reported that organic fertilizers amended with biofertilizers caused significant increases in the NPK content and uptake of wheat plants. The addition of organic materials enhances the metabolic activity within plants and promotes the migration of the metabolites through the root and stems toward leaves. Thereby, it may increase the percentages of nutrients in leaves and stems (Sikander, 2001).

Also, the application of organic materials in combination with molasses and APB to the soil supply microorganisms with their need from nutrients and energy sources to enhance their population and activity (Peppler, 1979; Shteinberg *et al.*, 1982; Shteinberg and Datsyuk, 1985).

In conclusion the successive additions of the investigated organic amendments (filter mud cake and farm yard manure) to the soil in combination with molasses and acid producing bacteria increased the available N, P and K in the soil. This also induced increases in the plant dry matter yields as well as N, P and K uptake by wheat and sorghum plants. Improvement in soil properties and soil fertility status occurred due to the successive additions of the investigated organic treatments. More studies are needed to investigate the effect of long term successive additions of such organic treatments on soil properties and available nutrients as well as, plant growth and nutrient uptakes under field condition.

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