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RESEARCH ARTICLE

Organic Tuber Potato Production by Aerobic Compost Tea, Beneficial Microbes, Chicken Manure and Plant Compost

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Abstract

Two field experiments were conducted at Agricultural Faculty (Saba-Basha) Alexandria University, in order to study the effect of Aerobic Compost tea (ACT), Beneficial microbes (BM), Chicken manure (CHM) and plant compost (PC) on yield and quality of potato (cv. Bamba). This study was carried out with randomized complete block design with three replicates. Efficiency of twelve treatments on yield and nutrient contents of shoots and tubers were determined. Results shown that (the mixture of CHM. and PC) with ACT or BM only or together them lead to significant increases of vegetative characters and nutritional status in leaves and tubers. Controlled plant gave the lowest mean values of the given characters. Treatments contained ACT, BM., PC and CHM significantly increased in all morphological characteristics and qualities of tuber potato. The mixture of CHM. and PC with ACT or BM only were caused the significantly increases in mineral contents, sugar, starch and T.S.S. % of tubers compared with controlled plant (T_{12}). The highest values of total yield were achieved by (the mixture of BM + 75% CHM. + 25% PC=T_5) compared to T_{12}. The use of T_5 was also increased mean values of the No. of tubers/plant and tuber weight significantly compared to T_{12}. This study demonstrated that ACT, BM., CHM and PC utilization to stimulate naturally occurring populations, organic potato production development and prevent the environmental pollution.

Keywords: Aerobic Compost tea; Beneficial microbes; Chicken manure; Plant compost; Potato tubers.

1. Introduction

Potato (*Solanum tuberosum* L.) is one of the most important vegetables in Egypt. It gained a considerable importance as an export crop to European markets and one of the national income resources. however, its production faces some challenges related to soil-borne diseases, marketable yield and quality, sugars and dry matter content of the produced tubers, tuber content in terms of nitrate, minerals, vitamins, bioactive compounds, and antioxidants, and consumer appreciation regarding the sensory characteristics of tubers and processed products (Djaman *et al*., 2021). Potatoes require high amounts of nitrogen, potassium and phosphorus fertilizers for optimum growth, production and tuber quality. Nutrition analysis showed that potato is a healthy food in terms of vitamins, minerals, proteins, essential amino acids and carbohydrates (Andre *et al*., 2007). Potato is the fourth important food in the world ranking at 365.8 million tons per year (FAOSTAT, 2014).

Aerobic compost tea (ACT) in modern terminology, is a compost extract brewed with a microbial food source molasses, kelp, rock dust, humic and fulvic acids. The compost tea brewing technique, an aerobic process, extracts and grows populations of beneficial micro-organisms (Mengesha *et al*., 2017). Compost tea was used as the source of organic substances. As so in recent years, compost tea has emerged as an important component of the integrated nutrients supply system and hold a great promise to improve crop yields through environmentally better nutrient

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supplies. Extracts of the finished composts were reduced bacterial toxicity Ana *et al.* (2021). Compost tea is a highly concentrated microbial solution produced by extracting beneficial microbes from vermi-compost and /or compost. It is a source of foliar and organic nutrients, contains chelated micronutrients for easy plant absorption and the nutrients for both plant and microbial uptake. The most widely described benefit of compost tea is their ability to decrease plant disease when used as soil drenches or foliar sprays (Scheuerell and Mahaffee, 2004; Kandil *et al*., 2011; Philip *et al*., 2011).

Beneficial microbes (BM) are the micro-organisms and their products which are utilized to increase soil fertility. Biofertilizers are products containing living cells of different types of micro-organisms, when applied to seeds, plant surface and rhizosphere to colonize around the plant that promotes growth by converting nutritionally important elements (Robert *et al*., 2012; Marta *et al*., 2021). They able to dissolve the macro and micro nutrients by their different organic acids produced, converted from unavailable to available through biological process such as nitrogen fixation and solubilization (Rokhzadi *et al*., 2004; Philip *et al*., 2011; Mengesha *et al*., 2017). El Yazid *et al*. (2007) found that beneficial microorganisms as biofertilizers accelerate and improve the plant growth and protect them from pests and diseases. Soil microbial activities are major factors that determine the availability of nutrients to plants, consequently they have significant influences on plant health and productivity (Jeffries *et al*., 2003; El-Tantawy *et al*., 2009). Beneficial microbes get benefit to crops, such as potato crop (Mengesha *et al*., 2017; Abou El Goud, 2020 a, b, c; Djaman *et al*., 2021).

Chicken manure plays an important role in potato production under sandy soil conditions. Organic fertilizers improve soil structure, which encourage the plant to have good roots and improving aeration in the soil. Many studies investigated the effect of organic fertilizers on potato production. In Egypt chicken manure is usually used as organic fertilizer. Generally, soil organic matter is considered as an important factor for improving physical, chemical and biological properties of the soil (Abdel Moez *et al*., 1999; El-Tantawy *et al*., 2009; Abou El-Goud *et al*., 2020).

Plant Compost able to modify the physical, chemical and biological soil properties in the root zone can be repaired by adding compost as a fertilizer (Mandic *et al*., 2011; Setiyo *et al*., 2016; Mona and Abou El-Goud. 2020). Soil acidity or pH, content of macro and micro nutrients, and CEC are the chemical properties of soil which can improve with compost (Ibrahim, 2018; Djaman *et al*., 2021). Fertilization with compost improves the soil biological properties by multiplying beneficial microbes' population.

Organic farming systems are based on three practical pillars; 1- Improving and increase the soil fertility by using organic fertilizers; 2- the deletion of synthetic fertilizers and synthetic pesticides and the lower use of high energy consuming feedstuff (FlieBbach, *et al*., 2006; El-Wehedy, 2008; Djaman *et al*., 2021); 3- High application of bio and organic fertilizers are necessary not only to maintain soil fertility, increased the crop quality and yield but also to prevent the environmental pollution.

The objectives of this study are to focus on the effect of aerobic compost tea, beneficial microbes, chicken manure and plant compost on the growth, yield and chemical composition of potato tubers (cv. Bamba) along with avoiding the environmental pollution from chemical fertilizers usage which lead to bad effects on potential health of plants, animals and humans.

2. Materials and methods

2.1. Experimental location and arrangement

Two field experiments were conducted at the Faculty of Agriculture (Saba-Basha), Alexandria University; during the fall seasons on 20th and 23rd of September of seasons 2017 and 2018 respectively, to study the response of potato plants cv. Bamba to different organic and biofertilizers such as Aerobic Compost tea, Beneficial microbes, Chicken manure and plant compost under drip irrigation system. A surface soil sample (0-30 cm) was collected before planting to identify some physical and chemicals properties [pH= 7.8, E.C.

(1:1 water extract) = 0.44 dS/m; O.M. %= 0.30%, available of N= 116.3 mg/kg, P=21.0 mg/kg and K= 430m g/kg and $CaCO_3$%= 32%]. The texture of soil was sand (55.9%), clay (23.7%) and loam silt (20.4%). As well as, physico-chemical properties of the applied organic fertilizers as (chicken manure and plant compost) samples were taken and analyzed before adding to the soil to determine (total organic matter%= 29.21 and 31.06%, organic carbon%= 14.23 and 16.38% , C/N ratio= 1:5.7 and 1:9.6 , pH= 7.3 and 7.9, E.C.= 2.3 and 1.97 dS/m , total amount of N= 2.5 and 1.7%, P= 3.23 and 2.7 % and K= 3.9 and 2.4%) , respectively during the two seasons according to Page *et al*., 1982; Chapman and Pratt, 1978 and Lowther, 1980 .

2.2. Experimental materials and design

2.2.1. B.M. (Beneficial microbes)

consist of *Azotobacter* as a source of (N) + *Bacillus megatherium* as a source of (P) + *Bacillus circulans* as a source of (K). Beneficial microbes were obtained from Cairo MIRCEN- Fac. Agric., Ain Shams Univ., Cairo Egypt. It was added at dose of 7 ml / hill during planting of potato tubers.

2.2.2. ACT (Aerobic Compost Tea)

according to (Ingham 2000; Mengesha *et al.*, 2017; Abou El Goud, 2020a), it was added as it soil drench (150 ml/hill). It was prepared to from500 g plan compost, 50 g humic maize meals), then left them 72 hr, for brewing cycle. After that, mixed 2 L of aerobic compost tea + 2 L of tap water (1:1) concentration.

2.2.3. Chicken manure (CHM.)

was added at two doses; $R_{75\%}$ (2 Kg /plot) and $R_{25\%}$ (0.7 Kg/plot), that calculated and attributed to the recommended dose of chicken manure is $R_{100\%}$ = 3.5 tons/fed.

2.2.4. Plant Compost (PC)

from plant residues was added at two doses; $R_{75\%}$ (3.4 Kg / plot) and $R_{25\%}$ (1.1 Kg / plot), that calculated and attributed to the recommended dose of compost is $R_{100\%}$ = 6 tons /fed. Total amount of plant compost and chicken manure for each treatment were applied prior to the soil about 25 days before planting on 24th of August at two seasons 2017 and 2018. Treatments were carried out in this investigation as follow;

T_1- B.M.
T_2- ACT
T_3-75%CHM+25%PC
T_4- 25%CHM+75%PC
T_5- B.M.+75%CHM+25%PC
T_6- B.M.+25%CHM+75%PC
T_7- B.M.+ACT
T_8- ACT+75%CHM+25%PC
T_9- ACT+25%CHM+75%PC
T_{10}- ACT+B.M.+75%CHM+25%PC
T_{11}- ACT+B.M.+25%CHM+75%PC
T_{12}- Control NPK (recommended doses of chemical fertilizer N, P and K of Ammonium nitrate 33.5% = 500 kg/fed. + Super phosphate 15.5%=500 kg/fed. + Potassium sulphate 48% =75 kg/fed). Two field experiments were carried out in a complete randomized blocks design with 3 replications (RCBD). Total plot area was (3.5m length × 0.80m width= 2.8 m^2) and the distance between two hills was 30 cm, seven plants per plot. Weeds were controlled by hand howling once a week after planting.

2.2.5. Organic protection

there were organic pesticides programme by using neem oil extraction as a foliar application on leaves (4 ml/ L) every 20 days after 50 days from planting to increase the plant defense against the pathogen and cover with net to protect the potato plants from insect (Emmanuel and Maerere, 2018).

2.2.6. Vegetative growth characters

Six plant samples per plot were randomly selected at 100 days after planting for (cv. Bamba) for the determination of the following growth parameters: plant height (cm), No. of leaves/ plant, No. branches/plant. Plant dry weight (g/plant) was determined by drying the fresh material at 70^{0}C for 48 h, then the weight fixing. Leaf chlorophyll indication (SPAD) for determination chlorophyll readings at harvest, greenness was done using a non- destructive method using a SPAD 502 chlorophyll meter for each plant, 3 recently full-expanded leaves were randomly chosen for SPAD (Soil Plant Analysis Development), measurement at the average of 3 readings were recorded (Yadava, 1985; Marquard and Tipton,1987).

2.3. Yield and yield component parameters

No. of tubers/plant which counted as the average number of tubers per plot. Average tuber weight (kg/plant): whereas the weight and number of tubers /plot were assessed, then the total weight was divided by the total number. Total tuber yield (ton/fed) was calculated in the harvesting time of cultivar (cv. Bamba) at 30th of December in both seasons, then calculated and attributed to the feddan (feddan = 4000m^2). Tuber quality characters such as; total sugars (%) were determined calorimetrically using phenol and Sulphur acid according to Malik and Singh, 1980. The percentage of starch was determined using a sample of 0.1 g of the residue by hydrolysis with concentrated HCL for 3h under reflux condenser (AOAC,1985). Total soluble solids of tubers (TSS%) were determined in the tuber juice as percentage by hand refractometer according to Chen and Mellenthin (1981).

2.4. Plant chemical analysis

measurement of mineral nutrients in the leaves and tubers N, P and K contents of leaves and tubers; The N, P and K percentages were determined in the dry leaves and tubers. Samples of leaves and potato tubers were washed by tap water then by distilled water and oven dried at 75°C for 3 days to fix dry weights. Dried samples of leaves and tubers were finely ground, then wet digested by using concentrate of H2SO4-H2O2 mixture according to (Lowther, 1980). The following determinations were carried out in the digested solution: Nitrogen content: was determined colorimetrically by Nessler's method (Chapman and Pratt, 1978). Phosphorus content was determined by the Vanadomolyate yellow method as given by Jackson (1967) and the intensity of color developed was read in spectrophotometer at 405nm. Potassium content: was determined according to the method described by Jackson (1967) using Beckman Flame photometer.

2.5. Statistical Analysis

Data were statistically analyzed using Costat Software (Steel and Torrie, 1980), and treatments means were compared using Duncan's Multiple Range test at 5% level of probability.

3. RESULTS AND DISCUSSION

The results of the soil analysis before cultivated showed that the soil which used in the experiment was sandy loam texture. The amounts of available macro and micro-elements were in the range of low availability for plant nutrition as compared to standard values (Soltanpour, 1985). The amount of available phosphorus of the soil was below (35 mg/kg) from the range of availability according to Landon (1991). This finding further signifies that the soil requires external application of nutrients for high growth and yield of the crop. Data presented from organic fertilizers analyzes indicated that, the compost tea and chicken manure which is rich in macro elements in the suitable range of the require for the plants.

3.1. Vegetative growth characters

The results in Table (1) demonstrated that all organic and bio-fertilizer treatments when applied on potato tubers plants significantly increased all vegetative growth characters as compared with control treatment (T_{12}), in both seasons. Generally untreated plants showed the lowest significant average values for all vegetative growth characters except for plant height cm, controlled plants gave the highest mean value as (136.50 cm) in the first season only. The recorded results indicated that the highest average values were obtained due to the application of T_{11} (ACT+B.M. +25%CHM+75%PC) for plant height (129.17 cm) in the first season and T_5

(B.M.+75%CHM+25%PC) was (140.13cm). About for number of leaves/ plant, it was observed that T_{10} (ACT+B.M.+75%CHM+25% PC), gave the highest mean value in the first season as (102.00) and T_5 (B.M.+75%CHM+25%PC) was (113.33) in the second season. Regarding number of branches per plant character, T_{10} gave rise the highest average value during first season was (8.00) but T_5 gave the highest data recorded as (9.67) in second season. About shoot dry weight, the highest mean value was obtained from T_5 (94.53 g/plant) in season 2018. The tabulated results indicated, clearly what, the bio and organic fertilizers, their modes of actions in regulating the physiological processes on growth and development of potato (cv. Bamba) under the study via using aerobic compost tea, beneficial microbes, chicken manure and plant compost application. The results obtained in this study are in agreement with other previous reports showed that certain beneficial microorganisms and aerated compost tea used in root applications, increased groups of different beneficial microorganisms which can be used for many purposes include mycoparasites (Fernandez-Luqueno *et al*., 2010; Larkin, *et al*., 2010; Mengesha *et al.*, 2017), rhizosphere colonies (Fernandez-Luqueno *et al*., 2010; Larkin, *et al*., 2010; Djaman *et al*., 2021), hyperparasitic fungi (Schonbeck and Dehne, 1986; Djaman *et al.*, 2021), epiphytic microbes (Fernandez-Luqueno *et al*., 2010; Larkin, *et al*., 2010) along with individual microbes such as Pseudomonas (Mengesha *et al*., 2017; Ibrahim, 2018), Azotobacter, Trichoderma and Bacillus (Pa pavizas, 1985; Djaman *et al.*, 2021). Apparently, disease suppressive microbes that have been found in compost tea and beneficial microbes are able to colonize the surface and roots of plants when applied properly. Organic manures such as chicken manure, plant compost and compost tea simply concentrate these beneficial microbes and allow the grower to concentrate form as nutrients and for resistance and diseases control (Mengesha *et al*., 2017 and Ibrahim, 2018; Ana *et al*., 2021). These are in accordance with our results which attributed to the high capacity of the plants due to the treatments in building metabolites which reflect on more vigorous plant healthy growth and major rooting surface area system which in turn contributes to increase the dissolving and translocation of macro and micro- elements concentration in root hairs for a good building of plant body health. These lead to enhance the plant growth, immunity system, plant hormones and regulators for increasing the crop yield and quality of potato tubers (Abou-Hussein, 2005; ElShazly, 2008; Ibrahim, 2018; Abou El Goud *et al.*, 2021; Abou El Goud, 2020a; Djaman *et al*., 2021). Leaf chlorophyll reading (SPAD), data presented in Table (1) divulged that highest reading values of chlorophyll index were found when plants fertilized with T_6, T_8 and T_9 as (38.40, 37.73 and 37.70) in the first season respectively, but T_5 (46.23) in the second season. This event may be occurred owing to the ability of organic and biofertilizers on potato leaf chlorophyll reading related to the important role of nitrogen, phosphorus and potassium in plant tissues that reflect on highly vegetative growth rates. The treatments mentioned above play vital roles in photosynthesis, carbohydrate transport, protein formation, control of ionic balance, regulation of plant stomata and water use activation of plant enzymes and other processes (El-Dissoky, 2008; El-Shazly, 2008; Shaheen *et al*., 2018; Ibrahim, 2018 Abou El Goud, 2020 a, b, c and Djaman *et al*., 2021).

3.2. Yield and its component characters

Table (2) expressed that application with T_5 (B.M.+75%CHM+25%PC) affected significantly all studied characteristics of the tested potato cultivar (No. of tubers per plant, average tuber weight, total tuber yield/fed.). Whereas, the lowest significant average values for all yield characters of potato tubers were derived from control plants compared with fertilized plants with those organic and biofertlizers during both seasons. Data presented in Table (2) cleared that the highest average values for number of tubers per plant character was obtained from T_5 treatment (13.00 and 13.33) at two seasons respectively. The average tuber weight of treatment T_3 (75%CHM + 25%PC) brought about the highest average values (1.500 kg/plant) during the first season and the treatment T_5 gave the highest mean values

(1.357kg/plant) in the second season. Regarding total yield/fed., plants treated with T_5 (B.M.+75%CHM+25%PC) lead to the highest average values (20.74 and 23.03 tons/fed.) during both seasons regularly. These results are in agreement with (Jeyabal and Kuppuswamy, 2001; Abou El Goud, 2020 c; Djaman *et al*., 2021), they showed that biofertilizers can prevent the depletion of the soil organic matter. Also, (Ibrahim, 2018; Abou El Goud, 2020 and Mona and Abou El-Goud. 2020), they focused on the organic agricultural production in Egypt in order to avoid plant and environmental pollution with different elements and to reduce the usage of chemical fertilizers. Biofertilizers are products when applied to seeds, plant surface or soil, colonize the rhizosphere and promotes growth by converting nutritionally important elements (nitrogen and phosphorus) from unavailable to available form through biological process such as nitrogen fixation and solubilization of rock phosphate (Marta *et al*., 2021; El-Shazly, 2008; El-Tantawy *et al*., 2009; Ibrahim, 2018;Abou El Goud, 2020 a, b, c). Organic fertilizers are useful for plants due to their beneficial effect on the physical, chemical and biological characteristics of the soil, which in turns, influenced growth and increase plant production (Meunchang *et al*., 2006; Shaheen *et al*., 2018; Djaman *et al*., 2021). These results are in agreement with (Bhattacharyya and Pati, 2000 and Abou El Goud, 2020a), they found that B.M., produced high amount of IAA in root zone. (El-Tantawy *et al*., 2009; Shaheen *et al*., 2018; Shoresh, 2010; Abou El Goud, 2020a; Djaman *et al*., 2021), they noticed that many autotrophic bacteria produce an endogenous phytohormones like auxin, cytokinens and gibberellins which enhance growth of roots, shoots and consequently plant yield. Several species of Trichoderma are reported to produce secondary metabolites with antibiotic activity and promote growth, improves crop yield, increase nutrient availability and enhance disease resistance, weight of shoots and roots and nodules number (Benetiz *et al*., 2004; Reino *et al*., 2008; Vinale *et al*., 2008; Abou El Goud, 2020a,b; Djaman *et al*., 2021). Furthermore, aerobic compost teas are considered advantageous compared with other organic wastes since they present a lower risk of toxicity due to the presence of heavy metals, pollutants, aromatic hydrocarbons, pharmaceuticals as well as viruses, fecal coliforms and salmonella (Benito *et al*., 2005; Moretti *et al*., 2015; Morales-Corts *et al*., 2018), and because of the interesting biological activity of ACT materials (Ros *et al*., 2005; Ana *et al*., 2021). Researchers studied the role of organic fertilizers, which were incorporated with biofertilizer, as stimulating the plant growth, total protein, nutrients uptake, tuber germination, good potato yield and quality.

3.2.1. Tuber quality's characters

total sugars, starch and TSS% in potato tubers; results postulated in Table (3) revealed that all applied organic and biofertilizer treatments showed the highest significant average values of total sugars, total starch and T.S.S characters compared with control plants (T_{12}). Plants that fertilized with T_9 (ACT+25%CHM+75%PC) lead to the highest values of the total sugars character, such as (0.87 %) in the first season and T_5 as (0.92 %) in the second season. As for T_2 (ACT) gave the highest mean values of total starch% as (13.90 %) in the first season and T_5 as (14.10 %) in the second season. Meanwhile, T_8 (ACT+75%CHM+25% PC) lead to the highest mean values of T.S.S.% as (8.33 %) in the first season but T_5 as (10.17 %) in the second season compared with controlled once (T_{12}) which gave the lowest mean values of the above mentioned characters. These are in agreement with that microbes are usually considered to play vital roles to reduce or eliminate chemical fertilizers inputs (Kandil *et al.*, 2011; Philip *et al*., 2011; Larkin *et al*., 2012; Djaman *et al*., 2021). Aerobic compost tea (ACT) plays a role in the suppression of crop pests and diseases (Mengesha *et al*., 2017; Ibrahim, 2018; Ana *et al*., 2021), including pathogenic nematodes, herbivores and particularly soil-borne fungal diseases (Philip *et al*., 2011; Larkin *et al*., 2012; Mengesha *et al*., 2017 and Djaman *et al*., 2021; Abou El Goud, 2020a, b) these led to enhance total sugars, total starch and T.S.S characters in potato tubers. The effect of ACT, B.M, CHM and PC, which increasing the production of active compounds including enzymes, antibiotics, siderophores, and the plant hormone indole-1,3-acetic acid (Shaban *et al*., 2015; Abou El Goud, 2020a, b, c; Djaman *et al*., 2021) which lead to increase total sugars, starch and TSS% which reflected on the potato tuber quality's characters. Also, the use of ACT in agriculture is emerging because of its ability to suppress a wide range of both soil and airborne pathogens (Martin, 2014). In this regard, compost teas are viewed as potential alternatives to the use of common synthetic fungicides in response to the increasing need for environmental sustainability of farming and food safety (Pane *et al*., 2012; Morales-Corts *et al*., 2018). The effectiveness of compost teas may vary due to differences in types of compost, management and procedures used for its preparation (Egwunatum and Lane, 2009; Pant *et al*., 2012). Martin (2014) indicated that the best results are obtained when aerated compost teas rather than non-aerated teas are replied, probably because dissolved oxygen supports microbial activity (Arancon *et al*., 2007).

3.3. Chemical analysis of leaves and tubers characters

3.3.1. Potato leaves N, P and K contents

Data outlined in Table (4) manifested that the highest percentages of leaves N concentrations were obtained when plants treated with T_4 (25%CHM + 75%PC) and T5 (B.M.+75%CHM+25%PC) as (4.47 and 4.53 %) during both seasons progressively. With regard to leaves P content during the two seasons, non-significant effects were found among the treatments. However, T_6 and T_{10} resulted in the highest mean values of P content of leaves were (0.31% for both) in the first season but T_5 as (0.31%) in the second season. The highest percentage values of K content in leaves were obtained from plants treated with treatments T_2, T_6, T_9, T_{10} and T_{11} during the first season as (0.064, 0.064, 0.062, 0.062 and 0.061 %) respectively but T_5 as (0.065) in the second season. Meanwhile, control treatment recorded the lowest percentage values of N, P and K contents in leaves for both seasons. The steady release of the nitrogen, phosphorus and potassium from chicken manure, ACT and B.M. may have resulted that, they have been taken up mainly in the form of available forms which probably caused nutrients accumulations in the plants tissues (Abou El Goud, 2020a, b and Djaman *et al*., 2021). Our results are in accordance with those reported by (Mengesha *et al*., 2017; Ibrahim, 2018; Abou El Goud, 2020 a, b ; Djaman *et al*., 2021 and Ana *et al*., 2021). These microbes that found in ACT and B.M stimulated the uptake of N, P, K, Mg, Fe, and Zn simultaneously. Furthermore, potato yields are limited by nutrient availability in fall and early summer season (Mengesha *et al*., 2017; Ibrahim, 2018; Abou El Goud, 2020a, b; Djaman *et al*., 2021), while these microbes may benefit the yield of potato by enhancing available nutrients accumulation during the growth periods (Mengesha *et al*., 2017; Ibrahim, 2018; Ana *et al*., 2021).

3.3.2. Potato tubers N, P and K contents

Data postulated in Table (5) illustrated that the highest mean values of N % in potato tubers were (3.03 and 3.23 %) when treated with T_3 and T_5 at two seasons respectively followed by T_4 and T_{11} gave also, the best values in the first season as (2.93 % for both treatments). Regarding P content in tubers, T_2, T_3,T_6 and T_9 treatments produced the highest mean values as (0.21% for all) at first season, meanwhile T_7 gave the highest mean value as (0.87 %) at the second season. With regard to tubers K content during the first season, non-significant differences were found among the treatments. Moreover, T_5 resulted in the highest mean values of K content of tubers were (0.05 and 0.07%) at two seasons orderly. That is mean, organic and bio fertilizers addition may be attributed to that organic matter is a good source for plant nutritional and growth promoting substances, which able to improve the plant healthy of plant growth and vital tissues development. Similar results were reported by (El-Wehedy, 2008; Mengesha *et al*., 2017; Ibrahim, 2018; Abou El Goud, 2020 b, c; Djaman *et al*., 2021), these are in agreement with the addition of bio and organic fertilizers increased the availability of soil nutrients and enhance the soil microbial propagation. Besides, the use of natural bio and organic materials increased the physiological and bio- chemical mechanisms in the plant tissues which led to increase the nutrients in the storage organs (Mengesha *et al*., 2017).

Table 1. Effect of Aerobic Compost tea (ACT), Beneficial microbes (BM), Chicken manure (CHM) and plant compost (PC) on Vegetative growth characters of potato (cv. Bamba) for both seasons 2017 and 2018.

Items	Plant height (cm)		No. of Leaves/ Plant		No. of branches/plant		Leaf chlorophyll index (SPAD)		Shoot dry weight (g/plant)
Treatments	2017	2018	2017	2018	2017	2018	2017	2018	2018
T_1-B.M.	108 bc	108.87 e	69.00 de	88.00 e	4.00 e	6.33 d	32.83 ab	35.90 e	61.53 e
T_2-ACT	99.17 cde	79.93 j	78.00 bcd	64.67 j	6.00 bc	3.33 g	35.10 ab	26.47 j	35.80 j
T_3-75%CHM+25%PC	99.17 cde	131.33 b	78.00 bcd	106.33 b	7.00 ab	8.33 b	36.00 ab	43.43 b	84.73 b
T_4-25%CHM+75%PC	113.83 b	116.13 d	74.33 bcde	94.00 d	4.67 de	7.33 c	36.83 ab	38.03 d	69.27 d
T_5-B.M.+75%CHM+25%PC	104.27 bcd	140.13 a	74.67 bcde	113.33 a	4.33 e	9.67 a	37.07 ab	46.23 a	94.53 a
T_6- B.M.+25%CHM+75%PC	94.27 de	102.23 f	79.00 bc	83.00 f	5.00 cde	6.33 d	38.40 a	34.20 f	55.50 f
T_7-B.M.+ ACT	99.67 cde	85.20 i	68.33 e	69.00 i	4.00 e	4.33 f	36.67 ab	28.20 i	40.47 i
T_8-ACT+75%CHM+25%PC	105.67 bcd	90.63 h	70.33 cde	74.33 h	4.33 e	4.67 ef	37.73 a	30.07 h	44.20 h
T_9-ACT+25%CHM+75%PC	89.33 e	75.43 k	66.33 e	60.33 k	4.67 de	2.67 g	37.70 a	24.63 k	33.07 k
T_{10}-ACT+B.M.+75%CHM+25%PC	101.33 cde	96.13 g	102.00 a	78.33 g	8.00 a	5.33 e	35.00 ab	31.67 g	50.17 g
T_{11}-ACT+B.M.+25%CHM+75%PC	129.17 a	121.73 c	82.00 b	100.67 c	5.67 cd	7.67 bc	31.13 bc	40.60 c	76.37 c
T_{12}-Control(NPK)	136.50 a	69.9 l	44.00 f	58.00 l	4.00 e	1.67 h	27.10 c	23.10 l	29.13 l
L.S.D. 0.05	8.296	1.259	8.074	1.841	1.167	0.951	5.232	0.859	1.199

Values with the same alphabetical letters, within a comparable group of means, don’t significant differ, using L.S.D test at 0.05 level.

Table 2. Effect of Aerobic Compost tea (ACT), Beneficial microbes (BM), Chicken manure (CHM) and plant compost (PC) on yield and yield components of potato (cv. Bamba) for both seasons 2017 and 2018.

Treatments	No. of tubers/plant		Average Tuber weight (kg/plant)		Total tuber yield(ton/fed)	
	2017	2018	2017	2018	2017	2018
T_1-B.M.	9.67 bcd	8.33 d	0.947 d	1.077 e	13.85 cd	18.10 e
T_2-ACT	7.67 e	3.33 g	0.721 e	0.782 j	10.64 e	13.09 k
T_3-75%CHM+25%PC	13.33 a	11.33 b	1.500 a	1.267 b	20.00 a	21.59 b
T_4-25%CHM+75%PC	11.00 b	9.67 c	0.990 d	1.145 d	15.24 bc	19.03 d
T_5-B.M.+75%CHM+25%PC	13.00 a	13.33 a	1.348 b	1.357 a	20.74 a	23.03 a
T_6- B.M.+25%CHM+75%PC	11.00 b	8.00 d	0.976 d	1.018 f	15.53 bc	16.86 f
T_7-B.M.+ ACT	8.00 de	4.67 f	0.737 e	0.842 i	11.33 de	13.99 i
T_8-ACT+75%CHM+25%PC	9.00 cde	6.00 e	0.741 e	0.891 h	11.41 de	14.89 h
T_9-ACT+25%CHM+75%PC	7.67 e	2.67 gh	0.743 e	0.743 j	10.84 e	13.30 j
T_{10}-ACT+B.M.+75%CHM+25%PC	9.67 bcd	6.67 e	0.946 d	0.945 g	13.64 cd	15.92 g
T_{11}-ACT+B.M.+25%CHM+75%PC	10.33 bc	10.67 b	1.217 c	1.201 c	16.72 b	20.31 c
T_{12}-Control(NPK)	5.67 f	2.00 h	0.406 f	0.498 k	6.25 f	9.01 l
L.S.D. 0.05	1.641	0.775	0.077	0.040	2.451	0.124

Values with the same alphabetical letters, within a comparable group of means, don’t significant differ, using L.S.D test at 0.05 level.

Table 3. Effect of Aerobic Compost tea (ACT), Beneficial microbes (BM), Chicken manure (CHM) and plant compost (PC) on potato tubers quality characters (cv. Bamba) for both seasons 2017 and 2018.

Treatments	Total sugar % in tubers		Total starch % in fresh tubers		T.S.S. % in tubers	
	2017	2018	2017	2018	2017	2018
T_1-B.M.	0.64 e	0.60 e	13.50 ab	9.17 e	4.00 c	8.50 d
T_2-ACT	0.78 bc	0.35 j	13.90 a	5.40 j	5.00 bc	6.03 i
T_3-75%CHM+25%PC	0.78 bc	0.83 b	12.57 b	12.50 b	4.93 bc	9.60 b
T_4-25%CHM+75%PC	0.76 bc	0.67 d	12.30 b	10.13 d	4.77 bc	8.90 c
T_5-B.M.+75%CHM+25%PC	0.65 de	0.92 a	12.47 b	14.10 a	6.00 b	10.17 a
T_6- B.M.+25%CHM+75%PC	0.78 bc	0.54 f	13.00 ab	8.40 f	5.60 bc	7.87 e
T_7-B.M.+ ACT	0.71 cde	0.38 i	12.67 b	6.03 i	5.50 bc	6.63 h
T_8-ACT+75%CHM+25%PC	0.64 e	0.44 h	13.30 ab	6.70 h	8.33 a	7.10 g
T_9-ACT+25%CHM+75%PC	0.87 a	0.32 k	12.37 b	4.90 k	6.00 b	5.27 j
T_{10}-ACT+B.M.+75%CHM+25%PC	0.80 b	0.49 g	13.00 ab	7.40 g	5.00 bc	7.50 f
T_{11}-ACT+B.M.+25%CHM+75%PC	0.71 cde	0.75 c	12.77 ab	11.13 c	5.50 bc	9.13 c
T_{12}-Control(NPK)	0.72 cd	0.29 l	12.67 b	4.17 l	4.80 bc	4.50 k
L.S.D. 0.05	0.066	0.016	1.067	0.220	1.542	0.345

Values with the same alphabetical letters, within a comparable group of means, don't significant differ, using L.S.D test at 0.05 level.

Table 4. Effect of Aerobic Compost tea (ACT), Beneficial microbes (BM), Chicken manure (CHM) and plant compost (PC) on leaves nutrient contents of potato plant (cv. Bamba) for both seasons 2017 and 2018.

Treatments	N % in leaves		P % in leaves		K % in leaves	
	2017	2018	2017	2018	2017	2018
T_1-B.M.	4.03 d	2.93 e	0.29 abc	0.20 e	0.060 ab	0.043 e
T_2-ACT	4.17 bcd	1.67 j	0.27 cd	0.11 ij	0.064 a	0.025 j
T_3-75%CHM+25%PC	4.30 ab	4.03 b	0.29 abc	0.27 b	0.059 ab	0.059 b
T_4-25%CHM+75%PC	4.47 a	3.33 d	0.25 d	0.23 d	0.059 ab	0.047 d
T_5-B.M.+75%CHM+25%PC	4.20 bcd	4.53 a	0.27 bcd	0.31 a	0.058 ab	0.065 a
T_6- B.M.+25%CHM+75%PC	4.37 ab	2.77 f	0.31 a	0.18 f	0.064 a	0.038 f
T_7-B.M.+ ACT	4.23 bcd	1.87 i	0.29 abc	0.12 i	0.060 ab	0.028 i
T_8-ACT+75%CHM+25%PC	4.07 cd	2.17 h	0.30 ab	0.14 h	0.059 ab	0.031 h
T_9-ACT+25%CHM+75%PC	4.27 bc	1.47 k	0.27 bcd	0.10 j	0.062 a	0.023 k
T_{10}-ACT+B.M.+75%CHM+25%PC	4.07 cd	2.37 g	0.31 a	0.16 g	0.062 a	0.035 g
T_{11}-ACT+B.M.+25%CHM+75%PC	4.23 bcd	3.63 c	0.27 cd	0.26 c	0.061 a	0.053 c
T_{12}-Control(NPK)	3.17 e	1.07 l	0.20 e	0.08 k	0.050 b	0.020 l
L.S.D. 0.05	0.185	0.097	0.022	0.010	0.009	0.001

Values with the same alphabetical letters, within a comparable group of means, don't significant differ, using L.S.D test at 0.05 level.

Table 5. Effect of Aerobic Compost tea (ACT), Beneficial microbes (BM), Chicken manure (CHM) and plant compost (PC) on potato tubers nutrient contents (cv. Bamba) for both seasons 2017 and 2018.

Treatments	N % in tubers		P % in tubers		K % tubers	
	2017	2018	2017	2018	2017	2018
T_1-B.M.	2.70 d	2.03 e	0.16 de	0.16 fgh	0.04 ab	0.04 de
T_2-ACT	3.00 ab	1.23 j	0.21 a	0.63 b	0.04 ab	0.02 gh
T_3-75%CHM+25%PC	3.03 a	2.87 b	0.21 a	0.22 def	0.04 ab	0.06 b
T_4-25%CHM+75%PC	2.93 abc	2.27 d	0.19 bc	0.18 efg	0.04 ab	0.04 d
T_5-B.M.+75%CHM+25%PC	2.80 cd	3.23 a	0.19 bc	0.24 de	0.05 a	0.07 a
T_6- B.M.+25%CHM+75%PC	2.83 bcd	1.83 f	0.21 a	0.14 gh	0.04 ab	0.03 e
T_7-B.M.+ ACT	2.80 cd	1.37 i	0.19 bc	0.87 a	0.04 ab	0.02 fg
T_8-ACT+75%CHM+25%PC	2.73 d	1.47 h	0.16 e	0.11 h	0.04 ab	0.03 ef
T_9-ACT+25%CHM+75%PC	2.83 bcd	1.03 k	0.21 a	0.53 c	0.04 ab	0.01 h
T_{10}-ACT+B.M.+75%CHM+25%PC	2.80 cd	1.67 g	0.20 abc	0.13 gh	0.04 ab	0.03 e
T_{11}-ACT+B.M.+25%CHM+75%PC	2.93 abc	2.57 c	0.18 cd	0.19 efg	0.04 ab	0.05 c
T_{12}-Control(NPK)	2.17 e	0.77 l	0.09 f	0.27 d	0.03 b	0.01 h
L.S.D. 0.05	0.165	0.086	0.018	0.057	0.009	0.008

Values with the same alphabetical letters, within a comparable group of means, don't significant differ, using L.S.D test at 0.05 level.

4. Conclusion and future prospects

Beneficial microbes (B.M.), Aerobic Compost Tea (ACT) , Chicken manure and plant compost are involved primarily in protection against diseases, resulting often, in improved plant growth, yield and eco-system health, the effects of beneficial microorganisms on potato cultivar (cv. Bamba). We conclude:

1. The potato tubers production require large quantities of resources (water, nitrogen, energy). Microbes in sustainable potato production systems may provide an alternative to high inputs of fertilizers.
2. Application of microbial additives to the soil must take as importance of microbial diversity especially in rhizosphere, to ensure a compatible combination, microbial community, for realistic and effective biotechnological applications, so organic and bio fertilizers appear to be the way forward.
3. Organic farming seems to be another way for yield enhancement and disease resistance in sustainable agriculture ecosystem. Currently, more attention could be paid to microbial diversity under this investigation, especially commercialization of beneficial microbes and ACT.
4. Potato tubers production require production of the organisms under commercial conditions while maintaining quality, stability, and efficiency of the products, compatibility with current application practices, cost, and safety testing (Marta *et al*., 2021).
5. Conducting field practical application of bio and organic fertlizers are another task which seems urgent and crucial, this will lead to improved understanding the composition of ACT, Beneficial microbial community, chicken manure and plant compost as a result, which might offer possibilities for advances in potato tubers production.
6. Following (Morales-Corts *et al*., 2018; Reeve *et al*. 2010 ; Marta *et al*., 2021; Ana *et al*., 2021; Abou El Goud *et al.*, 2021), the potential of ACT ,Beneficial microbes and plant compost for supplementing and additives of bio and organic fertilizers to the soil are still seem promising.

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