Effect of Some Bio-fertilizers on Growth, Productivity, Chemical Composition and Processing of Cassava Tubers

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ABSTRACT

Three types of bio- fertilizers along with the control were investigated in the present study to clarify their effects on vegetative growth and yield parameters of cassava cultivated at the two successive seasons 2014/2015 and 2015/2016. Moreover, Bio- fertilized cassava tubers along with counterpart control of the second season (2015/2016) were analyzed for the chemical composition, minerals, polyphenols and vitamin C along with estimation of organoleptic properties of boiled and fried cassava. The three types of bio fertilizer treatments included mixed algae (CMA), mixed algae extract (CMAE), and mixed bacteria (CMB) compared with the control treatment (CC). Results significantly revealed the highest values of the following parameters, in both growing seasons each in turn: plant height (CC, CMA and CMB); dry weight of plant (CC), total yield/plant (CC, CMA) tuber number plant (CC), tuber weight (CMA) and total yield/fed (CC) and (CMA). Cassava bio fertilized with mixed algae extract (CMAE) recorded the highest mean value of dry matter and the lowest moisture content. Meanwhile, the control sample (CC) exhibited the highest mean values in protein and crude fibers and CMA sample represented the highest content of fat and ash. Nitrogen free extract showed the highest content with CMAE and CMB samples. All studied cassava samples had a considerable amount of vitamin C ranged from 49.17 to 65.62 mg/100g dry weight whereas the highest amount was found in CMB sample followed by CC, CMA and CMAE, respectively and slightly little amount of polyphenols (42.27 - 67.35 mg/100g dry weight) and they were found in the highest amount in CC followed by CMB, CMA and CMAE samples respectively. All studied cassava samples are considered as good source of potassium whereas it ranges from 462.40 to 559.36 to mg/ 100g dry weight. Both fried and boiled products prepared from the studied cassava tubers were highly accepted by panelists.

Key words: Bio-fertilizers, Cassava tubers, Productivity, Chemical composition, Cassava processing, Organoleptic properties.

INTRODUCTION

Bio-fertilizers function as key player in sustainable agriculture by improving soil fertility, plant tolerance and crop productivity (Bhardwaj *et al.*, 2014). Biofertilizers are a large population of a specific or a group of beneficial microorganisms for enhancing the productivity of soil. In recent decades the use of chemical fertilizers has been a common practice, whereas bio-fertilizers were neglected but nowadays by reason of irregular application of chemical fertilizers and their detrimental effects on human and soil health, a lot of emphasis is being paid and organisms to provide nutrition requirement of plants (Astarai and Kochaki, 1996). A lot of emphasis is being paid to biofertilizers and it has emerged as one of the alternatives to application of chemical inputs for needs of fertilizers. Their use in agriculture in preference to chemical fertilizers offers economic and ecological benefits by improving soil health and fertility The characteristics of sandy soil play an important role in the plant's ability to extract water and nutrients. Therefore, the use of Bio fertilizers is a promising way to improve the physio-chemical conditions of sandy soils. However, the excessive use of NPK fertilizers create pollution of agro-ecosystem through contamination the underground water with nitrate and increasing NO_3 accumulation in food chain causing hazardous effects, as well as destroy micro-organisms and friendly insects, making the crop more disposed to diseases and reduced soil fertility (Fischer and Richter, 1984). The innovative view of farm production attract the growing demands of biological based organic fertilizers exclusive of alternative to agro chemicals (Raja, 2013 & Youssef and Eissa, 2014).

Cassava (*Manihot esculenta* Crantz) is a dicotyledonous plant belonging to the family of *Euphorbiaceae* (Enwere, 1998). Cassava cultures are found in numerous regions worldwide because of its resistance to adverse climate and soil conditions. It is an important economic crop cultivated in many tropical countries of South America, Africa and in parts of Asia, particularly Indonesia and Thailand (Niba *et al.,* 2002) where, it provides calories for millions of people (Lasekan *et al.*, 2004) and a high productivity per unit area (i.e., about 70 t/ha of fresh tubers; FAO, 1991). Cassava is a major staple food crop in most parts of Africa. Global production of cassava estimated at 192 million tons per annum (Moorthy *et al.,* 1996). Breeding programs with the aim of selecting high-yield, disease-resistant and lowcyanide varieties have been initiated in many countries (Padonou *et al.*, 2005). Cassava plays an important role in terms of food security and it is considered a complete plant, with roots rich in carbohydrates and leaves rich in provitamin A and vitamin C and protein as well as other nutrients (Wanapat, 2003; Fukuda, 2005 & Promkot and Wanapat, 2005). The root, apart from providing dietary energy is also an essential raw material in the textile, alcohol, paper, food, adhesives and animal feed industries. Cassava shows very efficient carbohydrate production per hectare. It produces about 250000 calories/hectare/d, which ranks it before maize, rice, sorghum, and wheat (Okigbo, 1980).Cassava can grow and yield reasonably well on soil of low fertility where production of most other crops would be uneconomical (Carter *et al.,* 1992)

Phytate in cassava is a storage form of phosphorus which is found in plant seeds and tubers (Dipak and Mukherjee, 1986). Phytic acid has the potential to bind calcium, zinc, iron and other minerals (Oke, 1990). On the other hand, phytate may play an important role as an antioxidant by complexing iron and thereby reducing free radical generation and the peroxidation of membranes, and may also act as an anticarcinogen, providing protection against colon cancer (Graf *et al.,* 1987). Therefore, interest in the assessment and manipulation of phytate contents, mineral and proximate composition in cassava breeding programs is increasing. Cassava is a good source of saponins. These phytochemicals may help lower unhealthy cholesterol levels in bloodstream. They do so by binding to the bile acids and cholesterol, thus preventing them from being absorbed through the small intestines. The antioxidant effects of saponins may help protect cells from damage by free radicals (Penh, 2015). The composition of cassava depends on the specific tissue (tuber or leaf) and on several factors, such as variety, geographic location, age of the plant, and environmental conditions. The tubers and leaves, which constitute 50% and 6% of the mature cassava plant, respectively, are the nutritionally valuable parts of cassava (Tewe and Lutaladio, 2004). The nutritional value of cassava roots is important because they are the main part of the plant consumed in developing countries. Cassava can be consumed in different ways. In many countries, cassava is handled similarly to potatoes, meaning they are eaten as mash, fried or boiled (Penh, 2015).

In Egypt, research information is quite scarce on response of cassava to application of bio fertilizers Therefore, the objective of this work is to study the effect of some different bio fertilization methods such, fertilization with bacteria, algae mixture, algae mixture extract on vegetative, yield parameters, chemical composition, minerals, ascorbic acid and polyphenols of cassava tubers and estimate the effect of studied bio fertilization methods on organoleptic properties of processed cassava.

MATERIALS AND METHODS

Cassava tubers (*Manihot esculenta* Crantz) type of Monihotaipi obtained from Ain Shams University were grown on the Research Farm of the Environmental Studies and Research Institute, University of Sadat City, Minofiya Governorate, Egypt, Longitude 30^{o} and Latitude 30^{o} 25`). The soil texture of the experimental site was predominantly sandy loam soil with water field capacity of 19.22%, welting point of 10.06%, and bulk density of 1.45 gm/cm^3. The soil of the trial plot was predominantly sandy loamy (75.5% sand, 8% cilt and 16,5% clay), well drained, low in P and K medium in Ca and Mg (1.2), 0.35% organic matter and 7,12: 7,33 pH, $CaCO_3$ 1.7%, Ec (1,114 ds/m) and the amount of salts in water was 768 ppm. Cassava was manually planted on15th March, 2014/2015 and 2015/2016 at .5m × 1.4m apart using cassava stem cuttings on one side of the ridge. The cuttings were similar in thickness and 25-30cm in length. The cuttings vertically inserted two thirds into the soil keeping one third of them over ground, then immediately irrigated after planting. The plots were arranged in a Randomized Complete Block Design (RCBD) with 3 replications. Each plot as an experimental unit area was (7,5 m 4.2 m = 31 m^2) consisted of three rows at 1.4 m apart. Plots were stalked off in the field and furrows opened and traditional fertilizer was applied for the control at the recommended dose (the first plot). All treatments were fertilized with 8 ton compost / fad. + 250 kg of mono calcium super phosphate were added during soil preparation before planting. The experiment included 4 fertilization treatments which were as follows:

1- CC: The control treatment as compost manure (its chemical analysis is presented in Table, 1) which was prepared by mixing plant materials of piece straw with fresh cattle manure and obtained from El-kalil Company in Tahrir city. Potassium carbonate, potassium silicate and potassium citirate were obtained from El-Gomhouria Company for chemical + 300 kg of ammonium sulphate and 200 kg of potassium sulphate were added per fed. but for the control CC nitrogenous, phosphorus and potassium fertilizers were added in three equal split doses at 30 days intervals starting from one month from transplanting. All of the other cultural practices were followed as recommended.

2- CMA: Cassava bio-fertilized with mixed algae (Acadian Sea plants % N-P-K (0.7 -0.2 – 17), seaweeds extract 20%, algenic acid 10%, manitol 4%, amino acid 4% Novascot., Canada(at the rate of 210 gm./fed.) + Green space % N-P-K (1.5 – 2-0) amino acids 6.5 % natural hormones 250 ppm, GSC Green Space for Chemicals IND, Egypt+ Citosan star powder % N-P-K (5- 5- 5) free amino acids 24% (200 cm/200 liter water, seaweeds extract 20%, OPAL (at the rate of 1 kg/ fed.).

3- CMAE: Cassava bio- fertilized with mixed algae extract (*Chlorella vulgaris* and *Anabaena oryzae*) prepared in microbial biotechnology Dept. Genetic Engineering and Biotechnology institute, Sadat City University

4- CMB: Cassava bio- fertilized with mixed bacteria *(Bacillus circulance* + *Azotobacter chroococcum* +*Azospirllium brasilenase* + *Bacillus megatrium*).

Microorganisms

Azospirillum brasilenase, and *Azotobacter chroococcum* were kindly obtained and prepared in Microbial Biotechnology Dept. Genetic Engineering and Biotechnology Institute, Sadat City University. While, *Bacillus circulans* and *Bacillus megatrium* strains were kindly provided from Central Laboratory of Organic Agriculture, Agricultural Research Center, Giza, Egypt. The *Azospirillum brasilenase* was inoculated and tested for purity on semi solid medium (Döbereiner *et al.*,1995. Atlas, 1997). Medium used to prepare *Azotobacter chroococcum* and *Bacillus* spp. was inoculated on LB medium (Bertani, 1951**)**. Four conical flasks, containing 500 ml suitable medium, were inoculated with ten ml of isolate and then incubated at 30°C for 4 days on a rotary shaker (150 rpm). Heavy cell suspensions containing about 10^8cell/ml of reference strains were diluted in 5.0 L irrigated water. Each plant was inoculated with 200 ml of the diluted suspension after 21 days of transplanting.

Algae cultivation

The green algae (*Chlorella vulgaris)* Beijerinck and *Anabaena oryzae* were taken from microbiology Lab., University of Sadat City. The algae were inoculated into BG11 medium at 25°C±1 (Stanier *et al.*, 1971). All flasks were kept at room temperature at (25± 1°C) under natural day and dark period for 25 days. Cultures were shaken three times daily (Sharma *et al.*, 2011). An aliquot 100 ml of algal culture containing appropriate two g of fresh weight were added to soil after 21 days of transplanting. Soil was inoculated with microorganisms (mixed algae and mixed bacteria) at the beginning of transplanting and thereafter every 21 days at six times, throughout the plant growth.

Recorded Data

Vegetative growth characteristics

Ten randomly chosen plants, in each plot, were tagged and the plant height (cm), number of stems/ plant and dry weight of branches /plant (g) were recorded after 210 days from transplanting, in both seasons.

Yield and its component of cassava tubers

Data were recorded on average of 10 random plants from each experimental plot at harvesting, 300 days from transplanting, in both seasons as follows: Number of tubers/plant, Total yield of tubers / plant, average tuber weight and total yield of tubers/fed. as calculated from plot yield

Analytical methods

Bio-fertilized cassava tubers along with counterpart control of the second season (2015/2016) were analyzed for the follow chemical and technological studies

Dry matter

Dry matter was determined according to Rimac- Brncic *et al.* (2004) by drying in a convection oven at 105°C until constant weight. Samples were weighed every 5 min until a constant weight was obtained.

Proximate chemical composition

All analysis were carried out in triplicates determination and expressed on dry weight basis. Moisture, crude protein, crude fat, crude fibers, and total ash were determined according to the AOAC (2003). Nitrogen- free extract (NFE) was calculated by difference.

Determination of ascorbic acid

Ascorbic acid was determined using 2,6 dichlorophenol indophenols dye from BDH company) according to AOAC (2003) standard methods (method No. 767.21, 2003), except that 4% oxalic acid in 8% glacial acetic acid was used as an extraction media for samples according to Plummer (1978).

Determination of polyphenols

Polyphenols were determined colorimetrically as tannic acid by Folin-Denis reagent method after extraction with methanol containing 0.1% HCl. according to AOAC standard methods (2003).

Minerals content

The minerals; Fe, Zn, Ca and Mg, Cu, Mn and P were determined according to the method described in AOAC (2003) which were determined using Perkin-Elmer 2380 Atomic Absorption Spectrophotometer. The Na and K were estimated by clinical flame photometer 410°C (Corning).

Organoleptic Properties

Colour, odour, taste, texture and over all acceptability of boiled and fried cassava samples were evaluated by ten panelists of Food Science and Technology Department, Faculty of Agriculture, Alexandria University, Egypt, the panelists were asked to score the aforementioned

Table 1: Chemical analysis of the compost manure during 2015 and 2016 seasons

Compost Manure	weight of m^3 (Kg)	pH	EC% (ds/m)	organic matter	C:N Ratio%	Huml value	Total N%	Total P%	Total K%	Fe ppm	Zn ppm	Mn ppm
2014/2015	625	7.4	4.7	32.5	18.2	23.15	1.22	0.65	1.14	1491	42	162
2015/2016	631	7.6	5.4	30.4	18.5	22.92	1.31	0.77	1.25	768	52	174

properties according to a standard hedonic rating scale from 9 (like extremely) to 1 (dislike extremely) according to Kramer and Twigg, (1970).

Technological methods

Cassava samples under study were washed, hand-peeled using stainless steel knives to remove a thin outer layer of peel and the peeled tubers were divided into two parts

1- Frist part was cut along the long axis with a manual operated cutter into a dimensions (9 x 9 x 60 mm strips) and deep fried at 180°C for 10 min until desired golden colour was reached.
2- Second part was cut into cubes with dimensions (20 x 20 x 20 mm) and boiled in water at 90°C for 10 min.

Statistical analysis

Data were statistically analyzed using Randomized Complete Block Design (R.C.B.D). Comparisons between means were carried out using least significant difference at 0.05 probability level (LSD 0.05) according to Steel and Torrie (1980).

RESULTS AND DISCUSSION

Effect of bio-fertilizers on vegetative growth characters of cassava

Plant height

Table (2) shows effect of bio-fertilizers on vegetative growth of cassava crop during two seasons (2014/2015 and 2015/2016). No significant differences could be figured out regarding plant height among the CC (cassava tubers without any bio fertilizing treatment and recommended dose of mineral fertilizer (control), CMAE (cassava bio fertilized with mixed algae (Acadian 0.7 – 0.2 – 17 + Green space 1.5 – 2- 0 + Citolan star 5- 5-5) and CMB (Cassava bio fertilized with mixed bacteria *(Bacillus circulance + Azotobacter chroococcum+ Azospirllium brasilenase+ Bacillus megatrium*) the aforementioned treatments (CC, CMA, CMB) achieved significantly the highest plant height. This was true in the two seasons of growth investigated here. On the other hand, the CMAE (cassava bio fertilized with mixed algae extract (*anabaena* + *chlorella*) possessed significantly the least plant height in the two seasons as compared to the three treatments of bio- fertilizers applied in the present study. Meanwhile,, CMAE was not significantly different from CMB treatment regarding height of plants treated with bio- fertilizers. Such a trend was almost comparable in both growth seasons (2014/ 2015 and 2015/2016).The treatments can be ordered descendingly in terms of plant height as follows: CMA>CC > CMB >CMAE

Main stems number

No significant differences could be traced among the main stems number, in both seasons of the control along with the other three bio fertilizer treatments investigated in the present study (Table 2). However, the treatments can be ordered descendingly in terms of main stems number as follows: CC (cassava tubers without any bio fertilizing treatment and recommended dose of mineral fertilizer (control) >CMB (Cassava fertilized with mixed bacteria *(Bacillus circulance + Azotobacter chroococcum+ Azospirllium brasilenase+ Bacillus megatrium*) > CMA (Cassava bio fertilized with Mixed algae (Acadian 0.7 – 0.2 – 17 + Green space 1.5 – 2- 0 + Citolan star)and> CMAE(Cassava bio fertilized with mixed algae extract (*Anabaena* + *Chlorella*) in the first season. In the second season, the treatments can be ordered in this respect as follows : CMA > CMB> CMAE > CC.

Dry weight of plant

From the results in Table (2), it was obvious that the control exhibited significantly the highest dry weight of plant (1217 and 1265g) in the first and second seasons respectively, followed by CMA (1029 and 1027 g, in the two seasons, respectively). On the other hand, CMAE (941.1 and 786.79 g) and CMB (954.3 and 906.0 g) had significantly the least dry weight of plant in the first and second season respectively. The treatments investigated here along with the control can be ordered descending as follows in the first season: CC >CMA >CMB > CMAE. In the second season the order was as follows: CC > CMA>CMB > CMAE.

Table 2: Effect of bio- fertilizer on vegetative growth of cassava crop during two seasons (2014/2015 and 2015/2016)

Character	Plant height (cm)		Main stems number		Dry weight of plant (g)	
Treatment	First	second	first	second	First	Second
CC	149.56^{a}	157.8^{a}	2.67^{a}	2.11^{a}	1217^{a}	1265^{a}
CMAE	132.11^{b}	135.9^{b}	2.11^{a}	2.22^{a}	941.1^{c}	786.7^{d}
CMA	149.67^{a}	155.9^{a}	2.33^{a}	2.44^{a}	1029^{b}	1027^{b}
CMB	147.78^{ab}	154.1^{a}	2.44^{a}	2.33^{a}	954.3^{c}	906.0^{c}

Means in a column within treatment not sharing the same superscript are significantly different at $P \leq 0.05$

CC: Control cassava without any bio- fertilizing treatment CMA: Cassava bio- fertilized with mixed algae

CMAE: Cassava bio- fertilized with mixed algae extract CMB: Cassava bio- fertilized with mixed bacteria

Such a result can be explained on the basis that the sandy soils of the experimental sites have relatively low amounts of nutrients, thus the application of compost improved the physical, chemical and biological properties of the soil during the growing period. Data presented here regarding growth characters of cassava as influenced by bio fertilizer are in agreement with results obtained by Luo *et al.*, (.2008) and Shafeek *et al.*, (2012). These studies concluded that inoculation with mixture forms of bio fertilizer (*Azotobacter* spp, *Azisprillum* spp and *kelbsilla*) stimulated the vegetative growth of cassava plants in most studied parameters. These microbial inoculation stimulated plant growth either directly, by producing plant hormones and improving nutrient uptake, or indirectly, by changing the microbial balance in rhizosphere in favour of beneficial microorganisms (Amara *et al* ., 1995 & lazarovits and Nowak, 1997).

Effect of bio fertilizers on cassava yield

Total yield / plant

Data presented in Table (3) indicated that the control and CMA treatments were significantly comparable, since they gave the highest total yield / plant. In this regard, the control (CC) and CMA, were followed by CMB treatment. Data indicated that application of bio fertilizer in CMAE treatment significantly resulted in the least total yield / plant. Such a trend was clear, in both seasons. The descending order of treatments in terms of total yield / plant was: CC > CMA >CMAE

Tubers number/ plant:

Table (3) shows that the comparable control cassava (CC) significantly produced the highest average tubers number/ plant (10.14 and 8.22) in the first and second seasons, respectively. The control (CC) was followed by CMAE and CMB treatments, on contrary to CMA treatment which had significantly the lowest average tuber number (5.22 and 5.997) in the first and second seasons, respectively. No significant difference could be traced between CMAE and CMB regarding tubers number / plant in the first season and second seasons. The treatments under investigation can be ordered descendingly as follows: CC > CMAE > CMB > CMA.

Average tuber weight

Application of bio fertilizer in CMA treatment significantly gave the highest average tuber weight (422.49 and 398.71 g) followed by CMB treatment (383.13 and 317.36 g), in the first and second seasons respectively .In contrast, the control (CC) and CMAE treatment gave significantly the lowest average tuber weight. This was true, in both seasons (2014 /2015 and 2015 /2016). Therefore, the treatments under study can be ordered descendingly as follows: CMA > CMB > CC > CMAE. (Table 3).

Total yield

Table (3) shows that the control and CMA treatment significantly exhibited the highest total yield (Ton / fad.). The control (CC) and CMA treatment were followed by CMB treatment which gave 10.89 and 12.74 Ton / fad. in the first and second seasons, respectively. On the other hand, the CMAE significantly gave the lowest total yield as compared to the control and other treatments, being 8.88 and 9.17 Ton/ fed. in the first and second seasons, respectively. The treatments can be ordered descendingly as follows: CC > CMA >CMB > CMAE .

Data presented here concerning cassava yield and its components are in accordance with other authors. According to Cacciari *et al.* (1989), N- bio fertilizer bacteria enhanced the plant growth by N-fixing in the cultivated soil and / or contributing some growth hormones such as gibberellins, auxins and cytokinins. Recently, these beneficial effects were concordant with many investigators (Zhongyong *et al.,* 2006; Luo *et al.,* 2008 and Leaungvutiniroj *et al.,* 2010) on cassava plants.

It is worth to mention that, numerous research papers have been published regarding effects of seaweed (algae) bio-fertilizers on vegetative parameters of crops, other than cassava. Generally, application of such bio-fertilizers improved the vegetative parameters (Ghoneim *et al.,* 2009; Abdel-Mawgoud *et al.,* 2010[a]; Abdel-Mawgoud *et al.,* 2010[b] and Abd El-Aal *et al.,* 2015).

Table 3: Effect of bio fertilizer on yield and its components of cassava crop during the two seasons (2014/2015 and 2015/2016).

Character	Total yield/ Plant (g)		Tuber number/ plant		Tuber weight (g)		Total yield (ton/fed)	
Treatment	**First**	**Second**	**First**	**Second**	**First**	**Second**	**First**	**Second**
CC	2336.1[a]	2617.7[a]	10.14[a]	8.22[a]	232.34[bc]	289.2[bc]	13.35[a]	14.96[a]
CMAE	1554.0 [c]	1605.0[c]	7.49 [b]	7.11[b]	207.31[c]	225.82 [c]	8.88 [c]	9.17[c]
CMA	2199.7[ab]	2391.1[ab]	5.22 [c]	5.997 [c]	422.24 [a]	398.71 [a]	12.57[ab]	13.66 [ab]
CMB	1905.7 [b]	2229.0 [b]	6.77 [b]	6.67[bc]	283.13 [b]	317.36 [b]	10.89 [b]	12.74[b]

Means in a column within treatment not sharing the same superscript are significantly different at $P \leq 0.05$

CC: Control cassava without any bio- fertilizing treatment CMA: Cassava bio fertilized with mixed algae

CMAE: Cassava bio- fertilized with mixed algae extract CMB: Cassava bio fertilized with mixed bacteria

Effect of bio-fertilizers on moisture and dry matter content of cassava

Table (4) shows the effect of different bio-fertilizers used in the present study on each of moisture and dry matter content of cassava tubers. Results indicate that there were significant differences between studied cassava samples in moisture content and dry matter, whereas the control sample (cassava tubers without any bio- fertilizing treatment) represented the highest moisture content 64.84% followed by tubers bio- fertilized with mixed bacteria (CMB) 63.72%, mixed algae (CMA) 60.13% and mixed algae extract (CMAE) 59.55%, respectively. In contrast of moisture content, the descending order of dry matter content was, CMAE followed by CMA, CMB and CC, respectively. The percentage of moisture in cassava obtained in the present study is in agreement with that reported by Ekpenyong (1984), who found that moisture in cassava was 65.2%, meanwhile Ayankunbi *et al.* (1991) found that cassava moisture was 63.0%. Montagnac *et al.* (2009) reported the nutritional value of cassava root (100g) was follows:- Moisture 45.9 – 85.3(g) and dry weight 29.8 – 39.3(g/100g).

Table 4: Effect of bio- fertilizers on moisture and dry matter content of cassava tubers

Sample	% Moisture	% Dry matter
CC	$64.84^{a}\pm0.09$	$35.16^{d}\pm0.09$
CMA	$60.13^{c}\pm0.07$	$39.87^{b}\pm0.07$
CMAE	$59.55^{d}\pm0.11$	$40.45^{a}\pm0.11$
CMB	$63.72^{b}\pm0.12$	$36.28^{c}\pm0.12$

Means in a column not sharing the same superscript are significantly different at $P \leq 0.05$
CC: Control cassava without any bio- fertilizing treatment
CMA: Cassava bio- fertilized with mixed algae
CMAE: Cassava bio- fertilized with mixed algae extract
CMB: Cassava bio- fertilized with mixed bacteria

Effect of bio- fertilizers on chemical composition of cassava

Data in Table (5) illustrate the effect of used bio fertilization methods on chemical composition of studied cassava tubers (on dry weight basis). From this result, it could be concluded that all cassava samples under study had a noticeable amount of protein, ash, crude fibers with a little amount of fat. Protein content in studied samples ranged from 3.21 to 6.95 % (on dry weight basis), whereas the control cassava (CC) recorded the highest mean value of protein followed by cassava bio-fertilized with mixed algae (CMA), cassava bio-fertilized with mixed bacteria (CMB) and cassava bio-fertilized with mixed algae extract CMAE, respectively. All studied cassava tubers had a high amount of nitrogen free extract ranged from 79.82 to 86.61% (on dry weight basis) whereas CMAE and CMB significantly exhibited the highest amount of nitrogen free extract followed by CMA and CC treatment. The control cassava (CC) had the highest amount of protein, crude fibers and a middle amount of fat, ash and free nitrogen extract, meanwhile CMA sample had the highest amount of fat and ash with middle amount of protein and free nitrogen extract. Crude fibers were found in the highest concentration in CC sample followed by CMAE, CMA and CMB respectively. From obtained results it could be noted that cassava may be regarded as a rich source of carbohydrates on the ground that the difference in the varying bio- fertilization treatments resulted in a significant differences in chemical composition of cassava tubers. Obtained results are in agreement with those reported by Ekpenyong (1984), who found that cassava contained 0.28% fat, 4.31% crude protein, 2.58% fibers and 1.43% ash (on dry weight basis), but carbohydrate content was higher than our determination whereas it was 94.25%. Also, Bradbury and Holloway (1988) found that chemical composition of cassava was protein 1.89%, fat o.3% and ash 2.04% (on dry weight basis). Meanwhile, Buitrago (1990) found that the protein content in cassava is low at 1% to 3% on a DM basis and also Ayankunbi *et al*. (1991) reported that cassava is a cheap source of carbohydrate and it forms one of the staple foods for Nigeria. It can be processed into a number of acceptable foods and they found 2.7% ash, 3.24% protein in cassava and from 80% to 90% carbohydrates on a dry matter (DM) basis. Cassava roots are good and inexpensive source of carbohydrate (Berry, 1993).

Table 5: Effect of bio- fertilizers on proximate chemical composition of cassava tubers (on dry weight basis)

Sample	Protein	Fat	Ash	Crude fibers	NFE *
CC	$6.95^{a}\pm0.42$	$1.53^{c}\pm0.02$	$2.84^{b}\pm0.07$	$8.86^{a}\pm0.04$	$79.82^{c}\pm0.31$
CMA	$3.88^{b}\pm0.13$	$1.84^{a}\pm0.05$	$4.04^{a}\pm0.52$	$5.48^{c}\pm0.06$	$84.76^{b}\pm0.54$
CMAE	$3.21^{c}\pm0.03$	$1.61^{b}\pm0.04$	$2.30^{c}\pm0.03$	$6.27^{b}\pm0.74$	$86.61^{a}\pm0.71$
CMB	$3.71^{b}\pm0.12$	$1.65^{b}\pm0.03$	$2.93^{b}\pm0.04$	$5.14^{c}\pm0.30$	$86.57^{a}\pm0.4$

Means in a column not sharing the same superscript are significantly different at $P \leq 0.05$
*Nitrogen free extract (calculated by difference)
CC: Control cassava without any bio fertilizing treatment
CMA: Cassava bio- fertilized with mixed algae
CMAE: Cassava bio- fertilized with mixed algae extract
CMB: Cassava bio- fertilized with mixed bacteria

Gil and Buitrago (2002) clarified that the cassava root is a physiological energy reserve with high carbohydrate content, which ranges from 32% to 35% on a fresh weight (FW) basis, and from 80% to 90% on a dry matter (DM) basis. Eighty percent of the carbohydrates produced is starch. According to USDA (2007), chemical composition of cassava was protein 3.37%, total lipids 0.69%, ash 1.54% and carbohydrates 94.93% (DW).

Effect of bio fertilizers on vitamin C and polyphenols of cassava

Vitamin C and polyphenols content in cassava tubers under study are shown in Table (6) Data displayed that there was a noticeable amount of each of two components in all studied cassava samples. Vitamin C ranged from 49.17 to 65.62 mg/100 g on dry weight basis whereas the highest amount was found in CMB sample followed by CC, CMA and CMAE, respectively, while polyphenols in samples ranged from 42.27 to 67.35 mg/100 g dry weight basis and they were found in the highest amount in CC followed by CMB, CMA and CMAE samples respectively. Our data regarding vitamin C are relatively higher than that determined by Bradbury and Holloway (1988) who found that vitamin C in cassava was 44.08 mg/100g on dry weight.

Table 6: Effect of bio- fertilizers on polyphenols and vitamin C content of cassava tubers (mg/100g on dry weight)

Sample	Vitamin C	Polyphenols
CC	$63.85^{b}\pm0.65$	$67.35^{a}\pm0.25$
CMA	$58.84^{c}\pm0.56$	$48.35^{c}\pm0.14$
CMAE	$49.17^{d}\pm0.71$	$42.27^{d}\pm0.47$
CMB	$65.62^{a}\pm0.56$	$58.18^{b}\pm0.88$

Means in a column not sharing the same superscript are significantly different at $P \leq 0.05$

CC: Control cassava without any bio- fertilizing treatment

CMA: Cassava bio- fertilized with mixed algae

CMAE: Cassava bio-fertilized with mixed algae extract

CMB: Cassava bio- fertilized with mixed bacteria

Effect of bio- fertilizers on minerals composition of cassava

Results in Table(7) show significant differences between studied cassava samples in minerals content as a result of the impact of differences in the bio-fertilization treatments. Data in Table (7) reflected the considerable content of minerals in studied cassava tubers. These minerals included metals K, Ca, Na, Mg and many others. All cassava samples may be regarded as a rich source of potassium whereas it ranged from 462.40 to 559.36 mg/100 g (on dry weight) and it was found in the highest amount in the control sample (CC) followed by CMA, CMB and CMAE, respectively. Meanwhile, Na was found in the highest amount in CC followed by CMB, CMAE, and CMA samples, respectively. Also, Ca was found in all samples in a noticeable amount but the highest amount was found in CMB sample followed by CC, CMA and CMAE samples, respectively. In addition, phosphorus was found in all samples in a noticeable amount where, it is found in CMB sample in the highest amount flowed by CMAE, CC and CMA samples respectively, with amount ranged from 70.57 to 93.69 mg/100g dry weight. On the other hand, each of Mn, Zn, Cu were found in trace amounts in all studied cassava samples. Obtained results about minerals composition of cassava are in agreement with Okigbo (1980) who reported that cassava have calcium, iron, potassium, magnesium, copper, zinc, and manganese contents comparable to those of many legumes, with the exception of soybeans. The calcium content is relatively high compared to that of other staple crops and ranges between 15 and 35 mg/100 g edible portion. Bradbury and Holloway (1988) found that the mineral composition of cassava as mg/100g dry weight was Ca (56.2), P (91.7), Mg (85.79), Na (23.96), K(704.14), Fe(0.82), Cu (0.38), Zn(1.36) and Mn (0.177). Also, according to USDA (2007) minerals composition of cassava tubers (mg/100g on dry weight basis) was as follows: Ca (39.68), Fe (0.66), Mg (52.08), P (66.96), K(672.12), Na(34.72), Zn (0.84), Cu (0.25) and Mn (0.95). Penh (2015) reported that cassava is a good source of minerals such as calcium, phosphorus, manganese, iron and potassium. These minerals are necessary for proper development, growth and function of human body’s tissues.

Effect of bio- fertilizers on organoleptic properties of fried and boiled cassava

Table (8) shows the organoleptic properties of fried and boiled products prepared from studied cassava tubers. Presented data confirmed that all panelists accepted boiled and fried cassava samples and gave high scores for colour, taste, odour, and texture, that means that all prepared samples from cassava were highly accepted by panelist. The boiled samples slightly had higher values than fried ones which confirmed the more acceptability of boiled cassava compared with fried ones. Regarding the effect of bio- fertilizers on cassava processing, data reflected significant differences in organoleptic properties of fried samples whereas CC, CMA, CMB samples gained the highest values for colour, meanwhile; CMA, CMAE and CMB had the highest values in taste. All fried samples had approximately the same values in odour, texture and overall acceptability. Also, there were significant differences between boiled samples in each of colour, taste, odour and texture, The CC and CMA samples recorded the highest values for colour, but all samples were highly accepted regarding taste and texture. On contrary, CMB being the best one in odour. In this respect Safo-Kantaka *et al.* (2002) reported that the sensory quality of cassava is an important factor for the acceptance of new improved cultivars by farmers.

Table 7: Effect of bio fertilizers on minerals composition of cassava tubers (mg/100 g dry weight)

Minerals	Sample			
	CC	CMA	CMAE	CMB
Na	$62.92^{a}\pm0.2$	$25.89^{d}\pm.46$	$40.98^{c}\pm0.52$	$35.96^{b}\pm0.35$
K	$559.36^{a}\pm0.73$	$512.16^{b}\pm1.5$	$462.40^{d}\pm0.4$	$506.18^{c}\pm0.7$
Ca	$61.77^{b}\pm0.46$	$50.37^{c}\pm0.73$	$48.38^{d}\pm1.2$	$63.74^{a}\pm0.52$
Mg	$18.34^{d}\pm0.71$	$29.14^{b}\pm0.17$	$29.81^{a}\pm0.56$	$19.93^{c}\pm0.05$
Fe	$1.89^{b}\pm0.23$	$4.15^{a}\pm0.32$	$3.23^{a}\pm0.15$	$3.32^{a}\pm0.19$
P	$71.33^{c}\pm0.9$	$70.57^{c}\pm0.78$	$91.21^{b}\pm08$	$93.69^{a}\pm0.24$
Cu	$2.41^{a}\pm0.38$	$1.75^{b}\pm0.56$	$0.73^{c}\pm0.06$	$1.31^{b}\pm0.03$
Zn	$1.18^{c}\pm0.04$	$1.58^{a}\pm0.02$	$1.44^{b}\pm0.03$	$1.11^{c}\pm0.13$
Mn	$0.053^{b}\pm0.007$	$0.049^{b}\pm0.002$	$0.091^{a}\pm0.002$	$0.047^{b}\pm0.003$

Means in a row not sharing the same superscript are significantly different at $P \leq 0.05$

CC: Control cassava without any bio- fertilizing treatment CMA: Cassava bio- fertilized with mixed algae

CMAE: Cassava bio- fertilized with mixed algae extract CMB: Cassava bio- fertilized with mixed bacteria

Table 8: Effect of bio fertilizers on organoleptic properties of fried and boiled cassava

Sample	Colour	Taste	Odour	Texture	Over all acceptability
			Frying treatment		
CC	$7.0^{a}\pm0.87$	$6.0^{b}\pm0.66$	$7.5^{a}\pm0.75$	$5.92^{ab}\pm0.85$	$7.21^{b}\pm1.2$
CMA	$7.21^{a}\pm1.3$	$7.8^{a}\pm1.4$	$7.42^{a}\pm0.98$	$6.85^{b}\pm1.5$	$7.92^{b}\pm0.86$
CMAE	$6.0^{b}\pm0.6$	$7.8^{a}\pm1.2$	$6.92^{a}\pm1.3$	$6.85^{b}\pm1.1$	$7.14^{b}\pm1.1$
CMB	$7.78^{a}\pm0.8$	$7.1^{a}\pm1.4$	$7.21^{a}\pm1.4$	$7.57^{a}\pm1.5$	$8.92^{a}\pm1.6$
			Boiling treatment		
CC	$8.0^{a}\pm0.7$	$7.33^{a}\pm1.1$	$7.0^{b}\pm1.2$	$7.66^{a}\pm1.11$	$7.44^{b}\pm0.88$
CMA	$7.77^{a}\pm0.83$	$6.88^{a}\pm1.2$	$7.2^{b}\pm0.7$	$7.55^{a}\pm0.88$	$7.22^{a}\pm1.3$
CMAE	$7.22^{b}\pm0.97$	$7.0^{a}\pm1.0$	$7.0^{b}\pm1.4$	$7.44^{a}\pm1.01$	$7.55^{a}\pm1.2$
CMB	$7.0^{b}\pm0.86$	$6.77^{a}\pm1.5$	$8.0^{a}\pm0.78$	$7.33^{a}\pm1.5$	$6.44^{b}\pm1.8$

Means in a column within treatment not sharing the same superscript are significantly different at $P \leq 0.05$

CC: Control cassava without any bio- fertilizing treatment CMA: Cassava bio- fertilized with mixed algae

CMAE: Cassava bio- fertilized with mixed algae extract CMB: Cassava bio- fertilized with mixed bacteria

CONCLUSIONS

The present study revealed the effect of some bio fertilizers such mixed algae, mixed algae extract and mixed bacteria species compared with the control cassava tubers on vegetative growth, yield parameters, chemical composition, minerals, polyphenols and vitamin C content. Organoleptic properties of processing cassava tubers were also estimated in preset study. Data obtained concluded that using of mentioned bio-fertilizers had a noticeable significant effect on all studied parameters whether in agricultural properties or in chemical and organoleptic properties. All studied cassava tubers with various bio-fertilization methods had high amount of carbohydrate and also contained reasonable amounts of other nutrients. All processed cassava samples either prepared by boiling or frying were highly acceptable by panelists. Obtained results indicate the possibility of replacement chemical fertilization by biological one to achieve greater safety.

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الملخص العربى

تأثير بعض الاسمدة الحيوية على النمو، الانتاجية، التركيب الكيماوى والخواص التصنيعية لدرنات الكاسافا

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اجريت هذه الدراسة على ثلاثة أنواع من الأسمدة الحيوية بالاضافة الى الكنترول لتوضيح مدى تأثيرها على صفات النمو الخضري والإنتاجية للكسافا المنزرعة في موسمين متتاليين (٢٠١٥/٢٠١٤ و٢٠١٦/٢٠١٥). تم أخذ العينات من موسم الزراعة الثانى(٢٠١٦/٢٠١٥) لدراسه تأثير استخدام هذه الأسمده على كل من التركيب الكيماوى ومحتوى المعادن والمواد الفينوليه وفيتامين ج لدرنات الكسافا مع تقييم الخواص العضويه الحسيه لكل من منتجات الكاسافا المسلوقه والمقليه. اشملت الدراسة على ثلاثة أنواع من معاملات التسميد الحيوي: مخلوط الطحالب (CMA)، مخلوط مستخلص الطحالب (CMAE)، مخلوط من السلالات البكتيريه(CMB) بالمقارنه بالكنترول(CC) وهى طريقه التسميد المعدنى التقليديه. وحققت المعاملات التالية أعلى القيم معنويا، في كل من موسمي الدراسة: ارتفاع النبات(CC، CMA وCMB)؛ الوزن الجاف للنبات (CC)، المحصول الكلي/ نبات(CC، CMA) عدد الدرنات/ نبات (CC)، متوسط وزن الدرنة(CMA) والمحصول الكلي/ فدان (CC). اما بالنسبة للتركيب الكيماوى فقد احتوت العينه التى تم تسميدها بمستخلص الطحالب (CMAE)على اعلى نسبه من الماده الجافه مع أقل نسبه من الرطوبة بينما كانت عينه الكنترول هي الأعلى فى نسبه البروتين والألياف الخام. أما العينه المسمده بمخلوط الطحالب (CMA) فقد احتوت على أعلى نسبه من الدهن والرماد. أظهرت النتائج أيضا احتواء جميع عينات الكاسافا موضع الدراسه على نسبه عاليه من المستخلص الخالى من النيتروجين حيث كانت النسبه الاعلى فى العينة التى تم تسميدها بمستخلص الطحالب(CMAE) وكذلك المسمده بمخلوط سلالات البكتيريا (CMB) يليها المسمدة بمخلوط الطحالب ثم الكنترول. أحتوت جميع عينات الكاسافا موضع الدراسه على كميات محسوسه من فيتامين ج والذى تراوحت نسبتة من ٤٩.١٧ – ٦٥.٦٢ مجم/ ١٠٠جم مادة جافة حيث تواجد بالنسبه الاعلى فى الدرنات المسمده بمخلوط البكتيريا ثم الكنترول يليه مخلوط الطحالب ثم الدرنات المسمده بمستخلص مخلوط الطحالب. تراوح محتوى الدرنات من المواد الفينولية من ٤٢.٢٧ – ٦٧.٣٥ مجم/١٠٠جم مادة جافة وكانت النسبة الاعلى فى درنات الكنترول ثم الدرنات المسمده بمخلوط البكتيريا يليها المسمدة بمخلوط الطحالب ثم الدرنات المسمده بمستخلص الطحالب حيث مثلت الاخيرة أقل العينات فى محتوى المواد الفينوليه. تعتبر جميع عينات الكسافا المدروسة مصدر جيد للبوتاسيوم حيث تراوحت نسبته من ٤٦٢.٤٠ – ٥٥٩.٣٦ مجم/ ١٠٠جم وزن جاف. لاقت عينات الكاسافا المسلوقه والمقليه تقبلا لدى المحكمين بدرجات جيده ومتقاربة.