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Effects of Indigenous Microorganism Fertilizers (IMO), Effective Fertilizers (EM) and Mineral Fertilizers (NPK) on the Yield and Nutritional Value of Two Varieties of *Arachis hypogaea* Grown Locally in West Cameroon

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Abstract

This study was carried out with the aim of investigating the effect of indigenous microorganism (IMO), effective (EM) and mineral fertilizers (NPK) on the yield and nutritional value of groundnut (*Arachis hypogaea*) in Western Cameroon (Baboutcha-Fongam). The study was conducted during two consecutive years, using a completely randomized block design of 8 treatments repeated three times in each subblock. The sub-plots were enriched with 0, 10, 20 and 40 g corresponding to the treatment of EM and IMO respectively and 3.2 g of NPK in 2019. Subsequently, the best dose that resulted in excellent yields was repeated for the rest of the experiment in 2020. The yield parameters and nutritional value of the two varieties of *Arachis hypogaea* used in the two consecutive years increase with the contribution of the different doses compared to the control. Overall, a significant increase ($p < 0.001$) in these parameters was observed with the 20 g EM, 10 g IMO and 3.2 g NPK doses compared to the other doses. However, the evolution of the yields and nutritional parameters was not significant over time regardless of the treatment for the two varieties used. The difference between pod and seed yields of *A. hypogaea* plants fertilized with EM 20 g (2.15 ± 0.24 and 2.01 ± 0.23 t/ha) and plants fertilized with NPK 3.2 g (2.36 ± 0.65 and 2.04 ± 0.17 t/ha) was not significant.

On the other hand, there was a significant difference ($P \leq 0.05$) between plants fertilized with IMO 10 g (2.65 ± 0.17 and 2.24 ± 0.2 t/ha) and plants fertilized with EM 20 g and plants fertilized with NPK 3.2 g for both varieties during the two years combined. In addition to being local and therefore adapted to environmental conditions, IMOs could be a promising biological means for improving soil fertility in Cameroon.

Keywords

Arachis hypogaea, Biofertilizers, Mineral Fertilizers, Yield and Nutritional Value

1. Introduction

Peanut is a legume of the Fabaceae family, of the genus *Arachis* and is native to Latin America [1]. This genus includes more than 80 species in 9 sections [2]. The cultivated groundnut belongs to the section Arachis in which 29 species have been described and two subspecies: *Hypogaea* and *Fastigiata* [2]. In Cameroon, groundnuts are grown in the five (05) agro-ecological zones of the country, and occupy the first ranks in the hierarchy of speculations by producers and the speciation of this species has led to many varieties with ethnic affiliation [3].

Groundnuts are one of the main grain legumes consumed because of their importance in the eating habits of populations [4]. It is consumed either as seed after shelling the pods or as oil after crushing the seeds, in more or less elaborate forms (butter, pasta, flour, various confectionery), the use of groundnuts for the production of oil and flour is increasing in countries such as Senegal, Gambia, and Nigeria. This shows the importance of this crop in the national economy, which can serve both as a cash crop and as a food crop [5]. In addition, groundnuts contribute to self-sufficiency and food security, a source of lipids, proteins, mineral salts and vitamins A, B and C. In addition to its significant energy value, groundnuts have a high nutritional value due to their content of amino acids and essential fatty acids that cannot be synthesized by the human body [6] [7].

However, these energy and nutritional values vary from variety to variety and could be influenced by soil composition and the effect of amendments. The type of soil improver used and its composition could have an impact on nutritional and energy values, as the interest of fertilisers would be to increase the yield at harvest and improve crop quality. The need to improve crop productivity and quality is becoming a primary objective in the current context of desertification, deforestation and uncontrolled urbanization due to demographic pressure. To overcome this situation, soil fertility has been improved by using chemical inputs in industrialized countries. However, their harmful impact on the environment is no longer to be demonstrated. Research efforts have been increased on the biological components of soil dynamic microorganisms that are beneficial for plant growth [8]. These products include, indigenous microorganisms (IMOs) and effective microorganisms (EMs) [9]. IMO are beneficial members of the soil including filamentous fungi, yeast and bacteria collected from non cultivated soils near the area where they are applied. IMO is collected from the environment surrounding the farm and its use is aimed at protecting life and integrity of the natural world. However, a high degree of farm management needs to be put in place if maximum benefits from IMO need to be obtained [9]. EM consists of mixed culture of beneficial and naturally occurring microorganisms that can be applied as inoculants to increase the microbial density of soils and plants [10]. Research has shown that the inoculation of EM cultures to the soil/plant ecosystem can improve soil quality, soil health and the growth, yield and quality of crops [11]. Thanks to their role as mineralizers, they increase soil fertility, while making them less prone to compaction and erosion [12]. These microorganisms increase nutrient availability to host plants and increase water holding capacity [13]. However, they differ in terms of the number and types of microorganisms [14] [15]. In terms of cost, IMO is more cost-effective than EM [16]. EM contains well-combined microorganisms that produce a symbiotic and mutualistic interaction between the constituent microorganisms [11]. In contrast, IMO microorganisms do not have a mutualistic and synergistic effect like those of EM, as they are collected by chance [14]. Given these differences, it is obvious that the comparison of the effects of ME and IMO on crop productivity and nutritional values will vary according to these differences and that it will be difficult to say precisely which fertilizer will produce the best results in the soil types. In addition, the data explaining the behavior of these biofertilizers are little known in Cameroon. This is why this work was initiated and had the general objective of evaluating the effect of native microorganism (IMO) and effective (EM) fertilizers on the yield and nutritional value of *Arachis hypogaea*.

2. Materials and Methods

2.1. Geographical Location of the Study Site

Baboutcha-Fongam is a grouping located in the Haut-Nkam Department and in the Baku District, it extends between 5˚17' N latitude and 10˚10' E longitude with an altitude of 700 m (**Figure 1**). Its climate is tropical hot and humid. It is characterized by two seasons with a long rainy season (about 9 months) that runs from March to November and a short dry season that runs from December to February. The average annual rainfall was 3687 mm. The monthly temperature ranges from 24.8˚C in July and August to 27.7˚C in February with an annual average of 26.4˚C. Relative humidity ranges from 61.5% in May to 87.8% in August with an annual average of 77.5% Source: [17].

2.2. Collection of Microorganisms for the Preparation of the IMO Biofertilizer

The microorganisms at the study site were isolated according to the method of [18], using local material using previously. cooked rice as a carbon source, then introduced into the 50 cm × 50 cm × 12 cm wooden boxes and deposited in pockets of about 30,000 cm^3 at the experimental site for 7 days according to the method of [18] (**Figure 2**).

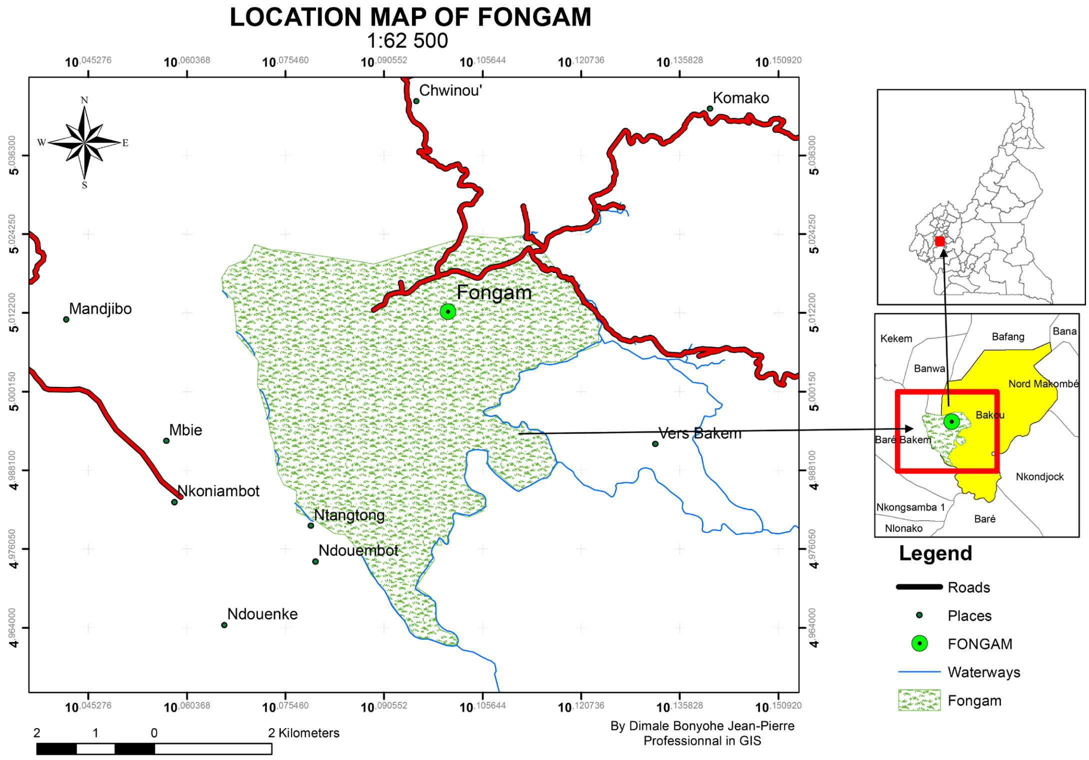

Figure 1. Location map of Baboutcha-Fongam: Source: [17].

(a) Box containing pre-cooked rice; (b) Box covered with foliage buried on the ground; (c) Box containing rice covered with white mold after 7 days of burial.

Figure 2. Procedure for collecting microorganisms.

2.2.1. Formulation of IMO Biofertiliser

After 7 days of fermentation, the rice was used as a carbon source was covered with the fungi. Brown sugar was added to this fermented rice in the same mass proportions and introduced into a pot placed away from light for 7 days. Wheat bran was then added to this mixture for a new fermentation away from the sun for a better proliferation of microorganisms (**Figure 3**).

(a) box containing rice covered with white mould after 7 days of burial; (b) blond sugar; (c) mixing rice covered with white mold with blond sugar; (d) clay pot 2/3 full of the mixture; (e) riddling of IMO to lower the temperature.

Figure 3. Growing manure IMO.

2.2.2. Preparation of Effective Microorganism Fertilizers

(a) 1l molasses and EM; (b) blond sugar; (c) molasses mixture, EM, blond sugar, rice and wheat husk.

Figure 4. Procedure for preparing EM manure.

The EM biofertilizer was prepared by the method of [19]. 50 kg of rice husk were mixed with 50 kg of wheat and then homogenized. In a plastic bowl, 1 kg of brown sugar was introduced and mixed with 2 L of hot water for a complete and fast dissolution of the sugar. This step is followed by the addition of 1 L of the EM solution. The mixture was homogenized by stirring by hand, distilled water was added to complete the volume at 20 L. A hole was made in the middle of the rice husk and wheat mixture, then the solution consisting of EM and sugar was introduced gradually while stirring several times with a shovel and hand until the mixture was completely homogenized. Humidity was controlled by squeezing a quantity of fertilizer into the hand and gradually stirring it from time to time until the moisture content varied between 30% and 40%. The mixture was covered with a tarpaulin for seven days. After day 7, the smell of fermentable sugar indicates that the EM fertilizer is ready for use (**Figure 4**).

2.3. Determination of the Effect of IMO and EM Fertilizers on the Agronomic Parameters and Nutritional Values of Groundnuts

2.3.1. Preparation of the Experimental Plot

A 610 m^2 experimental plot was cleared, ploughed and divided into two blocks for the two varieties of *A. hypogaea* (the local variety and the improved variety). Each block was divided into six sub-blocks of 7 m × 7 m each. Each sub-block is made up of five elementary plots of 1 m × 2 m representing the treatments. The sub-blocks were separated from each other by 1 m. A treatment is repeated three times in a sub-block and each sub-block is repeated six times.

2.3.2. Experimental Design

The experiments were conducted for two consecutive years in 2019 and 2020 in the field with a completely randomized block design of 8 treatments repeated three times in each subblock. The experimental sub-plots were enriched with 0, 10, 20 and 40 g corresponding to the treatment (T0, T1, T2 and T3) of EM and IMO respectively and 3.2 g of NPK (14.23.14) corresponding to the treatment (T4) in 2019. These fertilizers were buried in the ground one week before sowing and by surface application after sowing. Subsequently, the best dose that allowed for excellent yields was renewed for the rest of the experiment in 2020 for each fertilizer following the same experimental design. The spacing between subplots was 1 m and 0.4 m between the plants of *A. hypogaea*. Seeds were sown on sub-plots, at a rate of one seed per pocket at spacing of 40 cm × 40 cm with 10 plants per treatment [20].

2.3.3. Sowing and Crop Care

Sowing was carried out on the same day for all treatments, due to one seed per pocket at a depth of between 3 and 5 cm. From germination to the appearance of the first flowers, weeding was regularly carried out with a hoe, every two weeks in order to limit weed competition. Hilling was carried out between 45 - 50 days after sowing at the time of flowering to allow good penetration of the gynophores into the soil after fertilization and to limit diseases and pest attacks as much as possible [21].

2.4. Effects of Biofertilizers on Agronomic Parameters

2.4.1. Determining the Number of Pods Per Plant

After harvesting, the number of pods per plant was determined by manually counting each plot on 9 randomly selected plants.

2.4.2. Determining Pods and Seed Yields

After harvest, the pods from all plots were dried in the sun for two months, then weighed and the yield of the pods was calculated per hectare. The seeds were separated from the pods and sorted. The healthy seeds were weighed and their yield calculated according to the formula:

Pod yield = Total pod mass (t)/area (ha)

Seed yield = Total seed mass (t)/area (ha)

2.5. Effects of Biofertilizers on the Nutritional Values of Groundnuts

Biochemical parameters were determined on the seeds of each variety. After harvest, the seeds were removed from the pods per treatment and put in the oven at 45˚C for 72 h for biochemical assays of proteins, carbohydrates, fibres, lipids, and the determination of mineral elements (nitrogen, phosphorus, potassium, magnesium, calcium sodium, zinc, iron). This makes it possible to assess the importance of these fertilizers on the nutritional values of *A. hypogaea* (**Figure 5**).

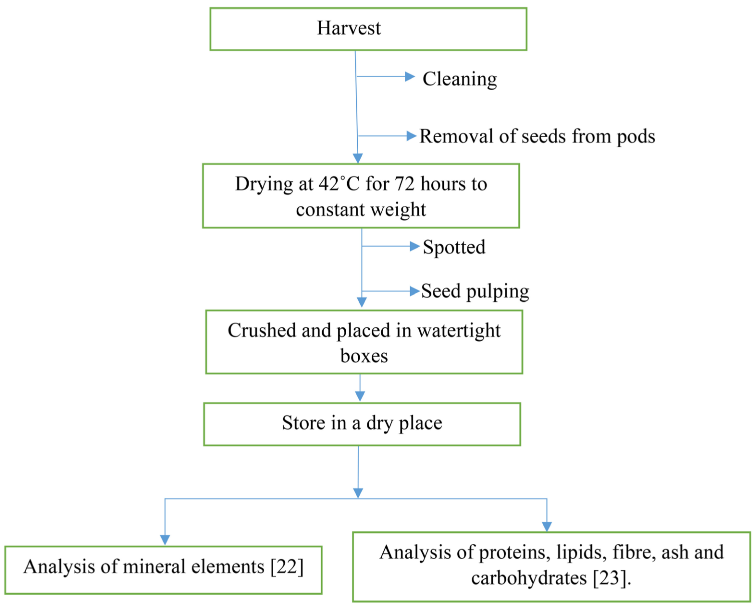

Figure 5. General scheme for treating *Arachis hypogaea* seeds to determine nutrients. [22] [23].

2.6. Statistical Analysis

The data were entered into an Excel sheet (Microsoft Office, USA) and analyzed with StatView version 5.0 (SAS Institute, Inc., USA) and GraphPad Prism 5.0 (GraphPad PRISM IBM, California, USA). Data were presented as a mean ± standard deviation (SD) in graphs and tables. One-way ordered analysis of variance (ANOVA) was used to make comparisons of these parameters. Dunnett's test and Student's t-test on unmatched series were then used to make the two-by-two comparisons. Repeated measures ordered analysis of variance (ANOVA) was used to investigate the variation in these parameters between follow-up weeks. The nonparametric tests of Mann-Whitney, Wilcoxon, and Kruskal Wallis were used to compare mean values when the assumptions of the tests cited above were not met. The significance threshold has been set at p-value < 0.05.

3. Results

3.1. Influence of IMO and EM on Agronomic Parameters

Table 1. Influence of fertilizers on agronomic parameters in Baboutcha-Fongam.

			Variété améliorée (JL24)			Variété locale (VL)		
Fertilisers	**Years**	**Doses (g)**	**Number of pods per plant**	**Pod yields (t/ha)**	**Seed yields (t/ha)**	**Number of pods per plant**	**Pod yields (t/ha)**	**Seed yields (t/ha)**
IMO	2019	0	25.33 ± 3.2^{e}	0.92 ± 0.3^{d}	0.85 ± 0.3^{d}	19 ± 2.65^{e}	0.86 ± 0.23^{d}	0.6 ± 0.05^{c}
		10	34.33 ± 2.52^{b}	2.3 ± 0.2^{b}	2.05 ± 0.3^{b}	27.33 ± 8.1^{b}	2.33 ± 0.2^{b}	$1.8 \pm 0{,}13^{b}$
		20	30.3 ± 5.1^{c}	2.2 ± 0.4^{b}	1.8 ± 0.1^{b}	27.67 ± 9.7^{b}	2.24 ± 0.1^{b}	1.74 ± 0.12^{b}
		40	25.7 ± 6^{e}	2.1 ± 0.3^{c}	1.7 ± 0.2^{b}	25.67 ± 4.2^{c}	2.2 ± 0.25^{b}	1.7 ± 0.1^{b}
	2020	0	28 ± 10.82^{d}	1.21 ± 0.12^{b}	1.1 ± 0.22^{c}	27.7 ± 8.51^{b}	0.71 ± 0.1^{d}	0.62 ± 0.03^{c}
		10	35.7 ± 2.5^{a}	2.99 ± 0.14^{a}	2.43 ± 0.1^{a}	29.7 ± 3.8^{a}	2.95 ± 0.62^{a}	2.12 ± 0.6^{a}
EM	2019	10	31 ± 3.5^{c}	1.6 ± 0.4^{c}	1.05 ± 0.04^{c}	24.67 ± 3.5^{c}	2.1 ± 0.1^{c}	1.7 ± 0.2^{b}
		20	34.33 ± 3.21^{b}	1.9 ± 0.03^{c}	1.99 ± 0.14^{b}	28 ± 5.3^{ab}	2.2 ± 0.85^{b}	1.7 ± 0.2^{b}
		40	20.3 ± 5.5^{f}	1.9 ± 0.4^{c}	1.4 ± 0.4^{c}	23 ± 1^{d}	2.2 ± 0.14^{b}	1.7 ± 0.1^{b}
	2020	20	35.3 ± 3.5^{a}	2.4 ± 0.5^{b}	2.02 ± 0.32^{b}	28.33 ± 9.1^{a}	2.02 ± 0.64^{c}	1.7 ± 0.4^{b}
NPK	2019	32	28 ± 10.82^{d}	2.3 ± 1^{b}	2.03 ± 0.24^{b}	27 ± 5^{b}	2.1 ± 0.31^{c}	1.74 ± 0.4^{b}
	2020	32	36 ± 2^{a}	2.42 ± 0.3^{b}	2.05 ± 0.1^{b}	29.7 ± 5.13^{a}	2.1 ± 0.4^{c}	1.85 ± 0.5^{b}

The means with the different letters are significantly different at the significance level (* = P < 0.05; ** = P < 0.01; *** = P < 0.001). According to the t-tests of Student, ANOVA and Dunnett.

The application of IMO, EM and NPK fertilizers had a positive impact on the yield parameters of the two varieties of *Arachis hypogaea* used in the two consecutive years. The number of pods per plant, the yield of pods and seeds increase with the contribution of the different doses compared to the control. Overall, a significant increase (p < 0.001) in these parameters was observed with the 20 g ME, 10 g IMO and 3.2 g NPK doses compared to the other doses in both varieties for the two consecutive years. However, the evolution of these parameters was not significant over time regardless of the treatment for the two varieties used. However, plants fertilized with IMO 10 g, EM 20 g and NPK 3.2 g produced similar pod counts per plant. In addition, plants fertilized with EM 20 g and those fertilized with NPK 3.2 g had similar pod and seed yields in the two consecutive years. The difference between pod and seed yields of *A. hypogaea* plants fertilized with EM 20 g (2.15 ± 0.24 and 2.01 ± 0.23 t/ha) and plants fertilized with NPK 3.2 g (2.36 ± 0.65 and 2.04 ± 0.17 t/ha) was not significant. On the other hand, there was a significant difference (P ≤ 0.05) between plants fertilized with IMO 10 g (2.65 ± 0.17 and 2.24 ± 0.2 t/ha) and plants fertilized with EM 20 g and plants fertilized with NPK 3.2 g for both varieties during the two years combined. Overall, the improved variety (JL24) and the local variety (VL) had similar yields. Indeed, the difference between plants fertilized with IMO 10 g (2.65 ± 0.17 and 2.24 ± 0.2 t/ha), EM 20 g (2.15 ± 0.24 and 2.01 ± 0.23 t/ha) and NPK 3.2 g (2.36 ± 0.65 and 2.04 ± 0.17 t/ha) respectively the pod and seed yields of the improved variety (JL24) and those of plants fertilized with IMO 10 g (2.64 ± 0.41 and 1.96 ± 0.37 t/ha), EM 20 g (2.11 ± 0.17 and 1.7 ± 0.3) and NPK 3.2 g (2.1 ± 0.36 and 1.8 ± 0.45 t/ha) respectively the pod and seed yields of the local variety (VL) was not significant during the two consecutive years (**Table 1**).

3.2. Influence of IMO and ME on the Nutritional Potential of *Arachis hypogaea*

The application of increasing rates of IMO, EM and NPK fertilizers on the micro and macro element contents of *A. hypogaea* seeds showed that these fertilizers significantly increase ($P < 0.001$) the concentrations of micro and macro elements in the seeds of *A. hypogaea* compared to the control of the two varieties used during the two consecutive years (**Table 2**) However, the seeds of the plants fertilized with IMO 10 g, EM 20 g and NPK 3.2 g allowed a significant increase ($P < 0.001$) in the micro and macronutrient contents in the seeds of *A. hypogaea* of the two varieties used compared to the other doses. Overall, there is a significant decrease ($P < 0.05$) in the micro and macronutrient contents in the seeds of the two varieties of *A. hypogaea* over time, with the exception of fibre, phosphorus (P) and sodium (Na^+) which increase significantly ($P < 0.001$) from 3.98 ± 0.05; 356.89 ± 0.1; 118.03 ± 0.01 in 2019 to 4.96 ± 0.06; 395.35 ± 0.1 and 174.72 ± 0.01 in 2020 for IMO fertilizer, Phosphorus (P) and Sodium (Na^+) which significantly increased by 336.69 ± 0.1; 118.03 ± 0.01 in 2019 to 410.75 ± 0.1; 174.72 ± 0.01 in 2020 for EM fertilizer and Fiber, Phosphorus (P) and Sodium (Na^+) which increased significantly by 3.98 ± 0.06; 341.18 ±0.1; 136.93 ± 0.01 in 2019 to 4.57 ± 0.06; 378.77 ± 0.1 and 155.83 ±0.01 in 2020 for NPK fertiliser representing the local variety (VL) respectively, and with the exception of proteins, nitrogen and iron, which increased significantly from 26.47 ± 0.12; 4.1 ± 0.01 and 2.8 ± 0.03 in 2019 to 31.20 ± 0.12; 4.99 ± 0.02 and 2.99 ± 0.04 for the fertilizer IMO, proteins, Nitrogen (N), Iron (Fe) and Phosphorus (P) which significantly increase by 25.52 ± 0.12; 3.77 ± 0.01; from 2.7 ± 0.03 and from 395.04 ± 0.1 in 2019 to 31.38 ± 0.12; 5.02 ± 0.02; 3.16 ± 0.04 and 410.19 ± 0.1 for EM fertiliser and with the exception of proteins, nitrogen and iron, which increase significantly from 26.47 ± 0.12; 4.1 ± 0.01 and 2.8 ± 0.03 in 2019 to 31.20 ± 0.12; 4.99 ± 0.02 and 2.99 ± 0.04 for NPK fertilizer respectively for the improved variety (JL24). Overall, the seeds of plants fertilized with IMO 10 g had higher micro and macronutrient contents than those of plants fertilized with EM 20 g and NPK 3.2 g for both varieties. However, the seeds of plants fertilized with EM and those of plants fertilized with NPK had similar micro and macronutrient contents for both varieties. Overall, the improved variety (JL24) and the local variety (VL) had similar micro and macronutrient contents in the two consecutive years (**Table 3**).

Table 2. Influence of treatments on micro and macronutrient contents in the seeds of Arachis hypogaea improved variety (JL24) in 2019 and 2020 in Baboutcha-Fongam.

Fertilizers	Years	Doses (g)	Fibres %	Lipids %	Proteins %	N (mg/100 g)	Fe (mg/100 g)	P (mg/100 g)	Ca (mg/100 g)	Mg (mg/100 g)	Zn (mg/100 g)	K (mg/100 g)	Na (mg/100 g)	Ashes %	Glucide %
IMO	2019	0	3 ± 0.05^{f}	18.06 ± 0.05^{c}	18.95 ± 0.12^{f}	3.03 ± 0.01^{f}	1.98 ± 0.03^{e}	304.71 ± 0.1^{g}	176.12 ± 0.02^{g}	14.63 ± 0.01^{f}	0.79 ± 0.1^{f}	289.71 ± 0.1^{k}	99.14 ± 0.01^{d}	2^{a}	44.89 ± 1^{e}
		10	5.85 ± 0.05^{a}	21.06 ± 0.05^{a}	26.47 ± 0.12^{b}	4.2 ± 0.01^{b}	2.8 ± 0.03^{b}	434.31 ± 0.1^{a}	312.12 ± 0.02^{a}	38.93 ± 0.01^{b}	1.99 ± 0.1^{a}	319.75 ± 0.1^{i}	325.89 ± 0.01^{a}	1^{a}	69.92 ± 1^{a}
		20	3.98 ± 0.05^{c}	19.06 ± 0.05^{b}	22.02 ± 0.12^{e}	3.52 ± 0.01^{e}	2.02 ± 0.03^{e}	323.22 ± 0.1^{g}	248.12 ± 0.02^{d}	24.35 ± 0.01^{d}	1.85 ± 0.1^{ab}	299.71 ± 0.1^{j}	155.83 ± 0.01^{b}	3^{a}	49.72 ± 1^{d}
		40	3.79 ± 0.05^{d}	19.06 ± 0.05^{b}	21.57 ± 0.12^{e}	3.45 ± 0.01^{e}	2.64 ± 0.03^{c}	367.55 ± 0.1^{d}	248.12 ± 0.02^{d}	19.49 ± 0.01^{e}	1.13 ± 0.1^{d}	500.1 ± 0.1^{d}	155.83 ± 0.01^{b}	2^{a}	55.25 ± 1^{c}
	2020	0	2.02 ± 0.06^{g}	13.06 ± 0.05^{e}	6.27 ± 0.12^{g}	1 ± 0.03^{g}	1.89 ± 0.04^{f}	332.76 ± 0.1^{e}	144.12 ± 0.02^{h}	14.63 ± 0.01^{f}	1.13 ± 0.01^{d}	239.59 ± 0.1^{n}	99.14 ± 0.01^{d}	2^{a}	34.94 ± 1^{g}
		10	3.98 ± 0.06^{c}	19.06 ± 0.05^{b}	31.20 ± 0.12^{a}	4.99 ± 0.02^{a}	2.99 ± 0.04^{a}	410.19 ± 0.1^{b}	208.12 ± 0.02^{f}	19.49 ± 0.01^{e}	1.31 ± 0.01^{cd}	259.63 ± 0.1^{m}	99.14 ± 0.01^{d}	3^{a}	45.78 ± 1^{e}
EM	2019	10	3 ± 0.05^{f}	19.06 ± 0.05^{b}	23.59 ± 0.12^{d}	3.77 ± 0.01^{d}	2.41 ± 0.03^{d}	368.67 ± 0.1^{e}	240.12 ± 0.02^{e}	29.21 ± 0.01^{c}	1.03 ± 0.1^{de}	359.82 ± 0.1^{h}	99.14 ± 0.01^{d}	2^{a}	44.25 ± 1^{e}
		20	4.96 ± 0.05^{b}	21.06 ± 0.05^{a}	25.95 ± 0.12^{c}	4.15 ± 0.01^{c}	2.74 ± 0.03^{b}	393.91 ± 0.1^{b}	272.12 ± 0.02^{c}	58.37 ± 0,01^{a}	1.71 ± 0.1^{bc}	520.14 ± 0.1^{c}	155.83 ± 0.01^{b}	3^{a}	58.15 ± 1^{b}
		40	3.1 ± 0.05^{f}	18.06 ± 0.05^{c}	22.02 ± 0.12^{e}	3.52 ± 0.01^{e}	2.67 ± 0.03^{c}	327.15 ± 0.1^{cd}	240.12 ± 0.02^{e}	24.35 ± 0.01^{d}	1.58 ± 0.1^{c}	560.22 ± 0.1^{a}	99.14 ± 0.01^{d}	3^{a}	49.2 ± 1^{d}
	2020	20	4.18 ± 0.06^{b}	16.06 ± 0.05^{d}	26.92 ± 0.12^{b}	4.31 ± 0.02^{b}	3.13 ± 0.04^{a}	410.19 ± 0.1^{b}	304.12 ± 0.02^{b}	24.35 ± 0.01^{d}	1.23 ± 0.01^{d}	379.86 ± 0.1^{f}	118.03 ± 0.01^{c}	3^{a}	43.11 ± 1^{e}
NPK	2019	32	3.98 ± 0.05^{c}	19.06 ± 0.05^{b}	25.52 ± 0.12^{c}	4.08 ± 0.01^{c}	2.7 ± 0.03^{b}	395.04 ± 0.1^{bc}	304.12 ± 0.02^{b}	29.21 ± 0.01^{c}	1.78 ± 0.1^{b}	540.18 ± 0.1^{b}	155.83 ± 0.01^{b}	2^{a}	49.9 ± 1^{d}
	2020	32	3.89 ± 0.06^{c}	19.06 ± 0.05^{b}	31.38 ± 0.12^{a}	5.02 ± 0.02^{a}	3.16 ± 0.04^{a}	410.19 ± 0.1^{b}	264.12 ± 0.02^{c}	14.63 ± 0.01^{f}	1.29 ± 0.01^{d}	399.90 ± 0.1^{e}	118.03 ± 0.01^{c}	4^{a}	36.02 ± 1^{f}

The means with the different letters are significantly different at the significance level of (* = P < 0.05; ** = P < 0.01; *** = P < 0.001). According to Student's test.

Table 3. Influence of treatments on micro and macronutrient contents in seeds of Arachis hypogaea local variety (VL) in 2019 and 2020 in Baboutcha-Fongam.

Fertilizers	Years	Doses (g)	Fibre %	Lipid %	Proteins %	N (mg/100g)	Fe (mg/100 g)	P (mg/100 g)	Ca (mg/100 g)	Mg (mg/100 g)	Zn (mg/100 g)	K (mg/100 g)	Na (mg/100 g)	Ashes %	Glucide %
IMO	2019	0	2.91 ± 0.05^{d}	15.06 ± 0.05^{e}	21.58 ± 0.12^{j}	3.45 ± 0.01^{g}	2.11 ± 0.03^{f}	192.5 ± 0.1^{n}	128.12 ± 0.02^{g}	14.63 ± 0.01^{d}	1.1 ± 0.1^{c}	319.75 ± 0.1^{f}	61.35 ± 0.01^{g}	2^{a}	34.56 ± 1^{e}
		10	4.1 ± 0.05^{b}	22.06 ± 0.05^{a}	35.58 ± 0.12^{a}	5.69 ± 0.01^{a}	2.8 ± 0.03^{a}	356.89 ± 0.1^{e}	312.12 ± 0.02^{a}	24.35 ± 0.01^{b}	2.15 ± 0.1^{a}	540.18 ± 0.1^{a}	118.03 ± 0.01^{d}	2^{a}	47.84 ± 1^{b}
		20	3.98 ± 0.05^{b}	18.06 ± 0.05^{c}	31.2 ± 0.12^{d}	4.99 ± 0.01^{c}	2.15 ± 0.03^{f}	334.44 ± 0.1^{h}	240.12 ± 0.02^{d}	19.49 ± 0.01^{c}	2.15 ± 0.1^{a}	480.1 ± 0.1^{c}	99.14 ± 0.01^{e}	3^{a}	44.42 ± 1^{c}
		40	3 ± 0.05^{d}	16.06 ± 0.05^{c}	27.70 ± 0.12^{g}	4.43 ± 0.01^{e}	2.35 ± 0.03^{e}	319.86 ± 0.1^{k}	192.12 ± 0.02^{f}	19.49 ± 0.01^{c}	1.71 ± 0.1^{b}	419.94 ± 0.1^{e}	61.35 ± 0.0^{g}	4^{a}	42.99 ± 1^{c}
	2020	0	1.24 ± 0.06^{e}	13.06 ± 0.05^{f}	27.3 ± 0.12^{g}	4.36 ± 0.02^{e}	2.12 ± 0.04^{f}	375.96 ± 0.1^{c}	128.12 ± 0.02^{g}	4.91 ± 0.01^{f}	0.64 ± 0.01^{d}	419.94 ± 0.1^{e}	136.93 ± 0.01^{c}	3^{a}	34.29 ± 1^{e}
		10	4.96 ± 0.06^{a}	17.06 ± 0.05^{d}	32.95 ± 0.12^{b}	5.27 ± 0.02^{b}	2.18 ± 0.04^{a}	393.35 ± 0.1^{b}	176.12 ± 0.02^{f}	24.35 ± 0.01^{b}	1.31 ± 0.01^{c}	419.94 ± 0.1^{e}	174.72 ± 0.01^{a}	4^{a}	46.35 ± 1^{b}
EM	2019	10	3.98 ± 0.05^{b}	18.06 ± 0.05^{c}	30.76 ± 0.12^{e}	4.92 ± 0.01^{c}	2.57 ± 0.03^{c}	328.83 ± 0.1^{j}	248.12 ± 0.02^{b}	19.49 ± 0.01^{c}	1.1 ± 0.1^{c}	480.1 ± 0.1^{b}	80.24 ± 0.01^{f}	5^{a}	43.53 ± 1^{c}
		20	4.96 ± 0.05^{a}	19.06 ± 0.05^{b}	32.1 ± 0.12^{b}	5.13 ± 0.01^{b}	2.74 ± 0.03^{b}	336.69 ± 0.1^{g}	256.12 ± 0.02^{c}	43.79 ± 0.01^{a}	2.1 ± 0.1^{a}	520.14 ± 0.1^{a}	118.03 ± 0.01^{d}	2^{a}	57.77 ± 1^{a}
		40	3.79 ± 0.05^{c}	17.06 ± 0.05^{d}	28.58 ± 0.12^{f}	4.57 ± 0.01^{d}	2.31 ± 0.03^{e}	331.1 ± 0.1^{i}	216.12 ± 0.02^{e}	19.49 ± 0.01^{c}	1.25 ± 0.1^{c}	540.18 ± 0.1^{c}	80.24 ± 0.01^{f}	5^{a}	35.22 ± 1^{e}
	2020	20	3.98 ± 0.06^{b}	15.06 ± 0.05^{e}	27.62 ± 0.12^{g}	4.42 ± 0.02^{e}	2.74 ± 0.04^{a}	410.75 ± 0.1^{a}	216.12 ± 0.02^{e}	19.49 ± 0.01^{c}	1.09 ± 0.01^{c}	419.94 ± 0.1^{e}	174.72 ± 0.01^{a}	1^{a}	47.95 ± 1^{b}
NPK	2019	32	3.98 ± 0.05^{b}	18.06 ± 0.05^{c}	31.64 ± 0.12^{c}	4.92 ± 0,01^{c}	2.51 ± 0.03^{d}	341.18 ± 0.1^{f}	256.12 ± 0.02^{b}	24.35 ± 0.01^{b}	1.62 ± 0.1^{b}	520.14 ± 0.1^{b}	136.93 ± 0.01^{c}	1^{a}	40.44 ± 1^{d}
	2020	32	4.57 ± 0.06^{a}	17.06 ± 0.05^{d}	26.83 ± 0.12^{h}	4.29 ± 0.02^{e}	2.35 ± 0.04^{e}	378.77 ± 0.1^{d}	232.12 ± 0.02^{d}	9.77 ± 0.01^{e}	1.13 ± 0.01^{c}	419.94 ± 0.1^{e}	155.83 ± 0.01^{b}	4^{a}	40.8 ± 1^{c}

The means with the different letters are significantly different at the significance level of (* = P < 0.05; ** = P < 0.01; *** = P < 0.001). According to Student's test.

4. Discussion

4.1. Determination of the Influence of IMO and EM on Agronomic Parameters

Inoculation with IMO and EM fertilizers resulted in a significant increase in yield parameters (number of pods per plant, pod and seed yields) compared to the control. These results are due to the fact that EM and IMO are biofertilizers and that each has an important role in maintaining and improving the physicochemical and biological properties of the soil. These results are in agreement with those obtained by [13]. These authors showed that the application of these fertilizers (IMO and EM) to *Solanum tuberosum* plants increased the yield of the latter. In general, the application of EM fertilizers at the 20 g dose, IMO at the 10 g dose and NPK 3.2 g recorded the highest values of all these parameters of the two varieties used. These results show that these fertilizers act in lower doses. These inputs improve the level of soil fertility, in particular by reducing acidity and exchangeable aluminium levels and by increasing exchangeable element reserves [24].

This study also showed that the application of IMO and EM fertilizers above 500 and 1000 kg ha-1 respectively caused a decrease in yields. A negative response of plants for excess macronutrients has been explained by the plant's energy expenditure to transform and remove excess osmotic solutes associated with the accumulation of macronutrients, energy that would have been used for growth [20]. The local variety and the improved variety have similar yields, which could be explained by the fact that nutrient availability would depend on the concentration and synchronous release of nutrients with the needs of the crops.

In general, plants fertilized with IMO have a higher yield than those fertilized with EM. Plants fertilized with EM have a similar yield to those fertilized with NPK, this might be due to the fact that IMO and EM fertilizers act as background amendments by preventing rapid mineralization followed by leaching of organic matter which is an important source of mineral elements necessary for the proper development of the plants, which would in turn justify the yields obtained with NPK fertilizers. In addition, the study showed that IMO and EM fertilising products have properties comparable to those of NPK fertilisers and can replace the latter [25].

However, other experiments must be carried out in other sites with other varieties of groundnuts and even on other speculations, in order to be able to increase the effectiveness of these biofertilizers and promote them to farmers.

4.2. Determination of the Influence of IMO and ME on the Nutritional Potential of Groundnuts

Regarding the micro and macro nutrients contained in the improved (JL24) and local (VL) varieties, there was a significant difference between the treatments IMO, EM and NPK fertilizers compared to the control. This observation in general shows that the addition of these EM and IMO fertilizers improves the micro and macronutrient quality of the two varieties of groundnuts. The addition of different fertilizers would improve the mineral composition of the soil and greatly influence the mineral absorption of different varieties. These observations are consistent with those of [26] [27] who believe that the addition of high nitrogen levels facilitates the uptake of Ca and other minerals from the soil. These micro and macronutrient contents are significantly different from one treatment to another. However, the application of IMO, EM and NPK fertilizers at 10 g, 20 g and 3.2 g rates gives better results for the majority of the identified nutrients. [26] showed that treating soils with organic and organo-mineral fertilizers would promote increased uptake of N, P, K, Ca and Mg by plants. According to [28], an increase in NPK fertilizer content up to 150 kg would result in optimal concentrations of N and Ca^{2+} in *Abelmoschus esculentus*. These doses are therefore said to be effective and are those decided and recommended in the context of our study. Legumes are excellent sources of carbohydrates, protein, and fiber. The results obtained are higher than those found on legume varieties consumed in Ghana and Nigeria, with concentrations of 35.41% to 57.38% and 17.64% to 31.81% and 2.02% to 3.98% respectively for the JL24 variety. The protein, fat and carbohydrate content of the variety JL24 is 31.81%, 21.06% and 69.92% respectively. These values are almost similar to those of the VL variety, which are 22.06%, 35.58% and 57.77% respectively. Studies have reported similar values on cowpea varieties in Ghana from 20.37% to 25.28%, showing the protein richness of legumes [29] [30]. Lower values (10.44% to 13.06%) have been found by other authors [30]. These differences may be due to soil type, cultural practices, genetic and environmental factors [29].

During composting, the microbial community of IMOs is influenced by a number of factors such as available nutrients, humidity, temperature, pH and oxygen. And also the storage conditions and the growth of certain pathogens. Furthermore, the increase in yield can be attributed to the ability of these biofertilizers to compete with harmful microorganisms by producing not only nutrients for plant growth, but also inhibitory compound or secondary metabolites to lyse pathogenic microorganisms [13].

5. Conclusions

The response of the two varieties of *A. hypogaea* to IMO, EM and NPK fertilizers during the two fertilization years differed significantly for the yield parameters and nutritional values studied. In these cultural practices, the improved variety and the local variety have similar yields.

As far as mineral composition is concerned, the application of IMO, EM and NPK allowed an increase of these minerals in the seeds of both varieties of *A. hypogaea*. Thus, the seeds of *A. hypogaea* have considerable levels of essential nutrients, so consumption should be beneficial for human health and as green manures for smallholder agriculture.

All these results show that the use of organic fertilizers (IMO and EM) at 10 g and 20 g doses respectively, is a key element in the success of soil fertility improvement programs with a view to good agricultural yields on the one hand and good organoleptic qualities on the other hand and thus guaranteeing a balanced management of natural resources. In addition, IMO fertilizers have similar or even superior results to those produced by EM fertilizers and NPK mineral fertilizers, in addition to being local and therefore adapted to environmental conditions, IMOs could be a promising biological means for improving soil fertility in Cameroon.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Ferguson, M.E., Jarvis, A., Stalker, H.T., Williams, D.E., Guarino, L., Valls, J.F.M., *et al*. (2005) Biogeography of Wild Arachis (Leguminosae): Distribution and Environmental Characterisation. *Biodiversity and Conservation*, **14**, 1777-1798. https://doi.org/10.1007/s10531-004-0699-7

[2] Valls, J.F.M. and Simpson, C.E. (2005) Nuevas especies de Arachís (Leguminosae) de Brasil, Paraguay y Bolivia. *Bonplandia*, **14**, 35-63. https://doi.org/10.30972/bon.141-21387

[3] Essomba, N.B., Mekontchou, T. and Iroumé, R.N. (1998) Groundnut Production and Research in Cameroon. *Summary Proceedings* 1*st ICRISAT Regional Groundnut Meeting for West Africa*, Niamey, 37-39.

[4] Kouebou, C.P., Achu, M., Nzali, S., Chelea, M., Bonglaisin, J., Kamda, A., *et al*. (2013) A Review of Composition Studies of Cameroon Traditional Dishes: Macronutrients and Minerals. *Food Chemistry*, **140**, 483-494. https://doi.org/10.1016/j.foodchem.2013.01.003

[5] Tekam, M.L. (2016) Etude du stress salin sur la croissance, les caractéristiques physiologiques, biochimiques et agronomiques chez quelques variétés d'arachide (*Arachis hypogaea*). Thèse de Doctorat/PhD en Biotechnologie Végétal, Université de Yaoundé I, 99 p.

[6] Guèye, M. (1994) Approche modélisée pour l'évaluation de la campagne arachidière dans 12 bassins arachidiers: Le modèle ARABHY. Mémoire de fin d'Etudes, 40 p.

[7] FAO (2004) L'eau, l'agriculture et l'alimentation. Archives de documents de la FAO, département du développement durable, consulté le 5 mai 2020, 73 p.

[8] Higa, T. and Parr, J. (1994) Beneficial and Effective Microorganisms for a Sustainable Agriculture and Environment. International Nature Farming Research Center, 1-16.

[9] Helen, Leopold, G. and Gerry, G. (2006) A Handbook of Preparations, Techniques and Organic Amendments Inspired by Nature Farming and Adapted to Locally Available Materials and Needs in the Western Visayas Region of the Philippines. Nature Farming Manure. 137 p.

[10] Zimmermann, I. and Kamukuenjandje, R. (2008) Overview of a Variety of Trials on Agricultural Application of Effective Microorganisms (EM). Agricola. 17-26.

[11] Daly, M.J. and Stewart, D.P.C. (1999) Influence of "Effective Microorganisms" (EM) on Vegetable Production and Carbon Mineralization—A Preliminary Investigation. *Journal of Sustainable Agriculture*, **14**, 15-25. https://doi.org/10.1300/j064v14n02_04

[12] Narasimha, G., Sumathi, T., Janardhan, A., Srilakhmi, A. and Sai Gopal, D.V.R.

(2012) Impact of Indigenous Microorganisms on Soil Microbial and Enzyme Activities. *Archives of Applied Science Research*, **4**, 1065-1073.

[13] Muyang, R.F., Taffouo, V.D., Fotso, Nguepnang, N.E. and Mbouobda H.D. (2014) Impact of Indigenous Microorganism Manure on Soil Mineralization and Irish Potato (*Solanum tuberosum* L.) Productivity in Bambili, Cameroon. *International Journal of Development Research*, **4**, 2188-2193.

[14] Hiddink, G.A., van Bruggen, A.H.C., Termorshuizen, A.J., Raaijmakers, J.M. and Semenov, A.V. (2005) Effect of Organic Management of Soils on Suppressiveness to *Gaeumannomyces graminis* var. *tritici* and Its Antagonist, *Pseudomonas fluorescens*. *European Journal of Plant Pathology*, **113**, 417-435. https://doi.org/10.1007/s10658-005-5402-7

[15] Fosah, M.R., *et al.* (2016) Comparative Study of the Effects of Two Organic Manures on Soil Physico-Chemical Properties, and Yield of Potato (*Solanum tuberosum* L.). *Plant*, **4**, 1-7. https://doi.org/10.11648/j.plant.20160401.11

[16] Carandang, G.A. (2003) Indigenous Microorganisms: Grow Your Own Beneficial Indigenous Microorganisms and BioNutrients in Natural Farming. EM Application Manual for Asian Countries, Herbana Farms, 14 p.

[17] Park, H. and Duponte, W. (2008) How to Cultivate Indigenous Microorganism Manure. *Biotechnology*, **9**, 1-6.

[18] Higa, T. (1991) Effective Microorganism: A Biotechnology for Mankind. Sunmark Publishing Inc., 8-14.

[19] Wamba, F.O. (2016) Effet de la salinité, de la densité de semis, des associations culturales et des apports fractionnés des substances minérales et organiques sur le rendement et la valeur nutritionnelle de trois morphotypes de Voandzou (*Vigna subterranea* (L.) Verdc., Fabaceae) dans la zone littorale du Cameroun. Thèse, Université de Yaoundé I, 142 p.

[20] Wamba, O.F., Taffouo, V.D., Youmbi, E., Ngwene, B. and Amougou, A. (2012) Effects of Organic and Inorganic Nutrient Sources on the Growth, Total Chlorophyll and Yield of Three Bambara Groundnut Landraces in the Coastal Region of Cameroon. *Journal of Agronomy*, **11**, 31-42. https://doi.org/10.3923/ja.2012.31.42

[21] Pauwels, J.M., Van, R.E., Verloo, M. and Mvondo, Z.A. (1992) Manuel de laboratoire de pédologie. Méthodes d'analyses des sols et de plantes. Equipement, Gestion de stocks de Verrerie et de produits chimiques. L'AGCD, 267 p.

[22] DuBois, M., Gilles, K.A., Hamilton, J.K., Rebers, P.A. and Smith, F. (1956) Colorimetric Method for Determination of Sugars and Related Substances. *Analytical Chemistry*, **28**, 350-356. https://doi.org/10.1021/ac60111a017

[23] Ngueuleu, D.A., Muyang, R.F., Wamba, F.O., Ngotta, B.B., Tefouet, V.D., Nyemene, K.P.J., *et al.* (2021) Evaluation of Soils Fertility, Growth, Nutrient Uptake and Yield Traits of Peanut under Indigenous and Effective Microorganism Fertilizers in Sandy Ferralitic Soils in Douala, Cameroon. *African Journal of Agricultural Research*, **17**, 432-441. https://doi.org/10.5897/ajar2020.15075

[24] Christophe, J. (2004) Bouse: Historique, importance et écosystème. Thèse de doctorat vétérinaire, Université de Toulouse, 82 p.

[25] Makinde, E.A., Ayeni, L.S. and Ojeniyi, S.O. (2011) Effects of Organic, Organomineral and NPK Fertilizer Treatments on the Nutrient Uptake of *Amaranthus cruentus* (L) on Two Soil Types in Lagos, Nigeria. *Journal of Central European Agriculture*, **12**, 114-123. https://doi.org/10.5513/jcea01/12.1.887

[26] Imoro, Z.A., Khan, A.T. and Lawer, E.A. (2012) Effects of Organic and Inorganic

Fertilizers on Mineral Composition of *Cynodon dactylon*. *Greener Journal of Agricultural Sciences*, **2**, 323-328.

[27] Olaniyi, J.O., Akanbi, W.B., Olaniran, O.A. and Ilupeju, O.T. (2010) The Effect of Organo-Mineral and Inorganic Fertilizers on the Growth, Fruit Yield, Quality and Chemical Compositions of Okra. *Journal of Animal and Plant Sciences*, **9**, 1135-1140.

[28] Appiah, F., Asibuo, J.Y. and Kumah, P. (2011) Physical and Functional Properties of Bean Flours of Three Cowpea (*Vigna unguiculata* L. Walp) Varieties in Ghana. *African Journal of Food Sciences*, **5**, 100-104.

[29] Aaron, A.T., Robert, A., Adukpo, G.E., Diabor, E. and Kingsley, A.A. (2013) Assessment of Functional Properties and Nutritional Composition of Some Cowpea (*Vigna unguiculata* L.) Genotypes in Ghana ARPN. *Journal of Agricultural and Biological Sciences*, **8**, 2035-2045.

[30] Ouatara, S. (2008) Utilization des grains de Acacia macrostachya Reichend comme source de proteins dans l'alimentation des poulets de chair. Diplome d'Etudes Approfondies (DEA) en Gestion Intégrée des Ressources naturelles, 105 p.