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# IMPACT OF INDIGENOUS MICROORGANISM MANURE ON SOIL MINERALIZATION AND IRISH POTATO (*SOLANUM TUBEROSUM* L.) PRODUCTIVITY IN BAMBILI, CAMEROON

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**ABSTRACT**

Irish potato (*Solanum tuberosum* L) is one of the world's most consumed staple. It is eaten by more than a billion people worldwide. The amount of potato that is presently being produced in Cameroon is less than a third of the estimated production. An experiment was carried out in Bambili, North West Region Cameroon from March to June 2013 and 2014 in other to evaluate the effect of two organic fertilizers; Indigenous microorganism (IMO) and Effective microorganism (EM) manures on soil fertility improvement and productivity of Irish potato. A randomized complete block design of three treatments (IMO manure, EM manure and the control) and four replications was used. The study was carried out on the growth and yield of Irish potato and some soil analyses including C: N ratio, conductivity, pH and concentrations of $K^+$ and $Na^+$. Application of these fertilizers improves the plant growth and yield in different proportions. Plants treated with IMO manure had a significant increase in plant height (74.41 ± 19.44 cm), number of shoot (4.7 ± 2.36), leaf area (164.928 ± 37.18 $cm^2$) and the weight of tuber (241.64 ± 32.94 g). Plants treated with EM manure also had an increase in plant height (69.59 ± 17.05 cm), number of shoots (4.7 ± 2.30), leaf area (162.354 ± 48.26 $cm^2$) and weight of tubers (227.62 ± 44.58g). IMO manured soil had the highest $K^+$ and $Na^+$ concentration compared to EM and control with a positive and significant correlation between $K^+$ and $Na^+$ concentration and growth parameters in IMO plants. Thus, IMO manure improved the growth and productivity of *S. tuberosum* through a better mineralization and supply of nutrients (cations).



## INTRODUCTION

The world's population is growing at a rapid rate. In 2002, the population of Cameroon was estimated to be 15.3 million and is estimated to increase to 20 million by the year 2020 (FAO, 2004). Irish potato (*Solanum tuberosum* L.) is the world's fourth largest food crop after wheat rice and maize and it is an important source of food, employment and income in developing countries (FAO, 2008). This population increasingly deals with crop productivity. Due to sustainable agriculture, environmental protection is important. The increase in the use of chemical fertilizers has polluted the environment and the chemical residues in the food produced cause health problems to man and grazing animals. Unfortunately, human demands for survival and sustainability are a great challenge to meet up with. Agricultural output is fast becoming unfit for human survival and there is an urgent need to solve this problem. Agricultural output, being one of the most important means of energy supply, especially to man, other herbivores and omnivores needs an increase in supply to meet up with the growing population. Despite the increase in potato production in the tropics, yield is generally low (Fontem and Aighewi, 1991). There is need to improve its productivity especially in Cameroon where its yield varies from 3.3-6.7 t/ha (Njualem *et al.,* 2005). Soil quality is the key to a sustainable agriculture. Therefore a transition from chemical based farming systems to a more sustainable agriculture will depend largely on what farmers do to improve and maintain the quality of their agricultural soils. Application

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of organic matter positively affects the growth and development of plant roots and shoots (Ghosh *et al*., 2004). Microorganisms are used in agriculture for various purposes; as important components of soil amendments and compost, as legume inoculants for biological nitrogen fixation, as means of suppressing insects and plant diseases, to increase crop quality and yields (Higa, 1996). Effective microorganism (EM) is a commercial product containing selected species of microorganisms principally lactic acid bacteria and yeasts, and smaller numbers of photosynthetic bacteria, and they out compete with harmful pathogens while producing useful substances such as vitamins, enzymes, hormones amino acids and anti-oxidants (Higa and Parr, 1994). Indigenous microorganism (IMO) refers to organisms that enrich the nutrient quality of the soil including bacteria, fungi and cyanobacteria.

The benefits from IMO include; plant nutrition, disease resistance and tolerance to adverse soil and climatic conditions (Sumathi *et al*., 2012). IMO is collected from the environment surrounding the farm and its use is aimed at protecting life and integrity of the natural world (Mbouobda *et al.*, 2013). The use of chemical fertilizers in Cameroon to enhance the growth of plants have been successful but due to the fact that it, causes environmental pollution of which researchers use microbial methods and technologies in coordination with agricultural production in other to remediate it, (Reganold *et al*., 1990), it will be better for agriculture which is the backbone of Cameroon to be geared towards the use of IMO, and is a novelty for crop improvement. Therefore the objective of this study was to understand how IMO manure improves potato productivity through the analysis of some nutrients of cations in soil amended and tubers produced while EM was serving as a positive control.

# MATERIALS AND METHODS

### Location

The experimental was carried out from March to June 2013; then March to June 2014 at the research farm of the Higher Teacher Training College Bambili, University of Bamenda. It is found in Tubah sub-division, Mezam division of the North West region of Cameroon. It is located at latitude $5^0$ 99’ 0’’ north and longitude $10^0$ 15’00’’ east. It has a humid tropical climate with an annual rainfall of about 2200 mm. The temperature is about $20.67^0$C and an altitude of 900 m above sea level (Focho *et al.*, 2009).

### Land preparation

A piece of land 20 by 20 m was cleared, raked and ridges of 5 m by 0.75 m were formed. The experimental design used was the randomized completely block design (RCBD) with three treatments (EM manure, IMO manure and the control) and four replications.

### Preparation and application of manure

The IMO manure was prepared according to the method of Park and Du Ponte (2008) using local materials while EM manure was prepared according to the method of Higa (1991). The treatments were applied one week before planting, four and eight weeks after planting at a concentration of 38 g per hole. potato tubers that were green and had sprouted to about 2.5 cm were planted at a depth of 10 cm and a distance of 30 cm. Weeds were controlled manually and mulching was done at one month after the application of treatments. To control disease caused by Phytophthora, Manizan a fungicide was sprayed weekly from the 5th to the 12th week after planting.

### Evaluation of morphological parameters

The plant height was measured using a measuring tape from the base of the plant to the tip of the terminal bud beginning from four weeks after planting, every week for seven weeks according to the different treatment. The length and width of the leaf was also measured using the measuring tape. The leaf area index (A) was calculated using the following formula: $A = 0.75 \times L \times W$ (Ibeawuchi *et al*., 2007). Where A = Leaf area index; L = length of compound leaf and W = Width of compound leaf. The number of shoots per plant was also counted.

### Harvesting

Harvesting was done at twelve weeks after planting when all the leaves had turned yellow and started drying up. The weight of tubers was recorded per treatment.

### Soil collection and preparation for analysis

Soil samples were collected at the depth of 0 - 15 cm using a soil auger at different points then bulked before the application of the manures. This was done per treatment at one week before application; two weeks and six weeks after planting. These were air dried and sieved using a 2 mm sieve before analyses of pH, electrical conductivity, total potassium ($K+$), total organic carbon (TOC), total nitrogen content (TNC) and $Na+$ using the standard methods as described in Carter and Gregorich (2008).

### Data analysis

Data obtained was expressed as means ± SD and analyzed statistically using SPSS statistical software Version 17.0 (Spss Inc., Chicago). Significant difference between mean values was determined by using analysis of variance (ANOVA). Duncan Multiple Range Test (DMRT) was used to compare means at 0.05 level of significance.

# RESULTS

### Variation of the height of plants

It was observed generally that the height of the plants increased progressively from the fourth week to the eighth week for the control and to the tenth week for both EM and IMO treated plants. Plants treated with IMO manure had the highest plant height (74.41 ± 19.44 cm) which was significantly different from those of plants treated with EM manure (69.59 ± 17.05 cm) while the control plants had the lowest value (52.25 ± 15.09 cm) (Table1).

### Variation of the leaf area index

At 6 weeks after planting (WAP), plants treated with IMO manure had the highest value of leaf area index (164.928 ±

37.18 cm2), followed by those treated with EM manure (162.354 ± 48.26 cm2) and then the control plants (128.866 ± 49.48 cm2). There was no significant difference in the leaf area for all the three treatments at 9 WAP (Table 2).

**Table 1. Variation of the height of plants (cm) under different treatments over time (weeks)**

| Time (Weeks) | Control | EM | IMO |
|---|---|---|---|
| 4 | 24.58 ±9.51a | 27.32 ±9.72a | 25.155 ±9.41a |
| 5 | 42.673 ±9.16a | 47.195 ±7.50a | 47.76 ±10.60a |
| 6 | 48.306 ±10.62a | 55.565 ±9.55a | 52.635 ±9.55a |
| 7 | 49.285 ±14.03a | 59.105 ±11.41ab | 64.752 ±15.57b |
| 8 | 57.14 ±14.25a | 63.97 ±12.40ab | 68.31 ±14.84b |
| 9 | 56.153 ±17.88a | 65.965 ±14.20b | 65.445 ±16.52b |
| 10 | 52.246 ±15.09a | 69.59 ±17.05b | 74.41 ±19.44c |

Means with the same letter in the same line are not significantly different at $P \leq 0.05$ (DMRT)

**Table 2. Variation of the leaves area index under different treatments over time (weeks)**

| Time (Weeks) | Control | EM | IMO |
|---|---|---|---|
| 4 | 96.094 ±42.48a | 115.897 ±36.26a | 123.659 ±33.56a |
| 5 | 136.24 ±32.50a | 118.836 ±43.4a | 123.351 ±37.58a |
| 6 | 128.866 ± 49.48a | 162.354 ± 48.26b | 164.928 ±37.18b |
| 7 | 135.67 ±59.73a | 162.414 ±43.1a | 157.320 ±38.04a |
| 8 | 125.744 ±36.99a | 134.942 ±29.47ab | 152.693 ±42.66b |
| 9 | 132.806 ±55.2a | 128.197 ±40.29a | 126.876 ±31.59a |

Means with the same letter in the same line are not significantly different at $P \leq 0.05$ (DMRT)

## Variation of the numbers of shoots per treatment

From the results obtained it was noticed that plants treated with EM and IMO manure produced the highest number of shoots which were not significantly different (4.7± 2.30) and (4.7± 2.36) respectively while the control plants had the least (3.4 ± 1.35) (Fig. 1).

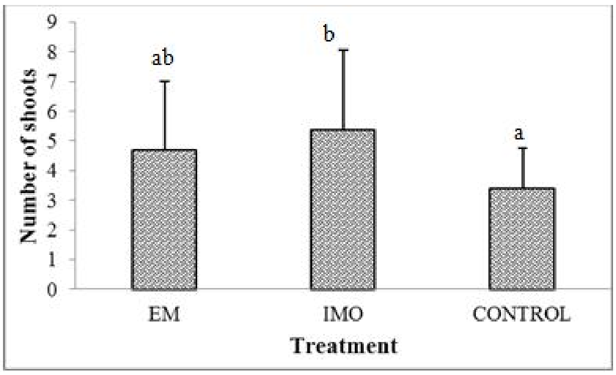


**Figure 1. Evaluation of number of shoots per treatment with time**

Histograms with the same letter are not significantly different at $P \leq 0.05$ (DMRT)

## Evaluation of the weight of tubers harvested

After harvesting, the fresh weight of tubers recorded showed that plants treated with IMO manure had the highest (241.64 ± 32.94g), followed by those treated with EM manure (227.62 ± 44.58g) and the least being the control (125.66 ± 31.63g) (Fig. 2)

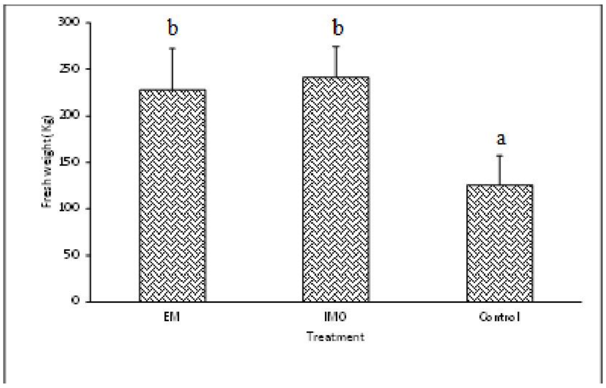


**Figure 2. Evaluation of the weight of tuber harvested under different treatments**

Histograms with the same letter are not significantly different at $P \leq 0.05$ (DMRT)

## Variation in some soil parameters

At week zero before application of treatments, IMO soil had the highest C/N ratio (37.02 mg.kg-1) followed by EM (33.2 mg.kg-1) and then the control (25.91mg.kg-1). At 2 and 6 WAP, that of the control and IMO treated soil increase meanwhile that of EM manure decreased (Table 3). The pH of the control soil dropped from 8.2 to 7.2 and to 7.3 at 0, 2 and 6 WAP respectively, that of EM manure moved from 8.11 to 6.64 and back to 7.17 while that of IMO manure changed from 8.36 to 6.12 and to 6.39. The control soil had the highest conductivity at week zero but dropped drastically at week two and six while at week two IMO manure soil had the highest. The K+ present in the control soil dropped from196.49 mg.kg-1 at week zero to 0.00 mg.kg-1 at 6 WAP. All the three treatments had a drop in Na+ present from 0 to 2 and 6 WAP.

## Correlation between plant morphological and soils parameters under different treatments

For the control plants, the plant height was strongly significant ($p < 0.01$) and positively correlated to the C/N ratio (1.000**) and pH (0.948**) of the soil, but significant and negatively correlated to the conductivity (-1.000**), K+ (-0.958**) and Na+ (-0.996**) of the soil (Table 4). The leaf area index (LAI) and the number of shoots at $p < 0.01$ level of significance were also significant and positively correlated to the C/N ratio but significant and negatively correlated to the conductivity, K+ and Na+ except for the number of shoots that was significant and negatively correlated to the K+ at p< 0.05(-0.978*). For plants treated with EM manure, the plant height and LAI were positive and significantly correlated to the C/N ratio and pH at $p < 0.01$ but significant and negatively correlated to conductivity, K+ and Na+. The number of shoots at p < 0.01was significant and negatively correlated to C/N ratio and Na+ while at $p < 0.05$ it was significant and positively correlated to the K+ (0.978*). Plants treated with IMO manure had their plant height significant and positively correlated to the C/N and pH, but significant and negatively correlated to the conductivity, K+ and Na+. The number of shoots at p< 0.05 was significant and positively correlated to the pH (0.908*) and negatively correlated to the pH.

**Table 3. Variation of some soil parameters under different treatments over time**

| Treatment | Week | C/N | pH | Cnd | K+ | Na+ |
|---|---|---|---|---|---|---|
| Control | 0 | 25.91 | 8.2 | 211.9 | 196.49 | 32.63 |
| | 2 | 34.168 | 7.2 | 45 | 4.74 | 17.67 |
| | | (24.162) | (13.89) | (-370.89) | (-4048) | (-84.67) |
| | 6 | 58.367 | 7.3 | 23.5 | 0.00 | 16.31 |
| | | (55.60) | (12.32) | (-801.70) | (-142962) | (-100) |
| EM | 0 | 33.2 | 8.11 | 478 | 359.81 | 72.69 |
| | 2 | 24.767 | 6.64 | 157.9 | 152.69 | 18.50 |
| | | (-34.04) | (22.14) | (-202.723) | (-135.65) | (-293.01) |
| | 6 | 25.182 | 7.17 | 30.6 | 13.02 | 18.81 |
| | | (31.84) | (13.11) | (-1462.1) | (-2663.0) | (-286.41) |
| IMO | 0 | 37.02 | 8.36 | 239 | 203.59 | 28.68 |
| | 2 | 70.815 | 6.12 | 332 | 156.25 | 18.75 |
| | | (-31.83) | (-36.61) | (28.01) | (-30.3) | (-52.95) |
| | 6 | 74.534 | 6.39 | 19.01 | 5.92 | 16.18 |
| | | (50.33) | (-20.64) | (-1157.23) | (-3339.0) | (-77.21) |

Values in brackets are coefficient of variation between week 0 and other weeks (2 or 6)

**Table 4. Correlation between morphological and soil parameters evaluated under different treatments**

| Control | C/N | pH | Cnd | K+ | Na+ |
|---|---|---|---|---|---|
| **Plant Height** | 1.000** | 0.948** | -1.000** - | 0.958** - | 0.996** |
| **LAI** | 1.000** | 0.963** | -0.989** | -0.976** | -0.939** |
| **N. Shoots** | 1.000** | 0.989* | -0.959** | -0.978* | -0.985** |
| **EM** | | | | | |
| **Plant Height** | 1.000** | 0.971** | -0.969** | -1.000** | 0.901** |
| **LAI** | 1.000** | 0.963** | -0.912** | -0.997** | 0.967** |
| **N. Shoots** | -1.000** | -0.974* | 0.967** | 0.978* | -1.000** |
| **IMO** | | | | | |
| **Plant Height** | 1.000** | 0.971** | -1.000** | -0.958** | -0.996** |
| **LAI** | -1.000** | -1.000** | 0.989** | 0.976** | 0.939** |
| **N. Shoots** | 1.000** | 0.908* | -0.934** | -0.951* | -0.947** |

C/N: Carbon Nitrogen ratio; Cnd: conductivity; K+: potassium ions; Na+: Sodium ions

## DISCUSSION

The results from this study showed that plant height increased gradually up to week 8 for plants of each treatment and then from week 9 to 10 for plants treated with EM and IMO manure. Plants treated with IMO manure had the highest height which was significantly different from those of plants treated with EM manure while the control plants had the lowest value. These differences in plant height might be attributed to the gradual release of essential nutrient elements required by Irish potato plants. EM and IMO manures continuously supply nutrients to plants which enhance growth. The microorganisms associated with these amendments enhanced the production of plant growth regulators (Arshad and Frankenberger, 1992). Plants treated with IMO manure had the highest value of leaf area index and number of shoots followed by those treated with EM manure and then the control plants. Increase in leaf area and shoot number could result to increase in the rate of photosynthesis. These could be explained by the advantage that IMO had over EM in term of adaptability despite its fewer number of microorganism (Daly and Stewart, 1999; Carandang, 2003) and growing within the same climatic and environmental conditions. EM therefore needs to adapt to their new area before performing their action. This result is in conformity with those obtained by Hoitink *et al*. (2006) in which beneficial microorganism in IMO significantly suppressed the activity of fungal pathogens in crops of mildly susceptible Rhododendron cultivars thereby enhancing growth. Depletion of nutrients during the cultivation period explains why control plants had the least plant height, leaf area index and number of shoot. Irish potato plants treated with IMO manure showed higher weight of tubers over those treated with EM manure and control. This could be due to adaptability of the soil biota with microorganisms found in IMO manure which led to enhanced growth. This result is in contrast to that of Yamada and Xu (2000) in which the highest productivity was obtain by plants treated with EM.

Looking at the effect of C:N ratio, pH, conductivity, potassium and sodium concentration on Irish potato growing under the influence of EM and IMO manure it was observed that each parameter had a different effect on the plants. Soil treated with IMO recorded a high C:N ratio at 2 WAP that increased at 6 WAP whereas those treated by EM and control. These high C:N observed in the soil amended with IMO manure was not in conformity with Brady and Weil (2008) who reported that the optimum C: N ratio for speedy decomposition of organic matter and subsequent mineralization is suppose to be less than 30. However, low mineralisation and decomposition rates are associated to high C: N ratio (Cesarz *et al*., 2013). Thus EM and control treatments with a C:N ratio below 30, was in the perfect conformity. This means that treatmens EM and control at the beginning contained more nitrogen in the proportion to the carbon; hence nitrogen was released into the soil from the decomposing organic matter for plant growth. This could be the reason why there was a positive and significant correlation ($P< 0.01$) between the C:N ratio and plant morphological parameters (plant height and leaf area) in the EM and control soil. However the high C:N ratio value recorded by IMO at the beginning could be explained by the lower mineralization of organic matter whereas the highest C:N ratio at the 6 WAP could be attributed to the growth of plants that reduce the initial nitrogen available in the soil rhizosphere that could induce the immobilization of soil nitrogen by soil microbial biomass for further decomposition (Daly and Stewart, 1999).

According to Sharma *et al*. (1995), nitrogen is one of the essential nutrients involved as a constituent of biomolecules such as nucleic acids, coenzymes and proteins and any deviation in these constituents would inhibit the growth and yield of plants. This could explained why a negative correlation at $P< 0.01$ between soil C:N ratio and LAI in IMO treated soil was recorded. Both treated soils were acidic respectively at 2 WAP which was ideal for optimum plant growth. The ideal pH level for most plant growth and adequate nutrient release should be within the range of 6.2 -6.8; at this level nutrients are readily available and if adequately supplied, plant growth is optimum. These pH values could be due to the presence of cations in high quantity in the soil rhizosphere at the beginning of the experiment. The pH values increased at 6 WAP around the neutral values. This may be due to the fact that, plants had absorbed the cations reducing their quantities inducing an increase in pH. Similar reports were made by Crozier and Hardy (2003) in which ammonium or urea in the chemical fertilizer speeds up the rate at which acidity develops. IMO treated soil had a higher conductivity over EM while the control soil had the least and these decreased considerably at six weeks after planting. The higher conductivity could be attributed to higher amount of salt (cation) contained in the soil that could be derived from the mineralization of IMO, and EM soil organic matter. The considerably decrease could be due to the gradual reduction of nutrients from soil to plant in other to enhance growth and productivity. At 2 WAP, IMO treated soil had a higher $K^+$ concentration over EM and decreased considerably at 6 WAP while the control had a very low $K^+$ at the beginning that decreased over time.

The high $K^+$ could be attributed to higher amounts of this cation in the soil rhizosphere due to the microorganism's action that supply soil with cation and other nutritive elements. The decrease in $K^+$ concentration could be due to the gradual removal of these cations by the roots of the plant for growth. The concentration of $K^+$ in the control soil decreased to zero because plants had abrorbed all the available $K^+$ for growth and was not replaced. IMO and EM manured soil almost had equal amount of $Na^+$ concentration higher than the control at two weeks after planting. It then decreased considerably at six weeks after planting for IMO manured soil and slightly for control while EM manured soil remained almost constant. This could be due to the fact that plants treated with EM manure and the control plants absorbed little amount of these cations while plants treated with IMO manure had absorbed a greatly amount suggesting why there was a positive correlation between $Na^+$ and morphological parameters suggesting that IMO plant needed $Na^+$ for growth and development.

**Conclusion**

IMO manure applied to the local environment does not only improved the growth of Irish potato but equally improves productivity through a better mineralisation and supply of nutrients (cations). Also plants grown with EM manure probably did not received a better supply of nutrients induced due to the non adaptability of EM in this area as a result of difference in climatic and environmental conditions. Further research should be done to know the appropriate quantity and time to apply IMO manure to the crop. The local community should be sensitised through workshops on the use of IMO to improve farming and thus alleviate poorverty.

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