Effects of NPK, Bio-Fertilizers and Manures on Growth of Maize (*Zea mays* L.) and Soil Nutrients Content in Maiduguri, Nigeria

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ABSTRACT

A pot experiment was carried out at screen house, Faculty of Agriculture University of Maiduguri to compare the effect of NPK, bio-fertilizers and manures applications on growth and nutrient uptake by maize. The experiment consisted of 9 treatments of combined application of NPK at half and full recommended rates for maize, *Azotobacter chroococcum*, *Bacillus megaterium* and *Pseudomonas fluorescense* biofertilizers and cow dung and poultry manures and replicated three times in a Completely Randomized Design (CRD). Result of the treatment having half recommended dose of NPK, biofertilizers and poultry manure recorded the highest plant height at 3, 6 and 9 weeks after planting (95.19 cm, 148.63 cm, 149.63 cm, respectively) the highest total shoot and root fresh and dry weights (74.40 g, 196.93 g, 28.83 g, 46.93 g/plant, respectively). Higher nitrogen, phosphorus, and potassium contents of the soil (2.76 g/kg N 0.13 mg/kg P₂O₅ and 1.41 Cmol/kg K₂O soil) were also recorded with the above treatments. Low values of growth parameters are obtained in pot treated with biofertilizers solely due to the absence of other nutrients and this can be overcome by adding organic and chemical fertilizers containing nitrogen and other nutrients such as potassium and phosphorus to plant inoculated with bacteria.

Keywords: Bio-fertilizers, maize, manure, nutrient uptake, yield.

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I. INTRODUCTION

Maize (*Zea mays* L.) is an important crop in Nigeria mainly as an energy giving food. Based on cropped land and quantity produced, maize is Nigeria's third most important cereal crop after sorghum and millet [1]. Maize production in the sub Saharan Africa has been reported to have an increasing trend of between 2-3% annually [2] thereby making maize an important crop to the growth and sustenance of Nigeria's agricultural sector. Total maize production in Nigeria has been reported to be 10 mt/ha compared to India with 22.23 mt/ha [3]. Therefore, maize production in Nigeria needs to be improved. Most of the required nutrients for maize productions are usually applied in form of inorganic fertilizers [4]. However, the high cost of inorganic fertilizers coupled with their inability to condition the soil has directed farmer's attention to organic fertilization or complementary application [5].

Organic manures apart from supplying all essential nutrients required by plants improve soil structure, aeration and encourage good root growth. Organic manure includes farm yard manure, farm compost, town compost, sludge,

green manure and other bulky sources of organic matter. All these manures contain organic matter in large quantities and supply nutrients to plants in small quantities. The manures have direct effect on plant growth like any other commercial fertilizer. This phenomenon is very important in most of the arable soils. Organic manure provides nutrients for the soil micro-organisms, thus increases the activities of microbes in soil, which in turn help to convert unavailable plant nutrients into available form for plant growth promotion. The use of bio-fertilizer as an organic source accelerates mineralization of organic residues in soil, therefore makes the nutrients more available [6].

Biofertilizer is defined as a substance which contains living microorganisms and is known to help with expansion of the root system and better seed germination. Biofertilizers are products containing living cells of different types of microorganisms, which have an ability to convert nutritionally important elements to available form through biological processes. [7]. There is a great interest in establishing novel associations between higher plants and various N₂-fixing microorganisms [8]. For the last one-decade, biofertilizers are used extensively as an eco-friendly

approach to minimize the use of chemical fertilizers, improve soil fertility status and for enhancement of crop production by their biological activity in the rhizosphere. Application of beneficial microbes in agricultural practices started 60 years ago and there is now increasing evidence that these beneficial microbial populations can also enhance plant resistance to adverse environmental stresses, e.g., water and nutrient deficiency and heavy metal contamination [9].

Biofertilizers include nitrogen fixing microorganisms such as *Rhizobium*, *Azotobacter*, *Azospirillum* and *cyanobacteria* and phosphate solubilizers like *Bacillus megaterium* var. *phosphaticum* or *Bacillus subtilis* or *Pseudomonas fluorescens* and phosphorus mobilizing fungi like *mycorrhizae*, plant growth promoting *rhizobacteria*, organic matter decomposers, etc. The purpose of applying biofertilizers is to bring such beneficial organisms in contact with radical and seminal roots and immediately after seed germination. *Azotobacter* inoculation has been found to be economically most advantageous at lower doses of N fertilizer which not only increased yields but resulted in saving of N fertilizer application when applied with FYM. The presence of high population surrounding the seed helps to ensure prompt and effective colonization. Therefore, this study was conducted to compare the effect of biofertilizers with NPK and different sources of manures on growth and nutrient uptake by maize and residual N, P and K content of soil.

II. MATERIALS AND METHODS

A. Description of the Study Area

A pot experiment was conducted during the dry season of 2019 at the Screen House of the Faculty of Agriculture, University of Maiduguri, in order to evaluate the effects of NPK, bio-fertilizers and manures and on growth, and nutrient uptake by maize. The soil used for the experiment was collected at the Teaching and Research Farm of the University of Maiduguri, (11° 8' N; 13° 13' E; 322 m above sea level). The environment is semi-arid with long term mean annual rainfall of 553 mm. Rainfall is unimodal, starting on average in mid-June and lasting till end of September. The soil was sandy loam in texture and classified as *Typic ustipsamment* [10], having parent material of aeolian sand. Crops grown in the area were millet, maize, groundnut, cowpea and sesame.

B. Treatments and Experimental Design

The experiment consisted of 9 treatments of NPK, biofertilizers and manures in various combinations. Half the recommended NPK fertilizer was combined with biofertilizers of *Azotobacter*, *Bacillus* and *Pseudomonas* species and manures from cow dung, and poultry. *Azotobacter* was included to produce plant growth promoting hormones, increased soil nitrogen through nitrogen fixation and nitrogen balance; *Bacillus* and *Pseudomonas* were included as plant growth promoting rhizobacteria, phosphate solubilizers and bio-control agents against soil borne plant pathogen. The full treatment combinations were as follows:

- i. control (no fertilizer applied);
- ii. $\frac{1}{2}$ NPK + *A. chroococcum* + *B. megaterium* + cow dung (7.0 t/ha);

iii. $\frac{1}{2}$ NPK + *A. chroococcum* + *B. megaterium* + poultry (6 t/ha);

iv. $\frac{1}{2}$ NPK + *A. chroococcum* + *P. fluorescens* + cow dung (7.0 t/ha);

v. $\frac{1}{2}$ NPK + *A. Chroococcum* + *P. flourescence* + poultry manure (6.0 t/ha);

vi. $\frac{1}{2}$ NPK + *A. chroococcum* + *B. megaterium* + *P. fluorescens* + cow dung (7.0 t/ha);

vii. $\frac{1}{2}$ NPK + *A. chroococcum*. + *B. megaterium* + *P. fluorescens* + poultry manure (6 0 t/ha);

viii. *Azotobacter. chroococcum* + *Bacillus megaterium* + *Pseudomonas fluorescens*;

ix. cow dung (7.0 t/ha) + poultry manure (6.0 t/ha).

These treatments were replicated three times in a completely randomized design (CRD). The biofertilizers were applied at the rate of 10 kg/ha, 10 days after application of the chemical fertilizers.

C. Data Collection and Analyses

The Bulk soil used for the experiment was collected at a depth of (0-15 cm) at the University of Maiduguri Teaching and Research Farm. The soil was air dried and sub sample collected and sieved through 2 mm sieve and used for the determination of the physico-chemical properties of the soil before the experiment. Texture of the soil was determined by hydrometer method, pH by using 1:2.5 soil-water extract and determined with pH meter, Electrical conductivity (EC) was determined on the extract for the pH using conductivity meter, organic carbon by wet oxidation method, total nitrogen by micro Kjeldahl procedure, available phosphorus by Bray-1 method, exchangeable bases determined after extraction with ammonium acetate. Calcium (Ca) and Magnesium (Mg) were determined by EDTA titration method, while potassium (K) by flame photometer. After harvest soil samples were collected from each pot and analyzed for residual NPK content using standard procedures.

Crop data were collected at three-week intervals for nine weeks after sowing (WAS). The parameters measured were plant height, number of leaves, stem girth, fresh and dried root and shoot weights. The plant height was measured from the soil surface to the apical tip of the plant using a measuring tape. Number of leaves was counted from each plant in the pot. Stem girth was measured using Vernier caliper, the caliper was held at right angle to the shoots with jaws on either side of the shoots. The fresh weights of root and shoot were recorded using a weighing balance. The samples were subjected to drying using an oven drying machine at temperature of 65 °C for 24 hours and then reweighed to obtain the dry weights. The oven dried shoot samples were finely grinded and subjected to laboratory analysis for N, P, and K content determination and uptake calculated. The nutrient uptake was calculated from the analyzed nutrient content (NC) of the plant tissue and the weight of the plant biomass yield (PBY) as shown below:

$$\text{Nutrient Uptake } \left(\frac{\text{g}}{\text{pot}} \right) = \frac{\text{NC (\%)} \times \text{PBY (g /pot)}}{100}$$

The data collected were statistically analyzed using analysis of variance (ANOVA) with the help of a statistical software *statistic 10.0*. Differences between treatment means

were compared using Duncan's new Multiple Range Test (DnMRT) at 5% level of probability.

III. RESULTS AND DISCUSSION

A. Physico-chemical Properties of the Soil and Manure

The result of the physico-chemical analysis of the soil used for the experiment (Table I) indicates that the soil is sandy loam in texture, the pH of the soil is neutral (7.1) with low nitrogen and phosphorus contents. Exchangeable calcium (4.3 Cmol/kg), magnesium (4.6 Cmol/kg), potassium (0.68 Cmol/kg), and sodium (0.07 Cmol/kg) were low in the soil, but percent base saturation was high. The analysis of the manure used (Table II) also indicated low nutrient in cow dung but adequate in poultry droppings.

TABLE I: PHYSICO-CHEMICAL PROPERTIES OF THE SOIL BEFORE COMMENCEMENT OF THE EXPERIMENT

Parameters	Values
pH in water (1:2.5)	7.08
Electrical conductivity (dS/m)	0.19
Organic carbon (%)	0.35
Total Nitrogen (g/kg)	1.10
Available phosphorus (mg/kg)	1.05
Exchangeable cations (Cmol/kg)	
Potassium	0.68
Sodium	0.07
Calcium	4.6
Magnesium	4.3
Cation exchange capacity	13.95
Base saturation (%)	96.54
Exchangeable acidity (Cmol/kg)	0.50
Clay (g/kg)	107
Silt (g/kg)	197
Sand (g/kg)	696
Textural class	Sandy loam

TABLE II: NPK CONCENTRATIONS OF COW DUNG AND POULTRY DROPPING USED FOR THE EXPERIMENT

Manure	N (%)	P (%)	K (%)
Cow dung	2.4	0.06	9.0
Poultry dropping	3.3	0.10	15.0

B. Effects of Treatments on Plant Height

Plant height was significantly ($P < 0.05$) affected by the treatments (Table III). The tallest plants at 3, 6, and 9 WAS were recorded with the half-recommended rate of NPK + A. *chroococcum*, B. *megaterium*, P. *fluorescence* + poultry manure, while control treatment recorded the shortest plants. The increment in plant height with treatment application could be attributed to the fact that organic manure represents a good energy source for *Azotobacter* spp. while in turn promoted the availability of nitrogen and growth promoting hormones to the crop [11]. Reference [12] indicated increase in plant height as a result of organic and bio-fertilizer application.

C. Effects of Treatments on Stem Girth

The effect of NPK, manures and biofertilizers on stem girth of maize is presented in Table IV. The highest stem girth at 3, 6, and 9 WAS was recorded on plant treated with half recommended rate of NPK, *Azotobacter chroococcum*, *Bacillus megaterium*, *Pseudomonas fluorescence* and poultry

manure with values 1.87 cm, 2.51 cm, and 2.58 cm, respectively, while the lowest was recorded with control (1.45 cm, 1.46 cm, and 1.56 cm, respectively). Apart from these there was no statistically significant difference among all the other treatments means. Reference [13] reported similar results that stem diameter increased by increasing nutrient application.

TABLE III: EFFECT OF NPK, MANURE AND BIOFERTILIZERS ON PLANT HEIGHT AT 3, 6 AND 9 WAS

Treatments	Plant height (cm)		
	3 WAS	6 WAS	9 WAS
Control	50.37 ^g	74.10 ^h	77.37 ^f
½ NPK+A+B+P+CD	89.22 ^b	134.3 ^b	135.33 ^b
½ NPK+A+B+CD	69.97 ^e	112.57 ^e	113.77 ^d
½ NPK+A+B+PM	78.87 ^c	117.67 ^c	119.80 ^c
½ NPK+A+P+CD	77.87 ^d	118.03 ^c	119.47 ^c
½ NPK+A+P+PM	78.13 ^d	116.23 ^d	118.43 ^c
CD+PM	69.67 ^e	112.23 ^f	113.57 ^d
½ NPK+A+B+P+PM	95.19 ^a	148.63 ^a	149.63 ^a
A+B+P	62.63 ^f	97.27 ^g	97.37 ^e
S.E	0.156	0.334	0.689

CD = Cowdung, PM = Poultry Manure, A = *Azotobacter chroococcum*, P = *Pseudomonas fluorescence*, B = *Bacillus megaterium*, WAS = Weeks after sowing.

TABLE IV: EFFECT OF NPK, MANURES AND BIO-FERTILIZERS ON STEM DIAMETER AT 3, 6 AND 9 WAS

Treatments	Stem diameter (cm)		
	3 WAS	6 WAS	9 WAS
Control	1.35 ^d	1.42 ^d	1.56 ^e
½ NPK+A+B+CD	1.55 ^c	1.62 ^c	1.97 ^c
½ NPK+A+B+PM	1.52 ^c	1.62 ^c	1.97 ^c
½ NPK+A+P+CD	1.51 ^c	1.62 ^c	1.91 ^c
½ NPK+A+P+PM	1.32 ^c	1.65 ^c	1.81 ^c
½ NPK+A+B+P+CD	1.81 ^b	2.12 ^b	2.26 ^b
½ NPK+A+B+P+PM	1.87 ^a	2.51 ^a	2.58 ^a
A+B+P	1.45 ^c	1.66 ^c	1.77 ^d
CD+PM	1.54 ^c	1.65 ^c	1.94 ^c
S.E.	0.016	0.015	0.029

CD= Cowdung, PM = Poultry Manure, A = *Azotobacter chroococcum*, P = *Pseudomonas fluorescence*, B = *Bacillus megaterium*.

D. Effects of Treatments on Number of Leaves

The effects of NPK, manure and biofertilizers on number of leaves are presented in Table V. The highest average number of leaves at 3, 6, and 9 WAS were recorded with plant treated with half recommended rate of NPK, *Azotobacter chroococcum*, *Bacillus megaterium*, *Pseudomonas fluorescence* and poultry manure (9.67, 12.67 and 12.00, respectively). This treatment effect was at par with half the recommended rate of NPK, *Azotobacter chroococcum*, *Bacillus megaterium* and *Pseudomonas fluorescence* and Cow dung at 9 WAS. The lowest number of leaves was recorded with control with values of 6.07, 7.33, 6.33, respectively.

The stunted growth of maize and yellowing of leaves which were seen in the control and some of the ones that were treated with the different forms of biofertilizers solely could be attributed to nitrogen deficiency because nitrogen encourages vigorous vegetative growth and impacts dark green colour to the leaves. Nitrogen deficiency symptoms could also be due to leaching, and/or low nitrogen content in the original soil.

TABLE V: EFFECT OF NPK, MANURE AND BIO-FERTILIZERS ON NUMBER OF LEAVES AT 3, 6 AND 9 WAS

Treatments	Number of leaves		
	3 WAS	6 WAS	9 WAS
Control	6.07 ^e	7.33 ^e	6.33 ^d
½ NPK +A+B+CD	7.67 ^c	10.00 ^c	9.00 ^b
½ NPK +A+B+PM	7.67 ^c	9.33 ^{cd}	8.00 ^{bc}
½ NPK +A+P+CD	7.67 ^c	9.34 ^{cd}	8.33 ^{bc}
½ NPK +A+P+PM	7.67 ^c	9.00 ^d	7.67 ^c
½ NPK+A+B+P+CD	8.67 ^b	11.67 ^b	11.00 ^a
½ NPK+A+B+P+PM	9.67 ^a	12.67 ^a	12.00 ^a
A+B+P	6.67 ^{de}	7.00 ^e	6.33 ^d
CD +PM	7.67 ^{cd}	9.00 ^d	8.00 ^{bc}
S.E	0.314	0.314	0.401

CD= Cowdung , PM = Poultry Manure, A = *Azotobacter chroococcum*, P = *Pseudomonas fluorescens*, B = *Bacillus megaterium*.

E. Effects of Treatments on Root and Shoot Fresh and Dry Weights

The effect of NPK, manure and biofertilizers on root and shoot fresh weight and dry weight is presented in Table VI. The highest root and shoot fresh weight (g) at harvest was recorded with plant treated with half recommended rate of NPK, *Azotobacter chroococcum*, *Bacillus megaterium*, *Pseudomonas fluorescens* and Poultry Manure (74.40 g, 196.93 g, 28.83 g, 46.93 g, respectively) while the lowest values were recorded with control (27.03 g, 45.00 g, 5.83 g, 18.97 g). The values for shoot fresh weight and dry weight for the treatment that received half recommended rate of NPK, *Azotobacter chroococcum*, *Bacillus megaterium*, *Pseudomonas fluorescens* and poultry manure (196.93 g/plant) and the treatment with half recommended rate of NPK, the 3 microbial inoculant and Cowdung (176.40 g/plant) did not differ significantly with each other, but significantly higher than the other treatments.

The result obtained was similar to the work of [14] and [15] who reported such increase in yield attributes of maize due to *Pseudomonas* inoculation. This might be due to more availability of nutrients from poultry manure and beneficial effects accrued due to *Azotobacter* and phosphate solubilizing bacteria inoculation which provide nitrogen and phosphorus to plant growth. It may also be due to production of amino acids, vitamins and growth promoting substances like indole acetic acid and gibberellic acid secreted by these introduced beneficial microorganisms which resulted in enhanced nutrient uptake, translocation and synthesis of photosynthate assimilates which resulted to increased plant growth characters and in obtaining economically profitable yield [16].

F. Effects of Treatments on Nutrient Uptake

The effect of NPK, manure and bio-fertilizers on nutrient content and uptake are presented in Table VIIA & VIIB. N content was high in treatment application of recommended dose of NPK+ *A. chroococcum* + *B. megaterium* + *P. fluorescens* + poultry manure. P and K contents were higher in treatment that received half recommended NPK dose, *Azotobacter*, *Bacillus*, *Pseudomonas* and cow dung. Application of half NPK recommended rate + *Azotobacter chroococcum*, + *Bacillus megaterium* + *Pseudomonas fluorescens* and poultry manure recorded significantly higher NPK uptake in the crop (2.47 N, 0.13 P₂O₅ and 1.90 K₂O g/kg soil, respectively). Also, the application of half NPK dose and

the 3 microbial inoculants and cow dung recorded higher uptake (2.76 N, 0.13 P₂O₅, 1.41 K₂O g/kg soil). Uptake of nutrient was found to be low in control (0.68 N 0.009 P₂O₅, 0.51K₂O g/kg soil, respectively). The N uptake in control (0.68 N g/kg soil) and treatment that received sole biofertilizers (0.82 N g/kg soil)

TABLE VI: EFFECT OF NPK, MANURES AND BIO-FERTILIZERS ON ROOT AND SHOOT FRESH AND DRY WEIGHT AFTER HARVEST

Treatment	Fresh weight		Dry weight	
	Root	Shoot	Root	Shoot
Control	27.03 ^f	5.83 ^d	45.00 ^d	18.97 ^e
½ NPK +A+B+CD	35.33 ^c	10.40 ^c	92.53 ^c	32.33 ^{bc}
½ NPK +A+P+PM	36.10 ^c	10.33 ^c	140.67 ^b	35.23 ^b
½ NPK +A+B+CD	31.10 ^d	9.60 ^c	131.93 ^b	26.43 ^d
½ NPK +A+P+PM	35.06 ^c	10.73 ^c	146.87 ^b	30.27 ^{cd}
½ NPK+A+B+P+CD	56.83 ^b	24.30 ^b	176.40 ^a	42.40 ^a
½ NPK+A+B+P+PM	74.40 ^a	28.83 ^a	196.93 ^a	46.93 ^a
A+B+P	28.80 ^e	8.73 ^c	58.18 ^d	20.13 ^d
CD+PM	30.63 ^d	10.43 ^c	127.67 ^b	28.20 ^{cd}
S.E	0.489	0.884	7.515	1.604

CD = Cowdung, PM = Poultry Manure, A = *Azotobacter chroococcum*, P = *Pseudomonas fluorescens*, B = *Bacillus megaterium*.

did not differ significantly, while the P and K uptake were greater in treatment that received sole biofertilizers than control. There was significant difference between these two treatments. Higher uptake of nutrients was due to better root proliferation induced by microbial inoculation and availability of nutrients which resulted in better uptake of nutrients. Similar findings were reported by [17].

TABLE VII A: EFFECT OF NPK, MANURE AND BIO-FERTILIZERS ON NUTRIENT CONTENT

Treatments	Nutrient content (%)			
	SDW	N	P	K
Control	18.97 ^e	3.60 ^d	0.08 ^c	3.76 ^e
½ NPK+A+B+CD	32.33 ^{bc}	4.45 ^{bcd}	0.24 ^{abc}	2.94 ^{de}
½ NPK+A+B+PM	30.27 ^{cd}	4.40 ^{bcd}	0.19 ^{bc}	3.13 ^{cde}
½ NPK+A+P+CD	26.43 ^d	5.27 ^b	0.24 ^{abc}	3.84 ^{bcd}
½ NPK+A+P+PM	35.23 ^b	3.89 ^{cd}	0.19 ^{bc}	3.42 ^{cde}
½ NPK+A+B+P+CD	46.93 ^a	4.15 ^{cd}	0.39 ^a	5.62 ^a
½ NPK+A+B+P+PM	42.40 ^a	5.81 ^a	0.32 ^{ab}	4.50 ^b
A+B+P	20.13 ^d	3.06 ^d	0.22 ^{bc}	4.09 ^{bc}
CD+PM	28.20 ^{cd}	4.41 ^{bcd}	0.24 ^{abc}	3.90 ^a
S.E.	1.604	0.533	0.579	0.355

CD= Cowdung , PM =Poultry Manure, A =*Azotobacter chroococcum*, P= *Pseudomonas fluorescens*, B =*Bacillus megaterium*, SDW = Straw dry weight.

TABLE VII B: EFFECT OF NPK, MANURE AND BIO-FERTILIZERS ON NUTRIENT UPTAKE

Treatments	Nutrient uptake (g/kg)		
	N	P	K
Control	0.68 ^d	0.009 ^c	0.51 ^e
½ NPK+A+B+CD	1.44 ^c	0.06 ^b	0.94 ^d
½ NPK+A+B+PM	1.33 ^c	0.05 ^{bc}	0.94 ^d
½ NPK+A+P+CD	1.34 ^c	0.06 ^b	0.98 ^d
½ NPK+A+P+PM	1.36 ^c	0.06 ^b	1.20 ^c
½ NPK+A+B+P+CD	2.76 ^a	0.13 ^a	1.41 ^b
½ NPK+A+B+P+PM	2.47 ^b	0.13 ^a	1.90 ^a
A+B+P	0.82 ^d	0.03 ^{bc}	0.61 ^e
CD+PM	1.33 ^c	0.05 ^{bc}	1.02 ^d
S.E.	0.355	0.167	0.160

CD= Cowdung , PM = Poultry Manure, A = *Azotobacter chroococcum*, P = *Pseudomonas fluorescens*, B = *Bacillus megaterium*.

G. Effects of Treatments on Residual Soil Nutrient Contents

The effect of NPK, manure and biofertilizers on residual N, P and K contents of maize is presented in Table VIII. The highest residual N, P and K in the soil was recorded with plant treated with half recommended rate of NPK, *Azotobacter chroococcum*, *Bacillus megaterium*, *Pseudomonas fluorescence* and poultry manure (1.05 g/kg N, 19.00 mg/kg P₂O₅ and 1.52 Cmol/kg K₂O, respectively followed by plant that received half recommended rate of NPK, *Azotobacter chroococcum*, *Bacillus megaterium* and *Pseudomonas fluorescence* and cow dung (1.04 g/kg N, 15.98 mg/kg P₂O₅, and 1.51 Cmol/kg K₂O, respectively). These two results did not differ significantly from each other. While the lowest residual N was recorded with application of half recommended rate of NPK, *Azotobacter chroococcum*, *Bacillus megaterium*, Cow dung and control. Although there was no significant difference between all the treatments with regards to P, lowest value was recorded with control (7.07 mg/kg P₂O₅) while lowest K was recorded with application of sole microbial inoculant (1.17 K₂O Cmol/kg).

More availability of nutrients in soil can be attributed to the efficiency of PSB resulting in better P solubilization and increased availability of nitrogen by *Azotobacter* in soil and slowly release of nutrients by poultry manure and cow dung. This led to increased concentration of nutrients that improved the soil chemical parameters. These results are in conformity with the findings of [18]. Low availability of nutrient can be attributed to lack of available nutrient in the original soil, similar results were also reported by [19, 20].

TABLE VIII: EFFECT OF NPK, MANURE AND BIO-FERTILIZERS ON RESIDUAL SOIL NUTRIENT CONTENT

Treatments	N (g/kg)	P (mg/kg)	K (Cmol/kg)
Control	0.85 ^b	7.07 ^c	1.17 ^b
½ NPK +A+B+CD	0.84 ^b	12.69 ^{cd}	1.12 ^c
½ NPK +A+B+PM	0.86 ^b	12.38 ^{cd}	1.14 ^{bc}
½ NPK +A+P+CD	0.85 ^b	13.00 ^{cd}	1.14 ^{bc}
½ NPK +A+P+PM	0.86 ^b	14.69 ^{bc}	1.14 ^{bc}
½ NPK+A+B+P+CD	1.04 ^a	15.98 ^b	1.51 ^a
½ NPK+A+B+P+PM	1.05 ^a	19.00 ^a	1.52 ^a
A+B+P	0.88 ^b	10.51 ^d	1.09 ^d
CD + PM	0.85 ^b	16.02 ^b	1.13 ^c
S.E.	0.024	0.911	0.011

CD= Cowdung, PM =Poultry Manure, A =*Azotobacter chroococcum*, P= *Pseudomonas fluorescence*, B =*Bacillus megaterium*.

IV. CONCLUSION

The study revealed that there was a positive response of maize crop to treatments tested and that good growth, yield and nutrient uptake by maize is promoted with the application of half recommended rate of NPK, *Azotobacter chroococcum*, *Bacillus megaterium*, *Pseudomonas fluorescence*, and poultry manure as evidenced by an increase in above ground biomass. In general, it appears that, as expected, application of biofertilizers improved yield and other plant criteria. From the results of the experiment, it is clear that biofertilizers shows better results as compare to that of the control. Low values of growth parameters are obtained in pot treated with biofertilizers solely due to the absence of other nutrients and this can be overcome either by adding organic and chemical fertilizers containing nitrogen and other nutrients such as potassium and phosphorus to plant

inoculated with bacteria as shown in this study. It is however recommended that cultivation of the plant should be done in the field instead of pots experiment, to provide an appropriate environment to the bacteria. Microbial analysis should also be done after the experiment to see the effect of microbial inoculants on soil chemical properties and micro flora.

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