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Dynamics of Nitrogen on Soybean Field Amended with Poultry Manure

M. O. Adigun[1*] and O. A. Babalola[2]

[1]Department of Biological Sciences, Crawford University, Faith City, Igbesa, Ogun State, Nigeria.
[2]Department of Soil Science and Land Management, Federal University of Agriculture, Abeokuta, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Author OAB designed the study, performed the statistical analysis and wrote the protocol. Author MOA wrote the first draft of the manuscript and managed literature searches. Authors OAB and MOA managed the analyses of the study and literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

A field experiment was carried out at the Federal University of Agriculture, College of Plant Science and Crop Production farm Abeokuta, Ogun State, Nigeria, to determine the effect of nitrogen releases from poultry manure, phosphorus source and bradyrhizobium inoculation on soybean (*Glycine max* L.) growth and yield. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three treatments consisting of poultry manure (0, 5, 10, tons/ha), phosphorus source (single super phosphate, mycorrhiza) and bradyrhizobium replicated three times. The poultry manure was applied two weeks before planting, phosphorus source and bradyrhizobium were applied at planting. Agronomic parameters in soybean were assessed at 4 to 14 weeks after planting (WAP) forthrightly: leaf area, stem girth and plant height all showed the same trend from the analyses i.e. not significant; effect of interaction of poultry manure, phosphorus source and bradyrhizobium inoculation on soil nitrogen (ammonium and nitrate), at 4 weeks after planting, single super phosphate and 5 tons of poultry manure had the highest effect on ammonium nitrogen. While at 8 weeks after planting, mycorrhiza and 0 ton of poultry manure had the highest effect on

**Corresponding author: E-mail: micadigun@yahoo.com;*

nitrate nitrogen and at 8 weeks after planting, single super phosphate and 0 ton of poultry manure had the highest effect on nitrate nitrogen. Mycorrhizal gives higher plant, girth and yield of soybean production, and increased soil nitrogen.

Keywords: Soybean; nitrogen; poultry manure; phosphorus; mycorrhiza; bradyrhizobium.

1. INTRODUCTION

Nitrogen is a common manure element in nature. Approximately 78% of the earth's atmosphere consists of Nitrogen gas (N_2). As nitrogen naturally cycles through the air, soil and water, it undergoes various chemicals and biological transformations [1]. These reactions result in the formation of nitrogen-based compounds and molecules, which are essential for the growth of plants, animals and humans. Agricultural production is dependent, in part, on the cycling of nitrogen within the rural environment.

Even though there is 33,000 tons of nitrogen in the air over every acre, the nitrogen gas is so chemically stable that plants cannot directly use it as a nutrient [2]. Plants readily take up and use two forms of soil nitrogen, ammonium (NH_4^+) and nitrate (NO_3^-). Under anaerobic (saturated) soil conditions, denitrifying organisms in the soil will reduce nitrate to nitrogen gas through a series of intermediate steps, (NO_3^- to NO_2 to NO to N_2O and finally to N_2). The final two forms are not available to plants.

Cultivation of crops for food production, economic benefit and husbandry of livestock have for long been dominant activities in human communities. Population growth, increasing living standards and the associated demand for food production are the driving forces for expansion and intensification of agriculture. Man has consistently depended on the environment for his food and survival. This has ranged from gathering of fruits to sowing of seeds for germination and multiplication. The increase in the population of man has pushed him to look for means of satisfying his primary need (food). The problem of over –fertilization is primary associated with the use of inorganic fertilizers, because of the massive quantities applied and the destructive nature of chemical fertilizers on soil nutrient holding structures. Over-fertilization alters some chemical properties of soil e.g. nitrogen and reducing the required nutrient intake by plant, and this will certainly reduce the crop quantity and quality. One of the most common sources of N for organic crop production is poultry manure. Poultry manure is one of the most economically efficient types of manure. This efficiency is due to its high pH, low organic C, high inorganic N and low C:N ratio compared with the other types of manure. [3] estimated that 35% to 50% of organic N could be mineralized within 14 days of incorporation into soil. Of all the essential nutrients, N is the one that is usually most limiting for non-legume crop production and N is often the most difficult nutrient to manage in an organic system. These materials (manure/ litter) generally are applied to agricultural land. An estimated 1.27 million tons of poultry waste with 37, 44 and 25 thousand tons of nitrogen, phosphate, and potash, respectively, are produced annually in North Carolina [4]. By increasing the efficient use of alternative nutrient sources, the nutritional needs of a crop can be met with fewer off-farm inputs, resulting in enhanced profitability [5]. Nitrogen is a vitally important plant nutrient, the supply of which can be controlled by man [6]. In the soil, N found in decomposing organic matter may be converted into ammonium N (NH_4^+) by soil microorganisms (bacteria and fungi) though has a positive charge may be held by soil colloids because they have a negative charge. This process is called micelle fixation [7]. Nitrogen in the form of NH_4^+ can then be adsorbed onto the surfaces of clay particles in the soil. The NH_4^+ ion that may be released from the colloids by way of cation exchange when released may be chemically altered through bacteria action or processes resulting in the production of NO. Because mineralization is required before plant -available N is released, the use of these waste products can provide a source of slow-release N in soils, which may limit groundwater contamination in soils most subjects to leaching [8]. Plants require N to grow roots, stems and leaves, and to reproduce. Nitrogen must be available continuously to feed the development of grains, fruits, nuts and vegetables essential to human nutrition. In a very real sense, N is necessary for all forms of plant and animal life. There is no substitute for it. This modern theory, findings and unambiguity has necessitated this study of the dynamics of nitrogen in soybean (*Glycine max*) field amended with poultry manure.

In 2001, for instance, the Soil Association concluded unambiguously that organic food contains less of the bad stuff, such as pesticides, and more of the good stuff, such as vitamins and minerals. [9] stated that organic manure contains high levels of relatively available nutrient elements which are essentially required for plant growth. Moreover, it plays an important role in improving soil physical properties. Poultry manure is generally considered the most valuable of animal manures. Poultry manure contains large amounts of N, P, and K as well as secondary and trace elements, e.g. substantial quantities of B, Ca, Cu, Fe, Mg, Mn, S, and Zn. Properly applied poultry manure can improve the health and productivity of soil and plants, as they provide essential nutrients to encourage plant growth. The digestion process converts organic nitrogen into mineralized form (ammonia or nitrate nitrogen) that can be taken up more quickly by plants than organic nitrogen. Timing of the plant uptake of ammonia and nitrate nitrogen is more predictable than the plant uptake of organic nitrogen from raw manure [10]. In plant nutrition, nitrogen is involved in the composition of all amino acids, proteins and many enzymes. Nitrogen is also part of the purine and pyrimidic bases, and therefore is a constituent of nucleic acids [11]. Typically, N content in plants ranges between 1 and 6% of the dry weight in leaf tissues. It is absorbed by plants in the form of nitrate and ammonium ions. Traditionally, poultry manure has been applied to farmlands to increase soil fertility on the basis of crop N requirement. The major effect of soil fertility decline is the observed reduced food production in most African countries, including Nigeria. In order to sustain soil and crop productivity, it is necessary to explore adequate soil fertility and nutrient replenishment strategies.

2. MATERIALS AND METHODS

2.1 Location of the Experiment

- The experiment was carried out at FUNAAB, College of Plant Science and Crop Production farm, University of Agriculture, Abeokuta, Nigeria.

2.2 Experimental Design

- The experimental design was randomized complete block design (RCBD).

2.3 Sources of Organic Material

Matured poultry manure free of bedding/litter materials was obtained from COLAMIN poultry farms (battery cage system). The rate of poultry manure application in this experiment was 0, 5 and 10 t/ha respectively, which were analyzed through digestion with HNO_3 and H_2SO_4 for macro and micro nutrients (% K, % N, and % P) by standard procedures [12].

2.4 Test Crop

The test crop was Soybeans – TGX 1448-2E variety seeds sourced from Obafemi Awolowo University, Institute of Agricultural Research and Training (IAR & T), Moor Plantation, Ibadan, Nigeria.

2.5 Bradyrhizobium

The bradyrhizobium was sourced from International Institutes of Tropical Agriculture (IITA) Ibadan and was inoculated into soybean by boiling 250 milliliters of distilled water to dissolve the gum Arabic. While 5 ml of gum Arabic was used for 500 grams of soybean and 2.5 grams of bradyrhizobium was weighed into 500 grams of soybean, it was then mixed thoroughly for even distribution.

2.6 Mycorrhizal

Inoculums of mycorrhizal used was obtain from IITA and cultured in Federal University of Agriculture, (FUNAAB) Abeokuta, Nigeria.

2.7 Single Super Phosphate

Single super phosphate was sourced from the Department of Plant Physiology and Crop Production, COLPLANT, Federal University of Agriculture, Abeokuta, Nigeria.

2.8 Land Preparation

The land was cleared manually. The seeds were planted in rows using drilling method, weeding was done manually as at when necessary. Plot size: Total plot was 36 plots, each plot was 3 m by 3 m = 9 m^2, Total Area = 625 m^2 plus alley, Soybean planting distance was 5 cm by 75 cm. plant population/ha = 266,000.

2.9 Physical and Chemical Analyses of Soil Sample

The laboratory analyses that were carried out on the soil samples at the beginning of the experiments were the following; particle size analysis using the hydrometer method, pH was

Table 1. Experimental layout

Myc	Myc	Myc	Brad/SSP	SSP	Brad/myc
0 kg/ton	10 kg/ton	5 kg/ton	0 kg/ton	0 kg/ton	5 kg/ton
Brad/SSP	SSP	Brad/myc	SSP	Brad/myc	Brad/myc
10 kg/ton	5 kg/ton	5 kg/ton	10 kg/ton	0 kg/ton	10 kg/ton
Myc	Myc	Brad/SSP	Myc	Brad/SSP	Brad/SSP
10 kg/ton	0 kg/ton	0 kg/ton	5 kg/ton	5 kg/ton	10 kg/ton
SSP	SSP	Brad/myc	SSP	Brad/myc	Brad/myc
5 kg/ton	0 kg/ton	0 kg/ton	10 kg/ton	10 kg/ton	5 kg/ton
Myc	Myc	Brad/SSP	SSP	Brad/SSP	Myc
5 kg/ton	10 kg/ton	10 kg/ton	10 kg/ton	0 kg/ton	0 kg/ton
Brad/SSP	SSP	Brad/myc	SSP	Brad/myc	Brad/myc
0 kg/ton	5 kg/ton	5 kg/ton	0 kg/ton	0 kg/ton	10 kg/ton

SSP :- Single super phosphate; Brad :- Bradyrhizobium; Myc :- Mycorrhizal

determined in a 1:1 soil to water suspension using a pH meter with glass electrode, total N was determined using macro-Kjedhal digestion technique, organic C using wet oxidation method. Available P was extracted using Bray-1 method and determined colorimetrically using the method. Exchangeable acidity was determined by titrimetry. Cation Exchange Capacity (CEC) was determined by summation of total exchangeable bases and total acidity while exchangeable bases were extracted with 1 N ammonium acetate buffer at pH 7.0. Exchangeable Na^+ and K^+ in the extract were determined by flame photometry while Ca^{2+} and Mg^{2+} were determined using AAS.

2.10 Agronomic Data Collection

The following data were taken from 4 weeks of planting to maturity-Plant height (cm), Leaf area (cm), Girth and dry matter yield.

2.11 Statistical Analysis

Data generated in the experiment were subjected to analysis of variance (ANOVA) using GENSTART 12th Edition while significance means were separated using least significant different (LSD).

3. RESULTS

Table 2 shows the result of the physicochemical properties of the soil before planting. The soil was sandy-loam with pH at 6.8, organic carbon 0.6%, nitrogen 1.4%, organic matter 1.0%, clay 44 g/kg, silt 46 g/kg and sand 910g/kg, available Phosphorus 17.73 mg/kg, Exchangeable acidity 1.31, CEC 1.61 cmol/kg, sodium 0.21 cmol/kg, potassium 0.18 cmol/kg, calcium 0.64 cmol/kg.

Table 3 shows the main effects of treatments on soya plant height at some of the sampling periods.

Table 2. Physical and chemical characteristics of pre-planting soil

Properties	Values
Sand g/kg	910
Silt g/kg	46.0
Clay g/kg	44.0
Soil texture class	Sandy-loam
pH (soil/water)	6.8
% Organic carbon	0.6
% Nitrogen	1.4
% Organic matter	1.03
Mg+ (cmol/kg)	0.58
Ca+ (cmol/kg)	0.68
Na+ (cmol/kg)	0.21
K+ (cmol/kg)	0.18
Exchangeable acidity (cmol/kg)	1.31
CEC (cmol/kg)	1.61
Available P (mg/kg)	17.73

Poultry manure (PM) at 14 WAP, plot amended without PM (0 t/ha) had significantly higher values than those with 5 and 10 t/ha.

Phosphorus source at 4-14 WAP, plots inoculated with mycorrhiza had significantly higher values than those amended with single super phosphate (SSP).

Bradyrhizobium at 10-12 WAP, plot amended without bradyrhizobium inoculation had significantly higher values than those with bradyrhizobium (brad).

Table 4 shows the response of plant height to application of interactive effect of treatments. It was observed that at 4, 6, 8, 10, 12 and 14 WAP, M + 10 PM had the highest effect on plant height except at 4 WAP, where B + S+10, B + M+5, M+5 and M have the highest effects on plant height.

Table 5 shows that no significant effect was observed at the different sampling periods for stem girth of the main treatment effects.

Table 6 shows the response of stem girth to application of interactive effect of treatment. It was observed that at 4, 6, 10 and 14 WAP, M had the highest effect on stem girth. At 8 and 10 WAP, M + 10PM had highest effect on stem girth.

Table 7 shows the main effects of treatments on soybean leaf area at some of the sampling periods. PM (5 t/ha) at 8, 10 and 14 WAP plots had significantly higher values than those with 10 t/ha. Phosphorus source at 8 WAP plots inoculated with mycorrhizal had significantly higher values than those amended with SSP. Bradyrhizobium at 8 and 10 WAP plots without bradyrhizobium inoculation had significantly higher values than those with bradyrhizobium.

Table 8 shows the response of leaf area to application of interactive treatment. At 4 WAP, B+M+ 10PM had the highest effect on leaf area, at 6 and 10 WAP, M had the highest effect on leaf area, at 8 and 14 WAP, B+M+5PM had the highest effect on leaf area, at 12 WAP, M+ 5PM had the highest effect on leaf area.

Table 9 shows main effect on the influence of treatment on soybean yield (kg/ha) and one thousand seeds weight at the end of planting. The poultry manure has no significant difference on the seed yield. 10 t/ha of poultry manure has higher value compared to 5 and 0 t/ha. P source has significant difference on the seed yield. Mycorrhizal is significantly different over SSP. Bradyrhizobium has no significant difference on the seed yield. Treatment without bradyrhizobium has higher value than treatment with bradyrhizobium.

Table 10 shows the interaction on yield parameter. There were significant difference on seed yield (kg/ha). Treatments with M+10PM and M have higher significant difference than other treatments while treatments with SSP have the lowest effect on seed yield. There were significant differences on one thousand seed weight (kg/plot). Treatment with B+M+10PM had the lowest effect.

Table 11 shows the effect of treatments on soil nitrogen (ammonium and nitrate) at 4 WAP and 8 WAP on soya bean field, effect of poultry manure at 0 t/ha application had the highest mean value over 5 t/ha and 10 t/ha of poultry manure application on soil ammonium nitrogen at 4 WAP and 8 WAP. In the phosphorus sources, at 4 WAP, SSP had the highest effect on soil ammonium nitrogen, at 8 WAP, SSP and mycorrhizal had the same mean value effect on soil ammonium nitrogen, at 4 WAP, SSP had the highest effect on soil nitrate nitrogen, and at 8 WAP, mycorrhizal had the highest effect on soil nitrate nitrogen, and bradyrhizobium inoculation, at 4 WAP bradyrhizobium had the highest effect on soil ammonium nitrogen, at 8 WAP, no bradyrhizobium (control) had the highest effect on soil ammonium nitrogen, at 4 WAP and 8 WAP, no bradyrhizobium(control) had the highest effect on soil nitrate nitrogen.

Table 12 shows the effect of interaction of poultry manure, phosphorus source and bradyrhizobium inoculation on soil nitrogen (ammonium and nitrate).

It was observed that the interactions of treatment had a significant effect on soil nitrogen. NH_4-N at 4 WAP was highest in plots amended with bradyrhizobium and mycorrhizal and lowest in plots amended with mycorrhiza and 10t/ha PM. At 8 WAP plots amended with only mycorrhiza had highest values of NH_3-N than most other treatments. NO_3-N at 4 WAP was highest in plots amended with only single super phosphate (SSP) and lowest in plots amended with mycorrhiza and 10 t/ha PM. At 8 WAP plots amended with only mycorrhiza had highest values of NO_3-N than most other treatments.

4. DISCUSSION

Soil nitrogen result shows that with 0 t/ha of poultry manure, soil ammonium released was not significant at 4 and 8 WAP while soil nitrate was highly significant at 4 WAP but not significant at 8 WAP. SSP not significant at 4 WAP and 8 WAP for soil ammonium, not significant at 4 WAP in soil nitrate and mycorrhizal at 8 WAP, bradyrhizobium is not significant at 4 WAP but significant at 8 WAP no bradyrhizobium (control) at the interaction stage of treatments in soil nitrogen, SSP + 5pm is significantly higher 4 WAP, but at 8 WAP mycorrhizal is highly significant in soil ammonium. In soil nitrate nitrogen, SSP was significantly high at 4 WAP, but 8 WAP, mycorrhiza was significantly high. In plant height, 10 tons of poultry manure application was not significant at 4 WAP, likewise 5 tons at 6, 8, 10, and 12 WAP but at 14 WAP, 0 ton was significantly high in plant. Mycorrhizal was significantly high in plant height at 4, 8, 10, 12 and 14 WAP, no bradyrhizobium (control) was significantly high in plant height at 6, 8, 10 and 12. The response of plant height to treatments interaction were all highly significant for B+M +5PM at 8 WAP, M + 10PM at 4, 6, 10 and 12 WAP and finally at 14 WAP. For stem girth, they were all not significant for 0 ton at 10, 12 and 14 WAP (5 tons at 8 WAP and 10 tons at 6 WAP. In phosphorus source, SSP were not significant at 6, 8, and 10 WAP and mycorrhizal at 4, 8, 12 and 14 WAP, no bradyrhizobium (control) were significant at 8, 10 and 14 WAP, likewise bradyrhizobium at 4, 6, and 12 WAP. The response of stem girth to treatment interaction were all highly significant for M+5PM at 12 WAP, M+10PM at 8 WAP, likewise M at 4, 6, 10 and 14 WAP respectively. In the leaf area, poultry manure source were highly significant for 5 tons at 8, 10 and 14 WAP, likewise mycorrhizal at 8 WAP at no bradyrhizobium at 8 and 10 WAP. The response of leaf area to treatment interaction were all highly significant for B+M + 5PM at 8 and 14 WAP, B+S + 10PM at 4 WAP, M + 5PM at 12 WAP, and finally M at 6 and 10 WAP.

Table 3. The effects of poultry manure, phosphorus source and bradyrhizobium on plant height (cm) at different sampling periods

Treatments	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP
Poultry manure source						
0 (tons)	12.22^{a}	21.55^{a}	29.58^{a}	35.20^{a}	42.78^{a}	47.99^{a}
5 (tons)	12.39^{a}	22.12^{a}	30.54^{a}	36.22^{a}	42.89^{a}	46.34^{ab}
10 (tons)	12.94^{a}	21.29^{a}	29.24^{a}	34.15^{a}	40.85^{a}	44.13^{b}
P value	0.18	0.37	0.39	0.19	0.34	0.04
Phosphorus source						
Mycorrhiza	13.23^{a}	22.09^{a}	30.69^{a}	36.32^{a}	43.56^{a}	48.11^{a}
SSP	11.80^{b}	21.21^{a}	28.89^{b}	34.07^{b}	40.79^{b}	44.19^{b}
P value	0.00	0.10	0.02	0.01	0.03	0.00
Bradyrhizobium source						
No bradyrhizobium	12.28^{a}	22.24^{a}	31.03^{a}	36.42^{a}	44.99^{a}	47.00^{a}
Bradyrhizobium	12.75^{a}	21.06^{b}	28.50^{b}	33.97^{b}	36.35^{b}	45.30^{a}
P value	0.20	0.02	0.00	0.01	0.00	0.18

Key: similar letters after the values in the columns are not significantly different at p< 0.05

Table 4. Response of plant height (cm) to interactive effect of treatment

Treatments	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP
B + M + 10PM	12.27^{ab}	19.27^{e}	25.84^{ef}	30.39^{de}	32.59^{c}	41.73^{cd}
B + S + 10PM	13.39^{a}	22.62^{abc}	31.97^{abc}	36.98^{abc}	38.58^{cd}	44.49^{bc}
M + 10PM	13.75^{a}	24.31^{a}	34.76^{a}	40.93^{a}	52.15^{a}	53.25^{a}
S + 10PM	12.27^{ab}	18.92^{e}	24.40^{f}	28.29^{e}	37.06^{d}	37.05^{d}
B + M + 5PM	13.45^{a}	21.90^{bcd}	30.81^{bcd}	37.83^{abc}	38.47^{cd}	45.71^{bc}
B + S + 5PM	12.92^{ab}	21.76^{bcd}	28.65^{cde}	34.11^{abc}	45.70^{b}	46.95^{bc}
M + 5PM	13.19^{a}	22.85^{ab}	32.18^{abc}	36.57^{bc}	47.05^{ab}	48.67^{ab}
S + 5PM	9.99^{c}	21.62^{bdc}	30.52^{bcd}	36.25^{bc}	40.34^{cd}	44.03^{bc}
B + M	13.02^{ab}	20.02^{de}	27.38^{def}	32.18^{de}	38.77^{cd}	45.65^{bc}
B + S	11.45^{bc}	20.41^{dce}	26.61^{ef}	32.30^{de}	39.00^{cd}	47.29^{bc}
M	13.69^{a}	23.99^{ab}	33.16^{ab}	39.90^{ab}	49.32^{ab}	53.67^{a}
S	10.71^{c}	21.76^{bcd}	31.18^{abc}	36.47^{bc}	44.05^{bc}	45.49^{bc}

Key: similar letters after the values in the columns are not significantly different at p< 0.05
B=Bradyrhizobium, M=Mycorrhiza, S=Single superphosphate, PM=Poultry manure in t/ha

Table 5. The effects of poultry manure, phosphorus source and bradyrhizobium on stem girth (cm) at different sampling periods

Treatments	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP
Poultry manure source						
0 (tons)	0.10^{a}	0.15^{a}	0.21^{a}	0.28^{a}	0.37^{a}	0.46^{a}
5 (tons)	0.10^{a}	0.27^{a}	0.23^{a}	0.27^{a}	0.36^{a}	0.44^{a}
10 (tons)	0.10^{a}	0.74^{a}	0.22^{a}	0.27^{a}	0.34^{a}	0.45^{a}
P value	0.16	0.18	0.20	0.51	0.10	0.10
Phosphorus source						
Mycorrhiza	0.10^{a}	0.37^{a}	0.22^{a}	0.27^{a}	0.36^{a}	0.46^{a}
SSP	0.10^{a}	0.40^{a}	0.22^{a}	0.28^{a}	0.35^{a}	0.44^{a}
P value	0.16	0.90	0.20	0.77	0.85	0.10
Bradyrhizobium source						
No bradyrhizobium	0.10^{a}	0.38^{a}	0.22^{a}	0.28^{a}	0.35^{a}	0.46^{a}
Bradyrhizobium	0.10^{a}	0.40^{a}	0.21^{a}	0.27^{a}	0.36^{a}	0.44^{a}
P value	0.16	0.94	0.10	0.38	0.25	0.10

Key: similar letters after the values in the columns are not significantly different at p< 0.05

Table 6. Response of stem girth (cm) to interactive effect of treatment

Treatments	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP
B + M + 10PM	0.1^{a}	1.30^{a}	0.21^{a}	0.27^{b}	0.35^{ab}	0.42^{cd}
B + S + 10PM	0.1^{a}	0.15^{a}	0.01^{a}	0.28^{a}	0.33^{ab}	0.45^{cd}
M + 10PM	0.1^{a}	0.17^{a}	0.23^{a}	0.27^{a}	0.35^{ab}	0.51^{ab}
S + 10PM	0.1^{a}	0.34^{a}	0.22^{a}	0.28^{ab}	0.32^{b}	0.42^{cd}
B + M + 5PM	0.1^{a}	0.14^{a}	0.22^{a}	0.28^{a}	0.32^{ab}	0.48^{abc}
B + S + 5PM	0.1^{a}	0.49^{a}	0.23^{a}	0.28^{ab}	0.37^{ab}	0.41^{d}
M + 5PM	0.1^{a}	0.28^{a}	0.23^{a}	0.27^{a}	0.35^{ab}	0.40^{d}
S + 5PM	0.1^{a}	0.16^{a}	0.23^{a}	0.28^{a}	0.36^{ab}	0.49^{ab}
B + M	0.1^{a}	0.17^{a}	0.21^{a}	0.27^{ab}	0.36^{ab}	0.45^{bcd}
B + S	0.1^{a}	0.14^{a}	0.21^{a}	0.26^{a}	0.40^{a}	0.46^{bcd}
M	0.1^{a}	0.15^{a}	0.23^{a}	0.31^{a}	0.37^{ab}	0.53^{a}
S	0.1^{a}	0.15^{a}	0.21^{a}	0.27^{ab}	0.33^{ab}	0.41^{cd}

Key: similar letters after the values in the columns are not significantly different at p< 0.05
B=Bradyrhizobium, M=Mycorrhiza, S=Single super phosphate, PM=Poultry manure in t/ha

Table 7. The effect of poultry manure, phosphorus source and bradyrhizobium on leaf area (cm^2) at the different sampling period

Treatments	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP
Poultry manure source						
0 (tons)	5.58^{a}	13.81^{a}	23.69^{ab}	29.78^{ab}	38.32^{a}	41.83^{ab}
5 (tons)	5.47^{a}	13.41^{a}	25.77^{a}	32.64^{a}	36.69^{a}	43.43^{a}
10 (tons)	5.59^{a}	12.18^{a}	21.82^{b}	27.07^{b}	35.41^{a}	38.28^{b}
P value	0.97	0.12	0.03	0.00	0.26	0.02
Phosphorus source						
Mycorrhiza	5.45^{a}	13.34^{a}	25.13^{a}	30.89^{a}	38.05^{a}	41.91^{a}
SSP	5.58^{a}	12.93^{a}	23.39^{a}	28.78^{a}	35.57^{a}	40.45^{a}
P value	0.73	0.55	0.02	0.12	0.09	0.36
Bradyrhizobium source						
No bradyrhizobium	5.73^{a}	13.65^{a}	25.50^{a}	31.30^{a}	37.65^{a}	41.99^{a}
Bradyrhizobium	5.31^{a}	13.61^{a}	22.02^{b}	28.38^{b}	35.96^{a}	40.36^{a}
P value	0.25	0.13	0.00	0.03	0.24	0.30

Key: similar letters after the values in the columns are not significantly different at p< 0.05

Table 8. Response of leaf area (cm^2) to interactive effect of treatment

Treatments	4WAP	6WAP	8WAP	10WAP	12WAP	14WAP
B + M + 10PM	4.10^{d}	9.57^{d}	18.39^{d}	21.48^{d}	28.70^{d}	31.75^{d}
B + S + 10PM	7.31^{ab}	13.45^{abc}	22.66^{bcd}	30.16^{abc}	35.33^{a}	44.85^{ab}
M + 10PM	6.45^{abc}	15.01^{ab}	28.44^{a}	33.64^{ab}	41.91^{a}	42.04^{abc}
S + 10PM	4.17^{d}	10.67^{cd}	17.82^{d}	21.48^{d}	34.17^{a}	34.48^{cd}
B + M + 5PM	4.84^{cd}	13.71^{abc}	27.94^{a}	34.86^{a}	36.97^{a}	47.82^{a}
B + S + 5PM	5.73^{bcd}	14.01^{abc}	22.28^{abcd}	30.74^{abc}	39.51^{a}	39.51^{abc}
M + 5PM	5.49^{bcd}	14.44^{ab}	27.89^{a}	33.66^{ab}	42.00^{a}	42.61^{ab}
S + 5PM	5.81^{abcd}	11.48^{bcd}	24.95^{abc}	31.32^{abc}	26.89^{b}	43.77^{ab}
B + M	4.36^{d}	10.84^{cd}	20.67^{bcd}	27.07^{bcd}	37.75^{a}	41.30^{abc}
B + S	5.50^{bcd}	14.11^{abc}	20.19^{cd}	25.96^{d}	36.10^{a}	36.92^{bcd}
M	7.50^{a}	16.45^{a}	27.46^{a}	34.63^{a}	40.95^{a}	45.94^{a}
S	4.98^{cd}	13.85^{abc}	26.44^{ab}	31.52^{abc}	38.46^{a}	43.15^{ab}

Key: similar letters after the values in the columns are not significantly different at p< 0.05

Table 9. The main yield in tons per hectares

Treatments	Yield (t/ha)	TSW (kg/plot)
Poultry manure source		
0 (tons)	100.1^{a}	8.84^{a}
5 (tons)	103.5^{a}	9.04^{a}
10 (tons)	106.8^{a}	8.32^{a}
LSD	8.20	1.12
Phosphorus source		
Mycorrhiza	109.8^{a}	9.07^{a}
SSP	97.1^{b}	8.40^{a}
LSD	5.12	0.89
Bradyrhizobium source		
No bradyrhizobium	106.1^{a}	8.82^{a}
Bradyrhizobium	100.1^{a}	8.66^{a}
LSD	6.54	0.92

Key: Similar letters after the values in the columns are not significantly different at p< 0.05
Key: TSW = thousand seed weight

Table 10. The influence of interaction on yield parameter

Treatments	TSW (kg/plot)	YPP (kg)
M + 10PM	90.97^{a}	106.3^{a}
B + M	85.93^{a}	89.733^{cde}
B + M + 5PM	84.83^{ab}	93.567^{c}
M + 5PM	83.5^{abc}	102.167^{ab}
B + S + 10PM	81.37^{abc}	91cd ^{c}
S	80.6^{abc}	82.6^{c}
S + 5PM	78.57^{abc}	84.367^{dc}
M	78.43^{abc}	104.767^{a}
B + S + 5PM	76.23^{bc}	92.5^{cd}
B + S	73.1^{abc}	83.633^{dc}
S + 10PM	64.57^{bc}	90.5^{cd}
B + M + 10PM	63.5^{c}	94.8^{bc}

Key: Similar letters after the values in the columns are not significantly different at p< 0.05
Key: TSW = thousand seed weight, YPP = yield per plot B=Bradyrhizobium, M=Mycorrhiza, SSP=Single super phosphate, PM=Poultry manure in t/ha

The improvement of the fresh weight of soybean due to inoculation when compared with other reports could be attributed to the increase in N_2 fixation. These results are in agreement with those reported by [13] and [14]. The beneficial effect of inoculation combined with manure and SSP was reported for some leguminous crops such as faba bean [15] and soybean [16]. The positive results of the residual effects of chicken manure and SSP reported here maybe due to the improvement of some soil properties such as, water uptake by plants, organic matter and microbial activities. Similar, results were obtained by [17] for guar, [18] for faba bean and [19] for fenugreek and [14] for soybean.

The ability of organic manure in enhancing the release of available P from SSP has been related to increase in microbial activities and the acidic soil conditions created by the decay of the organic manure [20,21,12,22,23]. Different organic materials will create different soil environmental conditions [24,25] and hence leading to differences in the release of available P from SSP in soil amendments. Such situations might be the reasons behind the significant performance of the PM in enhancing higher release of available P in the amendments because PM has been found to produce higher microbial biomass and hence acidic conditions in soil amendments [26].

Table 11. Effect of treatments on soil nitrogen (%)

Treatments	NH_3-N		NO_3-N	
Poultry manure source	**4WAP**	**8WAP**	**4WAP**	**8WAP**
0 (tons)	20.18^{a}	19.8^{a}	28.7^{a}	28.0^{a}
5 (tons)	19.37^{a}	19.7^{a}	26.7^{ab}	27.2^{a}
10 (tons)	18.6^{a}	18.1^{a}	24.6^{b}	25.2^{ab}
Phosphorus source				
Mycorrhiza	18.6^{a}	19.2^{a}	25.9^{ab}	26.9^{a}
SSP	20.2^{a}	19.2^{a}	27.5^{a}	26.7^{a}
Bradyrhizobium inoculation				
Bradyrhizobium	20.14^{a}	17.6^{b}	26.5^{ab}	17.6^{b}
Control	18.6^{a}	20.7^{a}	26.8^{a}	20.7^{a}

Key: Similar letters after the values in the columns are not significantly different at $p< 0.05$

Table 12. Effects of interaction of poultry manure, phosphorus source and bradyrhizobium inoculation on soil nitrogen (%)

Treatments	NH_3-N		NO_3-N	
	4WAP	**8WAP**	**4WAP**	**8WAP**
SSP + 0PM	20.1^{abc}	19.6^{b}	31.3^{a}	29.4^{b}
SSP + 5PM	21.9^{ab}	20.5^{ab}	29.9^{a}	28.9^{b}
SSP + 10PM	17.7^{abc}	19.6^{b}	23.8^{ef}	27.5^{bc}
B + 0PM	22.9^{a}	17.7^{b}	29.4^{ab}	25.2^{cd}
B + 5PM	18.2^{abc}	18.2^{b}	25.2^{de}	25.2^{cd}
B+ 10PM	19.6^{abc}	15.4^{b}	25.2^{de}	22.9^{d}
B + SSP + 0PM	20.5^{ab}	16.8^{b}	25.2^{de}	23.8^{d}
B + SSP + 5PM	17.7^{abc}	19.1^{b}	26.1^{cde}	25.2^{cd}
B + SSP + 10PM	21.9^{ab}	18.7^{b}	28.0^{bcde}	24.3^{cd}
M + 0PM	17.3^{bc}	25.2^{a}	28.9^{abc}	33.6^{a}
M + 5PM	19.6^{abc}	20.5^{ab}	25.7^{cde}	28.9^{b}
M + 10PM	14.9^{c}	18.7^{b}	21.5^{f}	26.1^{bcd}

Key: Similar letters after the values in the columns are not significantly different at $p< 0.05$

5. CONCLUSION

The experiment carried out has shown a great deal of production in the use of mycorrhizal which gives higher plant height, girth and yield of soy bean production, so also increase synthesis of soil nitrogen.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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