COMBINE EFFECTS OF LIQUID BIO-FERTILIZER AND POULTRY MANURE ON SOIL FERTILITY AND YIELD OF OKRA (*Abelmoschus esculentus L.*) IN MINNA, NIGERIA.

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ABSTRACT
*A study was conducted in the Screen-house of the Federal University Technology, Minna, to determine the combined effects of liquid bio-fertilizer (LBF) and poultry manure (PM) on soil fertility and yield of okra (Abelmoschus esculentus L). The study was carried out two times to ascertain the initial and residual effects of the treatments. In the initial trial, the treatments were four levels of LBF: 0 l ha^{-1}, 100 l ha^{-1}, 200 l ha^{-1} and 300 l ha^{-1} combined with three levels of PM: 0 t ha-^{1}, 6 t ha^{-1} and 9 t ha^{-1}. A 3x4 factorial design arranged in a Completely Randomized Design with four replications which gave a total of 48 pots. The same arrangement was repeated in the second trial but, there was no application of LBF and PM, since it was designed to investigate the residual effects of the treatments applied initially. The study was conducted using 15-litre plastic pots containing 10 kg of soil. In the second trial, the soil contents in the pots used in the initial trial were pulverized, mixed thoroughly and watered three days prior to sowing. Data collected were analyzed using analysis of variance (ANOVA) while treatments means where significant were separated using the Duncan's Multiple Range Test at 5 % level of probability. The study revealed the effectiveness of LBF and PM in improvement of soil organic carbon, total nitrogen, available phosphorus and overall yield of okra. Combination of LBF and PM (*300 l ha^{-1} + 9 t ha^{-1}*) also produced the highest residual effects on the soil and was optimum for production of okra under Screen house system at Minna.*

Key words: Combine Effects, Liquid Bio-Fertilizer, Poultry Manure, Soil Fertility, Nigeria

1.0 Introduction

Liquid bio-fertilizer is organic fertilizers in liquid form **(**Enujeke and Ojeifo, 2013). They are formulated from botanical extracts into liquids that are readily absorbed in soluble state and sometimes fortified with nutrient elements that promote healthy plants growth and development (Danbara and Green Planet, 2003). Seydeh *et al*. (2012) also defined bio-fertilizers as live formulates of microorganisms that are beneficial to improve the quality and the health of the soil and the plant species by increasing the nutrient availability of the soil.

Poultry manure consists of droppings, wasted feed, broken eggs and feathers (Oyebanjo and Otunaiya, 2011). It also includes dead birds and hatchery waste, all of which are high in protein and contain substantial amount of calcium and phosphorus due to high level of mineral supplement in their diet (Oyebanjo and Otunaiya, 2011). Available statistics showed that there is a steady increase in the population of chicken in Nigeria from 122 million in 1994 to 137.6 millions in 2003 (FAO, 2004).

Okra (*Abelmoschus esculentus* L.), originated from Africa and classified in the genus *Abelmoschus* (Olaniyi *et al.*, 2010). It is a good source of vitamins, minerals, calories and amino acid found in seeds and compares favorably with those in poultry, eggs and soybean (Schipper, 2000). Atijegbe *et al.* (2014) reported that okra is valued for its edible green pods (fruits), a capsule that contains many seeds. Its leaves are also eaten as a vegetable; seeds are used as a non-caffeinated substitute for coffee and also as a source of seed oil (FAO, 2006).

Decline in soil fertility, increased soil erosion and increasing shortage of food are major factors affecting food production in Africa (Serpil, 2012). Inorganic fertilizers which would have been a means of soil fertility and crop improvement are costly and out of reach of most poor farmers and there is also increasing evidence that inorganic fertilizers have caused adverse effects on the environment leading to loss of biodiversity (Serpil, 2012). According to Sharma and Mittra (1991), the use of inorganic fertilizers alone has not been helpful under intensive agriculture because it aggravates soil degradation.

More recently, attempts have been made to replace chemical fertilizers by bio-fertilizers to get good quality yield without loss in quantity (Shirin *et al.*, 2012). Application of bio-fertilizers are frequently recommended for improving biological, physical and chemical properties of soil and for high yield and clean agricultural products free from undesirable high doses of heavy metals and other pollutants (E-kramany , *et al.*, 2007).

Use of poultry manure has also been reported to have significantly improved growth and yield of okra by Akande *et al.* (2003). Onwu *et al.* (2002), also found that addition of poultry manure improved soil chemical properties soil such as pH, total N, available P, organic matter, exchangeable cations and cation exchange capacity. This study was, therefore conducted to specifically determine: (i) the initial and residual effects of combined liquid bio-fertilizer and poultry manure on soil organic carbon, nitrogen phosphorus, and potassium, yield and yield components of okra and (ii) the relationship between the above named soil properties and yield and yield components of okra.

2.0 Materials and Methods

Study Location and Soil Collection Site:
The research was conducted in the Screen house of the Federal University of Technology, Gidan Kwan, Minna. Surface Soil (0-15 cm) used was collected from the University Teaching and Research Farm. Geographic location of soil collection point is on latitude 09° 31′ 18.2″ N and longitude 6° 27′ 39.6″ E and elevation ranged from 229.5 to 250.4 m above sea level. Climate of Minna is sub-humid with mean annual rainfall of about 1284mm and a distinct dry season of about 5 months duration occurring from November to March. The mean maximum temperature about 33.5^0C remains high throughout, particularly in March and June (Ojanuga, 2006). The geology around Minna consists of gentle undulating high plains developed on basement complex rocks made up of granites, migmatites, gneisses and shists. Inselbergs of "Old Granites" and low hills of shists rise conspicuously above the plains. Beneath the plains, bedrock is deeply weathered and constitutes the major soil parent materials such as saprolites (Ojanuga, 2006). The soil has been classified as Typic Plinthustalf by Lawal *et al. (*2012). Prior to the soil collection, the site has been cultivated with yam, sorghum and maize with little or no fertilizer application over the years.

Source of Materials
Liquid bio-fertilizer used for the experiment was purchased from Golden Neo-Life Diamite (GNLD) natural products distribution centre at Ibadan in Oyo State. Poultry manure sourced from Femilex Farm, a commercial deep litter system poultry farm in Kangiwa, Chanchaga, Minna West Council Area of Niger State.

Treatments and Experimental Design
The treatments were four levels of LBF: 0 l ha^{-1}, 100 l ha^{-1}, 200 l ha^{-1} and 300 l ha^{-1} and three levels of PM: 0 t ha-^{1}, 6 t ha^{-1} and 9 t ha^{-1}. The experimental design was 3x4 factorial arranged in a Completely Randomized Design with four replications which gave a total of 48 pots.

Agronomic Practices
The experiment was conducted using 15-litre plastic pots containing 10 kg of soil. The pots were perforated at the base to allow excess water to drain out. The top soil collected was sun dried, gently crushed and sieved through a 2mm sieve to remove gravels and other particles and 10 kg soil weighed into each pot. The LBF was diluted at the ratio of l ml to 1 l of water as recommended by the LBF producer. Poultry manure was sun dried to reduce the moisture content and manually crushed into smaller particle size to enhance interaction and aid the release of nutrients into the soil by the material. Used materials and items which could serve as a host for pests and diseases or as source of contamination to the set up or interrupt even distribution of light and other climatic factors within and outside the screen house were first removed and cleared out of passages. The crop was planted 3 seeds per pot and later thinned to 1 per pot at 2 weeks after of sowing (WAS). Irrigation was carried out using watering cans during morning periods of everyday. The pots were watered to field capacity (half the volume of soil) while weeding was done as at when due by hand-pulling approach. Poultry manure was incorporated into the pots 1 week before sowing while LBF was applied using fertigation method. It was applied at 2 and 6 WAS which are the two important nutrient requirement stages of the test plant.

Soil Sampling and Analysis
Surface soil (0-15 cm) samples were collected at eight points along four diagonal transects and bulked together to form four composite samples used for the experiment. Four soil samples were again collected from the bulked samples for the initial characterization of the soil. At flowering stage and physiological maturity of the plant, soil samples were collected from each pot at four different depths during each experiment. The samples collected were air-dried, gently crushed and sieved with 2 mm opening to remove gravels, debris and determine some physical and chemical properties of the soil. The samples were also subjected to analysis using standard methods as described by Agbenin (1995). Briefly, particle size was determined by Bouyocous hydrometer method using sodium hexametaphosphate as dispersing agent (Gee and Or, 2002). The textural classes of the soils were then determined using IUSS soil Textural Triangle. Soil pH was determined in 1:2.5 soil to water and $CaCl_2$ using a glass electrode pH meter. Organic carbon was determined using Walkley-Black method (1945). Total nitrogen was determined by using the micro-Kjeldhal method (Miller and Houghton, 1947). Available phosphorus extracted with the Bray P 1 method and P in extract determined using spectrophotometer after adding P developer re-agent and allowed the solution to build up P content. Determination of the exchangeable bases was done using ammonium acetate (NH_4OAc) displacement method. Exchangeable K in the extract was determined by Flame Photometric method, while Ca and Mg were by Na-EDTA titrimetric method while Na was determined using a Jenway PFP7 Flame Photometer (Harro *et al.*, 1983).

Yield and Yield Components Analysis

The plant heights were recorded at 4, 6, 8 and 10 weeks after sowing (WAS) by a metre rule from the ground level to tip of the base of the flag of leaf. These were repeated at 4 6, 8 and 10 WAS. Pod yields and fresh weight were also determined at physiological maturity. Number of pods produced in each pot was counted, harvested and weighed immediately after harvest to avoid loss of moisture content. The plant total biomass was also determined (the pots were watered, the plants uprooted, carefully labeled, weighed and recorded).

Liquid bio-fertilizer and Poultry Manure Analysis

Samples of the LBF and PM were collected and analysed for total N, available P, and exchangeable K to determine their nutrients composition using the routine analysis as described by Tel (1984). Total N, by Kjeldahl approach and available P was determined colorimetrically after Bray-P1 extraction. Exchangeable K was extracted with 1N NH_4 AOc and determined using Flame Photometer and Atomic Absorption Spectrophotometer.

Statistical Analysis

Data collected were analyzed using analysis of variance (ANOVA). Treatments means where significant were separated using the Duncan's Multiple Range Test at 5 % level of probability unless otherwise stated. Correlation analysis (Pearson method) was carried between the soil properties and yield and yield components of okra. Values obtained from the selected soil properties and okra parameters were compared using t-test. All computation was done using the General Linear procedure (GLM) of SAS (SAS, 2002).

Results and Discussion

Physical and Chemical Properties of the Soil, Nutrient Composition of Poultry Manure and Liquid Bio-Fertilizer

The physical and chemical properties of the soil, nutrients composition of poultry manure and liquid bio-fertilizer used in the trials are shown Table 1. The soil had a loamy sand texture, with sand being the dominant particle (830 g kg^{-1}). The soil is slightly acidic (6.6); total N (1.96 g kg^{-1}) was moderate, but low in essential nutrients particularly organic carbon level (6.62 g kg^{-1}) and extractable P Bray1 (6 mg kg^{-1}). The exchangeable bases (cmol kg^{-1}) were Ca^{2+} (4.48), Mg^{2+} (1.36) and K^+ (0.13), Na^+ (0.62); whereas K^+ was low, exchangeable Na^+ and Ca^{2+} were medium while Mg^{2+} dominated the soil exchangeable bases. Poultry manure had high total nitrogen and exchangeable potassium but moderate in phosphorus content. Liquid bio-fertilizer was however low in total N, available P and exchangeable K.

The value of the soil pH indicated availability of most crop nutrients; as most crops nutrients are readily available to plants roots at pH range of 6.6 (Adeboye *et al.,* 2009). The organic carbon content of the soils was low. This is in agreement with the findings of Jamala and Oke (2013), who found that savannah soils are between the range of low to medium in organic carbon contents which can be attributed to rapid mineralization of organic matter, inadequate return of crop residues and other unfavourable arable crop management practices as well as other land use practices prevalent in the area. The soils total N and available P were also low. The total N status and available P of the soils may be ascribed to low organic matter contents which is the major reservoir of soil P and N in the soil.

The relatively high content of nitrogen, phosphorus and potassium in poultry manure suggests that it is a good source of crop nutrients. Mokwunye (2000), also confirmed that poultry manure contains high nutrients especially phosphorus which affected the growth and yields of vegetables crops positively. Robinson and Beauchamp (1982) reported that poultry manure produced the following percentage nutrients: nitrogen (65.5 %), phosphorus (68.5 %) and potassium (83.5 %). The liquid bio-fertilizer nutrient contents were very low, especially in exchangeable K (Chude, 2011). This may be ascribed to the rate of active ingredients used by the producer during the formulation process; moreover the recommended dilution rate (1 millimetre to 1 litre) may also have contributed to such low nutrients content of the fertilizer.

Table 1. Physical and Chemical Properties of the Soil, Nutrients Composition of Liquid Bio-Fertilizer and Poultry Manure Used in the Trials

Parameters	Soil value	Poultry manure	Liquid bio-fertilizer
Sand (g kg^{-1})	830	-	-
Silt (g kg^{-1})	63	-	-
Clay (g kg^{-1})	108	-	-
Textural class	Loamy sand	-	-
pH (H_2O)	6.60	-	-
pH ($CaCl_2$)	5.55	-	-
Organic matter (g kg^{-1})	6.62	-	-
Total N (g kg^{-1})	1.92	0.920%	0.0560%
Available P (mg kg^{-1})	6.00	0.050%	0.0026%
Exchangeable K (cmol kg^{-1})	0.13	0.065%	0.0002%
Na (cmol kg^{-1})	0.17	-	-
Ca (cmol kg^{-1})	4.48	-	-
Mg (cmol kg^{-1})	1.36	-	-
Exchange acidity (cmol kg^{-1})	0.62	-	-

Initial and Residual Effects of Combined Liquid Bio-Fertilizer and Poultry Manure on Plant Height at Different Growth Stages

The Initial and residual effects of combined liquid bio-fertilizer and poultry manure on plant height at different growth stages are shown in Table 2. Plant height was significantly affected by addition of liquid bio-fertilizer at 4, 8 and 10 WAS; while the residual effects were significant only at 6, 8 and 10 WAS growth stages of the plant. Among all the treatment levels, addition of 300 l ha^{-1} LBF to 9 t ha^{-1} produced the tallest okra which was statistically different from other levels of LBF both in the initial and the residual trial. The treatments interaction effect was significant only during the initial trial whereas their residual effects were insignificant all through the growth stages of the plant (4-10 WAS).

The residual effect observed in both trials, particularly at higher rate of poultry manure application implies that the release of nutrients into the soil by poultry manure is gradual. Abou, *et al.* (2005) also found that nutrients contained in poultry manures are released more slowly ensuring longer residual effects, improved root development and higher crop yields.

Initial and Residual Effects of Combined Liquid Bio-Fertilizer and Poultry Manure on Okra Yields

The initial and residual effects of combined liquid bio-fertilizer and poultry manure on pods and biomass yields of okra are shown in Table 3. Among all the yield parameters analysed, the effect of LBF addition was significant on plant biomass only during both initial and residual trial. Addition of LBF at the rate of 300 l ha^{-1} produced biomass which was higher than the control by 27 %. Poultry manure under different rates of combination with LBF also produced similar result. The interaction between PM and LBF was significant on weight of pods and biomass yield in the initial and residual trials while their effects on number of pods was insignificant. Initial and residual mean comparison between the values of number pods and their weights, as well as plant biomass yields are shown in Table 4. There was no significant difference between the Initial and residual trial among treatments on number of pods and plant biomass; however, weight of pods was significantly different between initial and residual values at 300 l LBF ha^{-1}, + 0 t PM ha^{-1}, 0 l LBF ha^{-1}, + 6 t PM ha^{-1} and 300 l LBF ha^{-1}, + 9 t PM ha^{-1} levels of combinations. This means that the nutrients released into the soil by the treatments during the initial trial was enough to sustain the plant and produced equivalent effect.

Interaction Effect of Combined Liquid Bio-Fertilizer and Poultry Manure on Okra Biomass Yields

The interaction effect of liquid bio-fertilizer and poultry manure when combined on biomass yield of okra is shown in Table 5. The results revealed that highest plant biomass was obtained when the highest level of LBF (300 l ha^{-1} LBF) was combined with the highest level of PM (9 t ha^{-1} PM) treatment. Similar result was also obtained from the interaction of their residual effects (Table 6). In each case, the lowest yield of biomass was obtained from the control.

Initial and Residual Effects of Combined Liquid Bio-Fertilizer and Poultry Manure and on Some Selected Soil Properties

The initial and residual effects of combined application of liquid bio-fertilizer and poultry manure on organic carbon, total N, available P and exchangeable K is presented in Table 7. The result indicates that during the initial trial, addition of liquid bio-fertilizer significantly affected only total N content of the soil, whereas the residues had no significant on any of the selected soil properties. It also revealed the significant influence of PM on the contents of organic carbon, total N and available P in the initial and residual trials. The treatments had no significant interaction during both trials. The highest residual value of organic carbon was obtained from addition of 9 t PM ha^{-1} treatment, which was 16% different from the values obtained when 300 l ha^{-1} treatment was added.

Table 8 presents the comparison of the initial and residual effects of combined liquid bio-fertilizer on some selected soil properties. Only the content of total N and exchangeable K were significantly different with the application of some of the treatments. 100 l LBF ha^{-1} + 0 t PM $ha^{-1,}$ 300 l LBF ha^{-1} +0 t PM ha^{-1}, 100 l LBF ha^{-1}+ 6 t PM ha^{-1}, 0 l LBF ha^{-1} + 9 t PM ha^{-1} and 200 l LBF ha^{-1} had a reduction in soil total N. Similarly, the application of treatments, 0 l LBF ha^{-1} + 6 t pm ha^{-1}, 300 l LBF ha^{-1} + 6 t PM ha^{-1}, 100 1 LBF ha^{-1} + 9 t PM ha^{-1} and 300 l LBF ha^{-1} + 9 t PM ha^{-1} produced significant reduction in soil exchangeable K.

The increased yields in weight of pods and plant biomass as a result of increase in the rate of application of liquid bio-fertilizer and particularly poultry manure demonstrate the effectiveness of the treatments and the fact that continual increase of the treatments to a reasonable rate will lead to more yield of okra. This findings agrees with Tran *et al*, 2004), who stated that among the available means to achieve soil fertility and sustainability in agricultural production in the tropics, organic manure and bio-fertilizer in combination play important roles in soil nutrient improvement.

Table 2. Initial and Residual Effects of Combined Liquid Bio-Fertilizer and Poultry Manure on Plant Height at Different Growth Stages.

	Plant height (cm) at Different Weeks After Sowing							
	Initial				Residual			
Treatment	4	6	8	10	4	6	8	10
LBF(l ha^{-1})								
0	22.9b	28.9a	33.4bc	50.7ab	18.9a	32.0bc	40.5b	44.4b
100	25.9b	33.0a	37.5b	50.9b	20.3a	32.2b	41.7b	42.4b
200	25.7b	33.4a	40.1ba	52.5ab	21.7a	35.1b	43.4ab	48.3ab
300	30.2a	32.8a	42.2a	56.8a	22.6a	36.3a	46.9a	51.8a
SE ±	1.14	2.55	1.45	1.98	1.42	1.08	1.10	1.90
PM (t ha^{-1})								
0	24.0b	31.4b	40.6a	48.7ab	18.4b	30.5c	40.7b	43.9b
6	25.2b	27.9b	34.7b	52.5b	20.1b	34.4b	44.2ab	45.3b
9	29.3a	36.7a	42.7a	56.9a	24.2a	38.8a	47.2a	52.9a
SE ±	1.06	1.61	1.25	1.10	1.12	0.93	1.32	1.14
Interaction								
LBF*PM	*	*	*	*	NS	NS	NS	NS

Mean followed by the same letter (s) in a treatment column are not significantly different at $P < 0.05$
*- Significant
NS- Not significant
LBF - Liquid bio-fertilizer
PM - Poultry manure

Table 3. Initial and Residual Effects of Combined Liquid Bio-Fertilizer and Poultry Manure on Okra Yields

	Initial			Residual		
Treatment	No of pods per plant	Weight of pods (g plant)	Biomass (g plant)	No of pods per plant	Weight of Pods (g $plant^{-1}$)	Biomass (g plant)
LBF(l ha^{-1})	2a	30.36a	65.11b	1a	16.85a	56.50b
0	2a	30.88a	64.12b	1a	19.70a	57.90b
100	2a	32.97a	70.02b	2a	24.33a	69.19a
200	2a	40.73a	83.86a	2a	24.42a	70.36a
300	0.19	3.82	2.67	0.19	3.92	2.32
SE $^{\pm}$						
PM (t ha^{-1})	1a	31.71a	67.14b	1a	18.37a	58.43b
0	2a	34.39a	73.06b	1a	26.27a	58.22b
6	2a	41.66a	85.11a	2a	26.27a	73.88a
9	0.16	5.67	4.81	0.15	3.88	1.85
SE $^{\pm}$						
Interaction						
LBF*PM	NS	*	*	NS	*	*

Mean followed by the same letter (s) in a treatment column are not significantly different at $P < 0.05$
NS - Not Significant.
*- Significant
LBF= Liquid bio-fertilizer
PM= Poultry manure

Table 4. Comparison of the Initial and Residual Effects Of Combined Liquid Bio-Fertilizer and Poultry Manure on Okra Yields

Treatments	No of pods per plant			Weight of pods (g)			Biomass (g)		
	Initial	Residual	SE±	Initial	Residual	SE±	Initial	Residual	SE±
0 LBF l ha^{-1} + 0 t PM ha^{-1}	2	2	NS	35.36	31.98	NS	73.76	55.38	NS
100 LBF l ha^{-1} + 0 t PM ha^{-1}	2	1	NS	39.86	27.15	NS	74.30	58.59	NS
200 LBF l ha^{-1} + 0 t PM ha^{-1}	2	2	NS	31.23	33.63	NS	60.79	61.87	NS
300 LBF l ha^{-1} + 0 t PM ha^{-1}	2	1	NS	25.42	11.93	*	71.23	57.90	NS
0 LBF l ha^{-1} + 6 t PM ha^{-1}	1	2	NS	42.68	24.97	*	61.85	59.58	NS
100 LBF l ha^{-1} + 6 t PM ha^{-1}	2	1	NS	17.27	8.66	NS	57.64	49.94	NS
200 LBF l ha^{-1} + 6 t PM ha^{-1}	1	2	NS	29.25	23.76	NS	72.39	63.35	NS
300 LBF l ha^{-1} + 6 t PM ha^{-1}	2	2	NS	30.38	16.11	NS	64.61	59.99	NS
0 LBF l ha^{-1} + 9 t PM ha^{-1}	2	1	NS	17.07	16.33	NS	59.72	54.86	NS
100 LBF l ha^{-1} + 9 t PM ha^{-1}	2	1	NS	33.94	14.34	NS	69.49	65.25	NS
200 BF l ha^{-1} + 9 t PM ha^{-1}	2	2	NS	42.73	15.60	NS	86.00	82.35	NS
300 LBF l ha^{-1} + 9 t PM ha^{-1}	2	2	NS	69.17	31.06	*	109.51	93.18	NS

*-Significant
NS- Not significant
LBF= Liquid bio-fertilizer
PM=Poultry manure

Table 5. Initial Interaction Effect of Combined Liquid Bio-Fertilizer and Poultry Manure on Okra Biomass Yield

Treatments	**Poultry manure ($t\ ha^{-1}$)**		
Liquid bio-fertilizer ($l\ ha^{-1}$)	**0**	**6**	**9**
0	57.64c	61.85c	59.72c
100	74.30bc	73.77bc	69.49bc
200	60.79c	72.39bc	86.00b
300	71.23bc	64.61bc	109.51a
SE±			5.08

Means followed by the same letter (s) are not significantly different at $P < 0.05$

Table 6. Residual Interaction Effects of Combined Liquid Bio-Fertilizer and Poultry Manure on Okra Biomass Yield.

Treatments	Poultry manure (t ha-1)		
Liquid bio-fertilizer ($l\ ha^{-1}$)	0	6	9
0	49.94b	54.86b	59.58b
100	58.59b	55.38b	65.15b
200	61.87b	63.35b	82.35a
300	57.89b	59.99b	93.18a
SE±			3.83

Means followed by the same letter (s) are not significantly different at $P < 0.05$

Table 7. Initial and Residual Effects of Combined Liquid Bio-Fertilizer and Poultry Manure on Some Selected Soil Properties

	Initial				Residual			
Treatment	O C (g kg^{-1})	TN (g kg^{-1})	Avail. P (mg kg^{-1})	Exch. K (cmol kg^{-1})	OC (g kg^{-1})	TN (g kg^{-1})	Avail. P (mg kg^{-1})	Exch. K (cmol kg^{-1})
LBF (t ha^{-1})								
0	5.87a	2.55c	20a	0.16a	5.10a	1.90a	17a	0.12a
100	5.66a	2.79bc	21a	0.18a	5.09a	1.82a	19a	0.14a
200	5.98a	3.04ab	21a	0.25a	4.97a	2.35a	18a	0.13a
300	6.06a	3.44a	20a	0.21a	5.32a	2.34a	18a	0.14a
$SE^{\pm}$	0.32	0.22	1.09	0.03	0.41	0.18	0.8	0.01
PM (t ha^{-1})								
0	5.15a	2.4b	17b	0.18a	4.35c	1.84b	16b	0.13a
6	5.96a	2.72b	22a	0.17a	4.19b	1.82b	19b	0.13a
9	6.56b	3.71a	22a	0.24a	6.11a	2.66a	20a	0.12a
$SE^{\pm}$	0.22	0.16	o.72	0.03	0.02	0.15	0.77	0.01
Interaction								
LBF*PM	NS	NS	NS	NS	NS	NS	NS	NS

Mean followed by the same letter (s) in a treatment column are not significantly different at P < 0.05
NS-Not Significant.
*- Significant
LBF= Liquid bio-fertilizer
PM= Poultry manure

Table 8. Comparison of the Initial and Residual Effects of Combined Liquid Bio-Fertilizer on Some Selected Soil Properties

Treatments	Organic Carbon (g kg^{-1})			Total N (g kg^{-1})			Avail. P (mg kg^{-1})			Exch. K (cmol kg^{-1})		
	Initial	Residual	SE±	Initial	Residual	SE±	Initial	Residual	SE±	Initial	Residual	SE±
0 LBF l ha^{-1} + 0 t PM ha^{-1}	4.46	3.57	NS	1.70	1.41	NS	15	14	NS	0.16	0.13	NS
100 LBF l ha^{-1} + 0 t PM ha^{-1}	5.05	4.65	NS	2.34	1.43	*	19	17	NS	0.16	0.21	NS
200 LBF l ha^{-1} + 0 t PM ha^{-1}	5.49	4.61	NS	2.51	2.47	NS	19	17	NS	0.22	0.14	NS
300 LBF l ha^{-1} + 0 t PM ha^{-1}	5.62	4.77	NS	3.18	2.04	*	15	15	NS	0.19	0.12	NS
0 LBF l ha^{-1} + 6 t PM ha^{-1}	6.21	5.22	NS	2.61	1.86	NS	22	19	NS	0.20	0.13	*
100 LBF l ha^{-1} + 6 t PM ha^{-1}	5.65	4.72	NS	2.65	1.75	*	22	20	NS	0.16	0.11	NS
200 LBF l ha^{-1} + 6 t PM ha^{-1}	5.18	4.76	NS	2.57	1.73	NS	22	20	NS	0.13	0.13	NS
300 LBF l ha^{-1} + 6 t PM ha^{-1}	5.62	4.91	NS	3.06	1.93	NS	20	18	NS	0.19	0.14	*
0 LBF l ha^{-1} + 9 t PM ha^{-1}	6.96	6.52	NS	3.32	2.44	*	22	19	NS	0.12	0.09	NS
100 LBF l ha^{-1} + 9 t PM ha^{-1}	6.08	5.91	NS	3.39	2.31	NS	22	19	NS	0.22	0.12	*
200 BF l ha^{-1} + 9 t PM ha^{-1}	6.27	5.71	NS	4.03	2.86	*	21	18	NS	0.41	0.11	NS
300 LBF l ha^{-1} + 9 t PM ha^{-1}	6.95	6.29	NS	4.09	3.05	NS	23	21	NS	0.20	0.17	*

*- Significantly different at $P < 0.05$.
NS - Not Significant.
LBF= Liquid bio-fertilizer
PM= Poultry manure

Conclusion and Recommendation

Combine application of liquid bio-fertilizer and poultry manure improved the following soil nutrients content: organic carbon, total N, available P and overall performance of okra. Combination of LBF and PM at 300 l ha^{-1} + 9 t ha- ^{1}also produced the highest residual effects on the soil fertility and was optimum for production of okra under Screen house system. This study, therefore, suggest that farmers combine GNLD liquid bio-fertilizer and poultry manure at 300 l ha^{-1} + 9 t ha^{-1} for effective soil fertility improvement with long lasting effect and optimum yield of vegetables crops.

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