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Influence of NPK 15-15-15 fertilizer and pig manure on nutrient dynamics and production of cowpea, *Vigna unguiculata* L. Walp

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Abstract: A constant challenge for farmers in Nigeria is how to increase crop production in the face of low inherent nutrient status and rapid soil fertility depletion. This has attracted studies on how to build up nutrient capital in soil. Influence of NPK 15-15-15 fertilizer and pig manure on nutrient dynamics and production of cowpea *vigna unguiculata* L. Walp were evaluated at the Teaching and Research Farm, Ekiti State University, Ado-Ekiti, Nigeria in experiments consisting of six treatments laid out in a randomized complete block design with three replicates. The treatments consisted of 60kg NPK 15-15-15, 4t/ha Pig manure (PM), 8t/ha Pig manure, 4t/ha PM+60kg NPK 15-15-15, 8t/ha PM+60kg NPK 15-15-15 and no fertilizer as control. Data on plant height, no of branches, no of leaves, no of nodules/plant, dry matter yield taken at 50% flowering, number of pods/plant, number of seeds/pod, 100 seed weight and seed yield were collected. The result showed that 8t/haPM+60kgNPK gave significantly ($p<0.05$) higher number of nodules.plant^{-1}(13.7), dry matter (40.3g.plant^{-1}), number of pods.plant^{-1} (23.7), number of seeds.pod^{-1} (12.3) and 100 seed weight (25.5g) respectively. Maximum seed yield of 1.40t/ha was obtained with application of 8t/haPM + 60kgNPK. Sole application of pig manure and its combination with NPK significantly increased soil N, P, K, Ca and Mg. It can be concluded that for maximum production, the amount of pig manure required can reduce the chemical fertilizer that would be needed for cowpea.

Keywords: Cowpea, Yield Attributes, Nutrient Dynamics, NPK Fertilizer, Organic Manure

1. Introduction

Cowpea *Vigna unguiculata* L. Walp is an important tropical food grain legume for man and especially livestock in the dry savanna zone of the tropics. The annual global output of cowpea is about 3.3 million metric tonnes [1] and Nigeria is the world's largest producer with 2.15 million MT between 2006 to 2008 [2] Cowpea is an important crop because it is a cheap source of protein for human and livestock nutrition. Cowpea forage (vines and leaves), fresh or as hay or silage is often used for fodder while attempts have been made at using cowpea leaf meal in feeding pig. The haulms, residues from seed production, contain about 45-65% stems and 35-50% leaves and sometimes roots [3] are an important by-product in sub-Saharan Africa [4] Cowpea pod husks obtained after threshing are also used to feed livestock [5]. Despite the increase in cowpea production in sub-Saharan Africa, cowpea yields remain one of the lowest among all food legume crops with an average of 450 kg ha^{-1} in 2006 to 2008, which is half of the estimated yields in all other developing regions. This low grain yield notwithstanding, cowpea has continued to be a popular crop among farmers because it does not require high fertilization. However, inherently poor soil fertility, depletion of soil nutrients as a result of continuous cropping and crop removal have been reported to reduce soil fertility which limit its yield and productivity in Nigeria [6].

Maintenance of soil productivity has been one of the constraints to tropical agriculture such that crop production is usually moved between fields in order to utilize only fertile soils for some years without the use of fertilizers. However, this cannot be sustained to meet increasing demand of a rapidly growing population [7]. Most of the soils in Nigeria are strongly weathered and dominated by low-activity clay minerals with low nutrient status. Thus, they are adversely affected by sub-optimal soil fertility even as erosion causes deterioration of nutrient status and changes in soil organism's population [8]. Therefore, the soils cannot supply the quantities of nutrients required such that crop yield levels decline rapidly once cropping commences. Soil degradation and nutrient depletion have become serious threats to agricultural productivity. Adepetu, [9] noted that the downward trend in food production should prompt farmers to amend the soils with different materials in order to supply the nutrients needed to enhance growth and yield of crops. Several organic materials recommended to subsistence farmers in West Africa as soil amendments for increasing crop yield include cow dung, poultry dropping, pig dung and refuse composts [10] and [11].

The improved management practice is to use these external inputs from organic and inorganic sources to supply nutrients. The combined use of organic and mineral fertilizer has proved a sound soil fertility management strategy for high yields of cowpea but the efficiency of the applied fertilizer(s) is rarely indicated. Previous researches have shown that there is a positive interaction between the organic manures and urea as nitrogen source [12]. Makinde *et al.,* [13] have reported that maize (*Zea mays* L) yields obtained from application of a combination of inorganic fertilizer and manure improved yield over manure alone. Akanbi *et al.,* [14] noted that the combined application of 4t/ha of maize straw compost and N mineral fertilizer at 30kg/ha improved yield than other combinations. Adeniyan and Ojeniyi, [15] found that integrated application of poultry manure and NPK fertilizer increased maize yield compared with poultry manure or inorganic fertilizer applications alone. This practice has shown the superiority effect of integrated nutrient supply over sole use of inorganic or organic source in terms of balanced nutrient supply [16], control of soil acidity, extended residual effect [17], improvement on soil physical and chemical properties than can be derived from the use of either inorganic or organic manure and crop yield [18, 19]. The benefits of using organic materials have not been fully realized in Nigeria agriculture due to the large quantities required to satisfy the nutritional needs of crops, transportation and handling costs [20]. Besides, the integrated application of organic manure and chemical fertilizer in cowpea is rarely reported. Therefore, the aim of this experiment was to study the effects of NPK fertilizer and Pig manure on nutrient dynamics and cowpea production in an Alfisols at Ado-Ekiti.

2. Materials and Methods

2.1. Description of Study Area

This study was conducted at the Teaching and Research Farm, Ekiti State University, Ado-Ekiti (long. 7º47'N and lat. 5º13'E). Ado-Ekiti is located in the dry forest zone and experiences a warm sub-humid tropical climate with long term mean annual rainfall of 1,367 mm received in 112 days between March and November [21]. The two-year field experiments evaluate influence of NPK fertilizer and Pig manure on nutrient dynamics and cowpea production at Ado-Ekiti, South-West, Nigeria. The soil in the study site is an Alfisols [22] of the basement complex, highly leached and with low to medium organic matter content. The site had been previously cultivated to some arable crops such as maize, melon, cassava, cocoyam and legumes with little or no fertilizer and intermittent fallows of short periods. At the commencement of the study, the site was covered by a weed spectrum of guinea grass (*Panicum maximum),* mucuna (*Mucuna mucunoides*), milk weed (*Euphorbia heterophylla)* and siam weed *Chromolaena odorata*. The vegetation was ploughed and harrowed.

2.2. Soil Sampling and Sample Analysis

Surface (0-15cm) soil samples were randomly collected and bulked to form a composite before planting and at the end of each cropping season another soil samples were collected. The soil samples and pig manure were air dried, crushed and allowed to pass through a 2mm sieve. Particle size distribution of the soil was carried out by the Hydrometer method, while the pH of soil and pig manure was determined using Pye unicam model 290 MK2 pH meter in a 1:2.5 soil/water suspension. Organic carbon was determined by the [23] dichromate oxidation method [24]. Total nitrogen was determined by the micro-kjeldahl digestion method as described by [25]. Available P was determined by [26] No 1 extraction method as described in [27] laboratory manuals; Exchangeable bases were extracted with neutral 1M NH_4OAC at a soil solution ratio of 1:10 and measured by flame photometry. Magnesium was determined with an atomic absorption spectrophotometry. Exchange acidity was determined by titration of 1M KCL extract against 0.05M NaOH to a pink end point using Phenolphthalein as indicator [28].

2.3. Experimental Setup: Design and Treatments

The experiment was laid out in a randomized complete block design with three replications. The treatments consisted of: (i) No NPK, No pig manure (control) (ii) 60kg NPK 15-15-15, (iii) 4t/ha Pig manure, (iv) 8t/ha Pig manure, (v) 4t/ha Pig manure + 60kg NPK 15-15-15 (T5) and (vi) 8t/ha Pig manure + 60kg NPK 15-15-15. The manure was well rooted Pig manure that had stabilized for about 100 days. Each plot size was 4 x 2m and separated by 0.5m paths while treatment blocks were 1m apart. Pig manure was applied 2 week before planting and the inorganic fertilizer NPK was applied 2 weeks after planting both for the single and combined applications. Seeds of improved cowpea variety 1190K-568.18 (Ibadan Brown) obtained from IITA Ibadan were sown at 2 seeds per hill at a spacing of 60x30cm and later thinned to one seedling to attain a population of 66,666 plants.ha^{-1}. Plots were weeded manually with hoe at frequency required. Cowpea insect pests were controlled by application of Nuvacron (Monocrotophos; Norrvartis, Switzerland) at 40ml in 15L of water. Spraying commenced at 5 weeks after planting and at 1 week interval until full pod formation. The experiment was repeated in the second year on the same plots without fertilizer application in order to assess the residual nutrients.

2.4. Data Collection

Plant data collected were plant height, no of branches, no of leaves, no of nodules per plant, dry matter yield and root length. At maturity, dry pods of cowpea were picked as from the 10th week of planting to avoid shattering. Yield components taken were: no of pods per plant, no of seeds per pod and 100 seed weight and grain yield. Six plants were selected per plot at random and were tagged for determination of plant growth and yield components parameters. Plant height was measured using a meter rule. Root length was measured using a ruler. Dry matter yields were determined by manually harvesting the six tagged cowpea plants per plot at 50% flowering. The plants were washed and cleaned to remove traces of soil and placed in a bag before oven drying at 70°C for 48 hours. The numbers of pods per plant and seeds per pod were counted at harvest. The 100 seed-weight was measured using an electronic weighing balance.

2.5. Data Analysis

Data were subjected to analysis of variance [29]. Means were separated with Duncan's Multiple Range Test at 5% level of probability.

3. Results and Discussion

3.1. Physical and Chemical Properties of the Soil Used

Table 1. *The physical and chemical properties of soil and pig manure used for the study.*

Parameters	Soil	Pig Manure
pH (water)	5.8	6.6
Organic carbon (g kg^{-1})	2.41	2.24
Total nitrogen (g kg^{-1})	0.09	0.26
Available phosphorus (mg kg^{-1})	5.30	4.60
Exchangeable Bases (cmol kg^{-1})		
K^+	0.17	0.20
Ca^{2+}	2.28	2.42
Mg^{2+}	2.92	0.45
Na^+	0.08	0.60
Exch. Acidity	0.17	0.16
Effective cation exchange capacity	5.62	3.83
Particle size analysis (g kg^{-1})		
Sand	746	
Silt	167	
Clay	87	
Textural class	Sandy Loam	

The results of the analysis of soil and pig manure used are presented in Table 1. The soil was a slightly acidic sandy loam with low organic carbon content, exchangeable cations while total N and available P content were 0.09g kg^{-1} and 5.82mg kg^{-1}. The total N and available P were very low compared with the critical levels of 0.1% for N and 10-12mg kg^{-1} for available P [30] obtained for soil in South-west, Nigeria [31]. Using the critical levels of 0.16-0.20cmol kg^{-1} exchangeable K was also low [32].

3.2. Effects of NPK and Pig Manure on Plant Height, Number of Leaves of Cowpea

The effects of pig manure and NPK fertilizer and their combinations on plant height, number of leaves and number of branches are indicated in Tables 2. For both seasons, the tallest plants were obtained with the application of 8t/ha Pig manure + 60kg NPK which indicated 99% and 126% increase relative to the control plants in 2012 and 2013 respectively. Sole or combined fertilizer rates gave significant ($p<0.05$) increase in plant height in the two seasons. Kuldeep, [33] have observed maximum values of green pod yield, plant height with combined application of organic and inorganic fertilizer. However, in 2013 plants were taller in all the treatments and this could be attributed to the residual effects of the organic fertilizer in the second year. Number of leaves and number of branches per plant were also significantly ($p<0.05$) increased with the rate of fertilizer application. Highest number of leaves and number of branches were observed with the application of 8t/ha Pig manure + 60kg NPK which ranged from (26.8 – 32.8, 4.2 - 7.3) and (26.4 – 37.6, 5.2 – 8.7) for 2012 and 2013 respectively.

3.3. Effects of NPK and Pig Manure on Number of Nodules and Dry Matter

The number of nodules per plant was significantly reduced as poultry manure increased. (Table 3). Ofori, [34] and Olatunji *et al.,* [35] have observed that nodulation in cowpea was significantly reduced at higher rate of N application. This implied that the increased plant height from the treatments was as a result of the fertilizer application and not from the effect of cowpea nodulation.

The highest mean root length of 26.6 and 25.8cm were observed in those plants that received the highest manure combined with mineral fertilizer while the least root length of 15.8 and 16.4 were observed form no fertilizer plots in both years.

The effects of fertilizer treatments on dry matter was significant ($p<0.05$) and the 8t/ha PM+ 60kg NPK gave the highest values of 36.9g. $plant^{-1}$ and 43.6g. $plant^{-1}$ in 2012 and 2013 respectively, while the lowest values (24.3 and 23.4g. $plant^{-1}$) were obtained in the control plot for both 2012 and 2013. However, dry matter yield obtained in 2012 was lower than the two years average of 40.3 g. $plant^{-1}$. Omotoso and Falade [36] had reported that application of 30mg Zn kg^{-1}soil and organo-mineral combination (Cow dung+$ZnSO_4$) significantly gave the highest plant shoot biomass (7.11 g pot $^{-1}$) base on dry shoot weight.

3.4. Effects of NPK and Pig Manure on Yield and Yield Characters of Cowpea

Pig manure and NPK fertilizer and their combinations significantly ($p<0.05$) increased the number of pods per plant, number of seeds per pod, seed weight and grain yield per plant (Table 4). The highest no of pod (24.6) was obtained at 8t/ha PM + 60kg NPK in 2012 while in 2013 no of pod were similar in 4t/ha PM + 60kg and 8t/ha PM + 60kg NPK application rates. Highest number of seed/pod (11.7 and 12.8), 100 seed weight (24.7 and 26.3g) and grain yield (1.39 and 1.42t/ha) for 2012 and 2013 respectively, was obtained with 8t/ha PM + 60kg NPK. The average no of pod/plant, average 100 seed weight and average grain yield produced by 8t/ha PM + 60kg NPK application rate for 2 years were 41, 40 and 29% increased relative to no fertilizer treatment. Increasing the rate of pig manure increased all the yield parameters. Ferreira et al., [37] studied the use of organic and mineral fertilizer for production of okra in soil of Rio de Janeiro, Brazil. The results indicated a significant increase in yield with increase in mineral fertilizer as well as manure. Nuruzzaman, et al., [38] revealed that yield characters of okra could be modified by the application of biofertilizer+cowdung. However, biofertilizers+cowdung treatments were comparable with treatment comprising of 60% N. Datt et al., [39] revealed that NPK fertilizer combined with farm yard manure significantly increased the green pod yield of pea and the maximum value was obtained in treatment where nutrients were applied at 30kg N + 39.3kg P +37.5kg K +10t FYM ha-1. Also, [33] observed that maximum values of green pod yield, plant height, number of green pods/plant, number of seeds/pod and 100 seed weight were obtained with combined application of organic and inorganic fertilizer at 20t FYM + 25kg N + 65kg P2O5 + 97.5kg K2O ha-1.

Table 2. *Effects of NPK fertilizer and Pig manure on growth characters of cowpea*

Treatments	Plant height (cm)		Number of leaves/plant		Number of branches/plant	
	2012	2013	2012	2013	2012	2013
No fertilizer (NF)	10.3f	12.6e	26.8e	26.4f	4.2c	5.2d
60kg/ha NPK	16.4c	21.9c	28.3d	30.3d	5.6b	7.3b
4ton/ha PM	13.2e	19.3d	28.4d	27.8e	5.3b	6.4c
8ton/ha PM	15.8cd	22.4c	31.3b	33.3b	5.4b	7.3b
4t/haPM+60kg NPK	17.3b	24.5b	30.4c	31.5c	5.5b	6.7c
8t/haPM+60kg NPK	20.5a	28.6a	32.8a	37.6a	7.3a	8.7a
Mean	15.6	21.6	29.7	31.2	5.6	6.9
SE±	0.57	0.59	1.26	1.27	0.35	0.32
CV (%)	39.12	39.10	24.67	24.96	2.13	2.26

Mean followed by the same letter(s) are not significantly different at P<0..05 using DMRT. Key: NF= no fertilizer, PM=Pig manure, NPK= 15:15:15

Table 3. *Effects of NPK fertilizer and Pig manure on number of nodule, dry matter and root length of cowpea*

Treatments	Number of nodules		Root length (cm)		Dry matter (g)	
	2012	2013	2012	2013	2012	2013
No fertilizer (NF)	10.3b	10.1d	15.8f	16.4e	24.3f	23.4f
60kg/ha NPK	10.5b	12.3c	17.6e	18.3d	30.8d	34.7d
4ton/ha PM	9.4bc	15.2b	20.0d	22.4c	29.3e	33.2e
8ton/ha PM	8.8d	11.3d	24.3b	24.7b	32.7c	42.1b
4t/haPM+60kg NPK	11.1a	16.4a	21.2c	24.8b	33.4b	39.2c
8t/haPM+60kg NPK	10.4b	15.2b	26.6a	25.8a	36.9a	43.6a
Mean	9.9	10.9	20.9	22.1	31.2	36.0
SE±	1.30	1.37	1.72	0.59	1.87	0.50
CV (%)	39.14	38.24	22.21	23.46	24.95	26.72

Mean follow the same letter(s) are not significantly different at P=<0.05 using DMRT. Key: NF= no fertilizer, PM=Pig manure, NPK =15:15:15

Table 4. *Effects of NPK fertilizer and Pig manure on grain yield and yield components of cowpea*

Treatment	No of pod/plant		Number of seed/pod		100 seed weight (g)		Yield t/ha	
	2012	2013	2012	2013	2012	2013	2012	2013
No fertilizer (NF)	16.2f	17.3e	7.4e	8.1e	14.3f	16.2f	0.89e	1.10e
60kg/ha NPK	18.4d	19.1c	8.3d	8.4e	19.4d	20.6c	1.14d	1.16d
4ton/ha PM	17.3e	18.2d	9.2c	10.3c	17.1e	18.5e	1.18c	1.20c
8ton/ha PM	19.3c	21.4b	11.6a	11.3b	20.5c	19.9d	1.19c	1.36b
4t/haPM+60kg NPK	21.4b	22.3a	10.4b	9.7d	22.4b	23.7b	1.23b	1.21c
8t/haPM+60kg NPK	24.6a	22.7a	11.7a	12.8a	24.7a	26.3a	1.39a	1.42a
Mean	19.5	20.2	9.8	10.1	19.7	20.9	1.17	1.24
SE±	0.58	0.57	0.52	0.54	0.69	0.67	0.045	0.043
CV (%)	24.6	25.9	3.84	2.13	23.9	25.4	8.48	8.54

Mean follow the same letter(s) are not significantly different at p<0.05 using DMRT. Key: NF= No fertilizer, PM=Pig manure, NPK

3.5. Effects of NPK Fertilizer and Pig Manure on Soil Nutrient Status

The nutrient status as affected by PM and NPK fertilizer after cropping season in 2012 and 2013 are presented in Table 5. Inorganic NPK fertilizer significantly reduced soil pH in both seasons and increased N and P content of the soil. This is in agreement with Olatunji *et al.,* 2012. Plots that received higher rates of sole manure and their combination with NPK fertilizer had higher pH than the control plots but the trend was different in plots that received inorganic fertilizer where the pH of the control plot was higher than the pH of plots that received 60kg/ha NPK fertilizer alone. This is consistent with Nnaji *et al*., [41] who reported that soil pH was increased by combined application of mineral fertilizer NPK with cow dung and attributed this to the release of some cations from decayed organic amendments. The decline in pH of plots treated with inorganic fertilizer in this study could be attributed to their rapid rates of release of nutrient, which are immediately used up by plants, leading to poor accumulation of exchangeable bases that neutralizes soil acidity. While the sole pig manure at 8t/ha gave values of (6.4 and 6.6) and the combined application of 8t/ha Pig manure + 60kg/ha NPK gave significantly ($p<0.05$) higher pH values of 6.6 and 6.5 in 2012 and 2013 respectively compared to the control. This is consistent with Ibiawuchi *et al,* [40] who reported that all the plots treated with poultry manure + inorganic fertilizer had high residual N, P, K, Ca and Mg while soil pH increased from 5.65 to 5.71. Therefore, in this study the increase in soil pH due to corresponding increase in the rates of pig manure could be attributed to increased microbial activity during the process of decomposition leading to cations like Ca, Mg and Na released from mineralisation and organic matter formation.

Relative to no fertilizer treatment, sole pig manure and combination of pig manure and NPK significantly ($p<0.05$) increase soil organic caebon (SOC) with 8t/ha Pig manure + 60kg/ha NPK producing the highest values (1.50 and 1.60g/kg) in 2012 and 2013 respectively, while sole application of 60kg/ha NPK caused a decrease in SOC. Also, using the 2 years average, application of 4t/ha, 8t/ha, 4t/ha +60kg NPK and 8t/ha + 60kg/ha NPK increased SOC by 19, 27, 22 and 29% respectively, relative to no fertilizer plot.

Inorganic fertilizer NPK 15-15-15 gave significantly ($p<0.05$) increase in N, P, K content but caused a decrease in Ca and Mg. The pig manure alone and combination of Pig manure + NPK 15-15-15 increased total nitrogen above the control in 2012 and 2013 with 8t/ha Pig manure + 60kg/ha NPK giving the highest average N value of 0.25k/kg for the 2 years. Available P was increased above the control by all the treatments in both seasons except the plot that received inorganic fertilizer alone in 2012. This is consistent with [42] who noted that combined application of pig manure and NPK to tomato increased N, P and K content and yield of tomato. Also, Agbede et al., [43] reported that poultry manure increased plant N, P, K, Ca and Mg status in leaf of Sorghum.

Table 5. *Effects of NPK fertilizer and Pig manure on Soil nutrient status after cropping season in 2012 and 2013*

Treatments	pH(H_2O)		Org. C (g/kg)		Total N (g/kg)		Avail. P (mg/kg)		Exchangeable bases (Cmol/kg					
									K		Ca		Mg	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Initial	5.80		2.41		0.09		5.30		0.18		2.28		2.92	
NF	5.20	5.10	1.20	1.20	0.09	0.10	4.62	5.10	0.11	0.13	3.10	3.10	2.62	2.02
60kg/ha NPK	4.46	4.20	1.13	1.15	0.10	0.14	5.20	5.38	0.27	0.25	2.14	2.27	1.92	2.01
4ton/ha PM	5.80	6.41	1.43	1.44	0.20	0.21	5.43	5.40	0.21	0.28	4.27	3.80	3.01	3.52
8ton/ha PM	6.40	6.60	1.53	1.54	0.22	0.20	5.71	5.92	0.39	0.31	4.42	4.12	3.04	3.46
4t/haPM+60kg NPK	6.36	6.50	1.41	1.52	0.10	0.21	5.20	5.62	0.36	0.29	3.02	3.10	2.82	3.21
8t/haPM+60kg NPK	6.60	6.50	1.50	1.60	0.24	0.25	5.90	6.10	0.42	0.44	3.93	4.63	3.06	3.16
Mean	5.76	5.89	1.40	1.45	0.17	0.21	5.33	5.59	0.29	0.28	3.76	3.73	2.87	2.78
SE±	0.86	0.85	0.38	0.04	0.041	0.043	0.04	0.07	0.03	0.03	0.085	0.085	0.09	0.09
CV (%)	4.66	4.63	8.49	8.62	1.35	1.38	4.87	3.84	1.36	1.34	3.86	4.25	2.64	2.59

Mean follow the same letter(s) are not significantly different at $p<0.05$ using DMRT. Key: NF= No fertilizer, PM=Pig manure, NPK= 15:15:15, respectively

4. Conclusion

The results of this study have demonstrated that the combined applications of pig manure and inorganic fertilizer NPK thus have a profound significant influence on cowpea and enhanced plant growth and development when compared to untreated plots. Maximum yield of 1.4t/ha was obtained with application of 8t/ha Pig Manure + 60kg NPK. While application of pig manure alone and its combination with NPK significantly ($p<0.05$) increased soil N, P, K, Ca and Mg. It can be concluded that for maximum production of cowpea the amount of manure required can reduce the chemical fertilizer that would be needed.

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