Journal of Agriculture and Social Research (JASR) Vol. 12, No. 1, 2012

EFFECT OF ORGANIC AND INORGANIC MANURES AND TIME OF APPLICATION ON SOIL PROPERTIES AND YIELD OF SWEETPOTATO IN A TROPICAL ULTISOL

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ABSTRACT
The effect of different rates of a mixture of organic and inorganic manure and time of application on the root yield of sweet potato (Ipomoea batatas(L) Lam) in a tropical Ultisol of South Eastern Nigeria was investigated during 2004 and 2005 cropping seasons. The research was carried out at the Eastern farm of National Root Crops Research Institute Umudike (NRCRI). The institute is located within latitude 0^5, 29^1 N and Long 7^0 33 E^1 of the Equator at an elevation of 122m above sea level. The aim was to determine the optimum rate and time of application of the mixture of organic and inorganic manure and their effect on some of the soil properties and root yield of Sweetpotato. The rates were 600kg/ha inorganic fertilizer,(NPK) 3.2t/ha poultry manure ,(PM) 450kg /ha NPK +0.8t/ha PM, 300kg/ha PM NPK+1.6t/ha, 150kg/ha NPK+2.4t/ha PM and a control. Time intervals were ;at planting,2 weeks after planting, 4 weeks after planting and 6 weeks after planting. Results showed that amongst the various rates and time intervals investigated, application of 300kg/ha NPK +1.6t/ha PM of the two manure sources gave the highest economic root yield. The time interval of between 2-4 weeks after planting also gave the highest economical root yield of the crop .At this period also the recommended range of the investigated soil properties favourable to the root yield of the crop were obtained. These were pH, organic matter, Nitrogen, Phosphorus, Potasium and Exchangeable acidity.

Key words: Manure mixtures, soil properties, time of application, root yield

INTRODUCTION
Fertilizers are made to supplement soil nutrients inadequacy which presents a current problem amidst farmers. Plants do not know the difference between organic fertilizers .Their small whiskers will soak up those minute nutrients irrespective of where they derive from or how they were made up .For obvious reasons scientists advocate the use of combined organic and inorganic manures for increased production. The significant effect of the two nutrient sources to balance the nutrient need is viewed as unparalleled advantage in crop production.
Timing of nutrient application in the field is governed by several basic considerations Brady and Weil (2002); nutrient availability when plants need it, avoiding wastage and enhance nutrient use efficiency. One clear cut advantage which chemical fertilizers have over organic fertilizers is the fact that they hold all the three of the major nutrients, Nitrogen Phosphorus and Potassium in a predetermined proportion except the manufacturer adds other important minerals. Chemical fertilizers are said to have the following characteristics Jim Ellison (2011); Water solubility of chemical fertilizers result in fast release. Any chemical applied will slacken or stop natural decomposition operations so that thatch may pile up. Many chemical fertilizers own high acid content like sulphuric and hydrochloric acids which going through soil acidity successfully results in the death of Nitrogen fixing bacterium, the organism that plays a central role in refurbishing a maturing plants nitrogen demands. The remainder of the components in the chemical fertilizer bag, apart from NPK, is typically comprised of neutral filler or perhaps a chemical that is not required.

A bag of chemical fertilizer owns zero energy if organic matter is not already existing in the soil, the chemicals may rapidly turn stressful, even harmful which subjects the plants to diseases and pests while; Water solubility of natural fertilizers allows slow release so that crops have time to profit from the complete application. Organic fertilizers manures and composts discharge their nourishing content only when they break down slowly through the intricate ecology of living creatures in the soil at that time they steadily discharge contents. All the components in the organic fertilizer bag beyond the NPK are completely essential soil nutrients.

The fact that the material is organic signifies that it is derived from a once living plant, animal or a mix of both, which assures us that all components there are crucial to life. In most beneficial organic fertilizer, everything in the bag is necessary and is in exact proportion to fertilize and keep up the next generation of life. A bag of organic fertilizer which is relatively cheaper has all the carbon and vitality to conform to the demands of soil microbs.The above characteristics of organic and in organic fertilizers which complements each other makes its combination a necessary component for crop production.

Sweetpotato *(Ipomoeae batatas (L Lam)* is a perennial crop belonging to the family of Convulvulaceae but it is cultivated as an annual crop . A lot of incoherence's surround the origin but Austin (1988) postulated that Sweetpotato originated between the Yucatan peninsula of Mexico near the Oronoco river of Venezualla It thrives in marginal soil but improved soil fertility increases its general performance and root yield. It ranks as the fifth most important food crop on fresh weight bases in developing countries after rice, wheat, maize and cassava' Its uses range from domestic to industrial and has recently assumed the front burner. This is because it is known to contain beta carotene which is a precursor for vitamin A. In Nigeria it is grown and eaten virtually everywhere.

While the importance of the mixture has been demonstrated Onunka et al (2002) there is dearth of information on optimum time of application of a mixture of organic and inorganic fertilizers at the right proportion for optimum performance of this crop by farmers. Research findings show that farmers still apply the mixture either at the recommended time for inorganic fertilizer four to six weeks after planting Nwinyi (1986) or whenever it is available to them. Also the effect of the inconsistent time of application on the physical and chemical properties of the soil which subsequently affect crop performance has not been determined. The objective of this study therefore is to determine the optimum time of application of the mixture and its effect on some of the physical an d chemical properties of the soil and root yield of the crop.

MATERIALS AND METHODS

This trial was carried out at the National Root Crops Research Institute, Umudike in 2004 and 2005 cropping seasons. Umudike is located within latitude 5^0, 29^1 N. 7^0 33^1 E , with an elevation of 122 m above sea level. The blocks used for this trial were maintained in a two year rotation, and in the penultimate year the blocks were planted with cassava. Soil fertility was enhanced with inorganic fertilizer application. The field was mechanically cleared, ploughed, harrowed and ridged. Plot size was 6 m x 5 m. After land preparation, soil samples were randomly collected with auger at a depth of 0-15 cm and thoroughly mixed from which a composite sample was obtained and analyzed to determine the preplanning physico chemical properties table 1. Four node cuttings of variety TIS 87/0087 were planted at the crest of the ridge at a spacing of 1mx0.3m to give plant population of 33,333 plant ha^{-1}. The poultry manure was sourced from Michael Okpara University of Agriculture poultry farm while the inorganic fertilize was purchased from the open market. From the analysis of the poultry manure 3.2 $tons/ha^{-1}$ of it was calculated to contain an equivalent of 600kg/ha NPK recommended for the crop. Four rates of the mixture viz 600kg/ha inorganic fertilizer

(NPK), 3.2t/ha poultry manure,(PM) then mixture of both at 450kg/ha+ 0.8t/ha, 300kg/ha+1.6t/ha and 150kg/ha+2.4t/ha and a control where no treatment was applied. The periods of application evaluated were at planting, (OWAP) two weeks after planting (2WAP), four weeks after planting (4WAP) and six weeks after planting (6WAP). The plots were separated from each other by cross bars to retain the effect of one treatment from the other. Manual weeding was done before the vines spread and smothered the weeds maintaining a weed free plot till senescence. The design was Randomized Complete Block in a factorial experiment. The sweet potato enlarged underground roots used to assess the performance were harvested after five months each year using digging fork according to treatments. From the measurements, the corresponding yields in tons ha^{-1} were determined and analyzed with mixed model of SAS (1989) edition. The physical and chemical properties of the soil in the experimental area in 2004 and 2005 are shown in Table 1.

Description of the Experimental Area.The area was cleared after a one year fallow. The dorminant vegetation was *Panicum maximum* slashed at a matured stage and burnt to reduce rhe stubble before ploughing, harrowing and ridging The percentage nitrogen content of the soil in both years was relatively the same. The percentage nitrogen during 2005 was a bit higher, this could be due to previous crop because the use of use of nitrogen is affected by such factors as leaching and nitrification. The level of phosphorus was lower in 2004 than 2005 cropping season. The organic matter and potassium were very low in both years necessitating the need for amendment for increased crop yield. The previously applied soil amendment may have been fully exhausted by the crops. Generally, the values of the chemical properties of the experimental area were less in 2004 than 2005 except percentage base saturation and pH this could also be attributed to crop removal as yields were higher in 2004 than 2005 cropping season. According to Laura Van Scholl (1988) such development could be due to the nature of the crops and previous treatment applied to these two areas . The exchangeable acidity in the soil was generally low. They are generally lower than 10.00cmol/kg. This is a characteristic of low activity clay of South Eastern Nigeria demonstrated by Agbede (1996).

Table 1 Physical and chemical properties of soils of the experimental area in 2004 and 2005 cropping seasons.

Soil Parameter	2004	2005
$P^H(H_20)$	5.4	4.4
Pmgkg^{-1}	31.2	0.08
N(%)	.084	0.79
OC(%)	0.71	1.36
OM	1.22	1.36
Cacmo1kg^{-1}	1.6	1.93
Mgcmolkg^{-1}	1.2	0.9
Kcmolkg^{-1}	0.087	0.15
Nacmolkg^{-1}	0.113	
Eacmolkg^{-1}	0.96	0.96
BS(%)	72.5	75.5
Sand(%)	74	72
Salt(%)	10	11
Clay(%)	16	17
Texture	Sandy Loam	Sandy Loam
Soil $_P{}^H$		

The result of the mixture of organic and inorganic manures and the time of application on the soil $_{P}H$ during 2004and 2005 cropping seasons is shown on table 2. The result in 2004 showed that application of a mixture of 300kg/ha+1.6t/ha each of the manures produced a mean pH value of 5.65 when the mixtures was applied at planting which is the highest acid medium across all the treatments including the control. The same was recorded at planting (OWAP) . The next was at the application of 3.2t/ha poultry manure alone and at the application at 4WAP There was significant difference in P^{H} between the application of 600kg/ha inorganic fertilizer and the application of 300kg/ha+1.6t/ha each of the nutrient sources in the pH levels (5.65 and 5.45). But there was significant difference between the pH level obtained at the application at OWAP and 6WAP. The interaction between the different mixtures and time of application was significant $p<0.05$. In 2005, similar to 2004, the mixture of 300kg/ha+1.6t/ha each of the nutrient sources produced lower mean pH value compared to the others including the control while application at 6 WAP produced a higher mean pH value.

According to Samuel et al (2003) soils of $_{P}H$ of 6.5 and 7 are considered optimum for crop production. but sweet potato is known to be acid tolerant. the increase in $_{P}H$ value with the application of increased organic manure agrees with the findings of Agboola et al (1975), who reported that there is reduced acidification and increased control of exchangeable cation when poultry manure is added to the soil thus enhancing crop growth and uptake of phosphorous. Since sweet potato is an acid tolerant crop and organic manure is slow in the release of the mineral, application at 2WAP which retains the soil at acidic medium on application of 300kg/ha+1.6t/ha each of the nutrient sources may be recommended for optimum root yield of sweet potato. The higher mean pH value observed in 2004 and 2005 compared to the control agrees with the work of Ogumole (2005) who observed that increase in pH contributes to creating a favourable medium for crop performance as recorded in 2005.

Table2: Effect of mixture of organic and inorganic manures and time of application on soil pH during 2004/5 cropping seasons.

	2004 Time of Application WAP					2005				
Trt/ha	O	2	4	6	Mean	0	2	4	6	Mean
600kgNPK	5.67	5.64	4.94	5.55	5.45	4.90	4.76	4.67	5.76	5.02
3.2tPM	5.34	5.23	3.36	5.92	5.56	4.61	5.04	5.05	5.21	4.98
450kg+0.8tPM	5.37	5.55	5.88	5.23	5.51	5.31	5.05	4.74	4.69	4.95
300kg+1.6tPM	5.93	5.30	5.86	5.52	5.65	5.29	4.94	5.55	5.33	5.28
150kg+2.4PM	5.88	5.85	2.85	5.41	5.00	5.07	4.91	4.91	5.03	4.98
Control	5.72	5.26	5.68	5.30	5.49	4.72	5.10	5.32	5.54	5.17
Mean	5.65	5.47	5.09	5.49		4.98	4.97	5.04	5.27	
SED NPK	0.22					0.21				
SED PM	0.16					0.13				
SED NPKXPM	0.36					0.31				

KEY PM=Poultry Manure
O at planting

2 Weeks after planting
4 weeks after planning
6 weeks after planning

Soil Organic Matter.

The effect of mixture of organic manure and time of application on soil organic matter is shown on table3 . The result showed that in 2004 application of 150kg/haNPK+2.4t/hPM produced the highest organic matter percentage (1.67). This was followed by application of300kg/ha+1.6t/ha each of the nutrient sources. There was progressive increase in the percentage of organic matter over the period of application, and the highest recorded at 6WAP . In 2005 450kg/NPKha+0.8t/ha PM produced the highest percentage organic matter followed by 3.2 t/ha PM poultry manure but the difference was not significant at $p<0.05$. But the time of application of 4WAP produced the highest organic matter percentage (0.96) followed by 0WAP (0.91), the soil organic matter was generally low and less than 2% typical of ultiso,l Enwezor et al (1989) however, all mixtures containing organic manure had higher percentage of organic matter. this finding is in line with the work of Laura Van scholl (1989) who stated that chemical fertilizers are depleted at the end of the season while organic matter continue to enhance soil fertility as well as soil structure at 2WAP more organic matter were in both years 1.61 and 1.07.

Table 3: Effect of Mixture of organic and inorganic Manures and time of application on soil percentage organic matter during 2005/5 cropping seasons.

	2004 Time Of Application					2005				
Trt/ha										
	0	2	4	6	Means	0	2	4	6	Means
600KgNPK	0.99	1.17	0.98	1.43	1.14	0.89	0.55	0.77	0.31	0.63
3.2tPM	1.55	1.42	1.44	1.16	1.39	1.17	0.93	1.06	0.75	0.98
450Kg+0.8tPM	1.20	1.57	1.37	1.08	1.30	1.10	1.04	0.95	1.10	1.04
300Kg+1.6tPM	1.42	1.61	1.50	1.39	1.48	0.91	1.07	0.67	0.69	0.83
150Kg+2.4tPM	1.51	1.13	1.66	2.38	1.67	0.45	1.12	1.13	1.01	0.92
Control	1.15	1.11	1.59	1.81	1.41	0.97	0.23	1.20	1.03	0.85
Mean	1,30	1.33	1.42	1.54		0.91	0.82	0.96	0.82	
SED NPK	0.19						3.95			
SED PM	0.12						3.15			
SED NPK X PM	0.27						7.73			

Soil Nitrogen

The result of the effect of mixture of organic manures and time of application on soil nitrogen is shown on table 4. In 2004, there was no definite trend in the percentage Nitrogen recorded across the various mixtures, however application of 450kg/ha+0.8t/ha pm recorded the highest nitrogen percentage 0.16, followed by 150kg/ha+2.4t/ha pm (0.11). Time of application of 4WAP had the highest nitrogen percentage (0.14) followed by 2WAP (0.1). The treatment effect was highly significant $p<0.01$. In 2005, 300kg/ha+1.6t/ha pm each of the sources produced the highest percentage of nitrogen (0.08) followed by 450kh/ha+0.8t/ha pm (0.06), there was no difference between the control and 150kg/ha+2.4t/ha pm. The result of 2004 cropping season is in contrast with the findings of Duruigbo et al (2007) who observed the highest reduction in organic carbon and total nitrogen from plots treated with inorganic fertilizer but agrees with the 2005 result where plots treated with inorganic fertilizer had nitrogen. The reduction in percentage nitrogen at 6WAP in both years may

indicate period of highest nitrogen need by the crop. It has been shown that about 40% need of nitrogen by sweet potato can be derived from atmospheric nitrogen though cultivar differences are large Yonayama et al (1998).

Application of nitrogen from organic and inorganic sources is essential to sustain and improve crop yield in continuous cultivation system. Low nitrogen application rates improper timing of nutrient application and faulty application method (De Datta et al 1983 Galhangu et al 2000) are some of the facts which lead to low potato yield.

Table 4 : Effects of mixture of organic and inorganic manures and time of application on percentage soil nitrogen during 2004/5 cropping season

		2005	Time	Of	Application Mean				**2005**	 Mean
Trt/ha	0WAP	2WAP	4WAP	6WAP		0WAP	2WAP	4WAP	6WAP	
600kgNPK	0.06	0.18	0.05	0.06	0.09	0.04	0.03	0.05	0.05	0.04
3.2tPM	0.08	0.09	0.06	0.07	0.08	0.06	0.06	0.07	0.04	0.06
450kgNPK+0.8tPM	0.08	0.09	0.43	0.05	0.16	0.07	0.06	0.07	0.06	0.07
300NPK+1.6tPM	0.06	0.09	0.09	0.08	0.08	0.06	0.05	0.17	0.04	0.08
150kgNPK+2.4tPM	0.05	0.1	0.11	0.16	0.11	0.04	0.07	0.05	0.06	0.06
Control	0.05	0.04	0.07	0.06	0.06	0.05	0.06	0.06	0.05	0.06
Mean	0.07	0.1	0.14	0.08		0.05	0.06	0.08	0.05	
SED NPK	0.02						0.14			
SED PM	0.02						0.11			
SED NPK X PM	0.05						0.02			

Soil Phosphorous

The result of the effect of mixture of organic and inorganic manure on soil phosphorous is presented on table 5. The result shows that a mixture of 150kgNPK/ha+2.4/t/haPM gave the highest soil phosphorous,(55.11) followed by application of only poultry manure 3.2t/ha(46.79) PM in 2004. As should be expected the least was recorded by the control. Time of application of 6WAP produced the highest soil phosphorous, followed by application at 2WAP, though there was no significant difference between them. The treatment effect was also very highly significant $p<0.001$. But in 2005, a different trend was observed where 600kgNPK/ha produced the highest soil phosphorous followed by the control. Also time of application of 6WAP produced the highest soil phosphorous followed by the control 2WAP. The treatment effect was generally non significant.

The result showed a general increase in the quantity of soil phosphorous in both years according to (Zsolnay et al 1994) the incorporation of manure and crop residues have been shown to increase the rate of desorption of phosphorous and thus improve the available phosphorous content of the soil. In 2004, the difference in the quantity of soil phosphorous recorded was small almost in line with the quantity of organic manure added to the soil and the changes were not much. A similar result was recorded by Ayoola et al (2006), in a similar experiment and they attributed it to the relatively immobile nature of phosphorous and strong

adsorption to soil particlesThe quantity of soil phosphorus available in the soil at the time of application of 2WAP and 6WAP was not significant hence 2WAP could be considered to give room for gradual release of the nutrient from the organic source.

Phosphorous deficiency and response to phosphorous application are most common in acid soils (Edison et al 2009) especially in laterite and red soils, such as oxisols, nullisols etc. which contains high level of Fe and Al. A mixture of nutrient which will catalyze the release and availability of the needed nutrient element and optimum time of application is important for optimum yield of the crop.

Table 5: Effect of mixture of organic and inorganic manure and time of application on soil phosphorous Cmolkg^{-1} during 2004 and 2005 cropping seasons.

	2004 Time Of Application					2005				
Trt/ha	0WAP	2WAP	4WAP	6WAP	Mean	0WAP	2WAP	4WAP	6WAP	Mean
600kgNPK	37.17	35.56	41.02	59.59	43.33	95.12	50.75	66.56	52.55	66.24
3.2tPM	32.89	67.60	50.63	36.03	46.79	48.11	31.47	49.78	55.18	46.14
450kgNPK+0.8tPM	56.25	33.48	33.63	51.49	43.71	46.17	49.78	30.36	56.99	45.82
300kgNPK+1.6tPM	37.43	57.02	28.90	41.07	41.10	40.90	49.64	44.79	44.51	44.96
150kgNPK+2.4tPM	66.05	48.29	34.34	71.78	55.11	59.91	42.15	43.26	70.86	54.04
Control	39.63	44.61	35.83	41.89	40.49	73.63	49.92	53.53	64.75	60.46
Mean	44.90	47.76	37.39	50.31		60.64	45.92	48.05	57.47	
SEDNPK	7.63						13.25			
SEDPM	6.24						12.70			
SED NPKXPM	15.24						17.43			

Soil Potassium

The result of the effect of a mixture of organic and inorganic manures and time application on soil potassium is shown on table 6. In 2004, the result showed that the application of 150kgNPK +2.4tPM gave the highest soil potassium (0.14cmol/kg-^{1}) followed by 3.2t PM, 450kgNPK +0.8tPM, 600kgNPK+1.6tPM and 600kgNPK while the least was the control. Time of application of 2WAP recorded the highest quantity of soil potassium followed by 4 WAP with similar quantity recorded at 4 and 6 WAP respectively. Both mixture and time of application were significant at $p<0.05$ while their interaction as not. In 2005 , a different trend was observed. It was in the order 150kgNPK+2.4tPM >600kgNPK >450kgNPK+0.8tPM >300kgNPK+1.6tPM ,> 3.2tPM >control. Time of application of 2WAP recorded the highest quantity of soil potassium closely followed by 0WAP, both 4 and 6 were respectively the same.

In both years, the presence of inorganic manure significantly affected the quantity of soil potassium. Application of the mixture at 2WAP appears to favour the availability of the minerals. This result differs from the work of Onunka (2010), who observed lower exchangeable potassium in an experiment involving the use of only organic manure. The presence of inorganic manure in this experiment may have provoked the mechanism for the release of more exchangeable potassium which may have let to the increase at the application at 2WAP. Potassium is involved in photosynthesis, protein and carbohydrate metabolism leading to translocation, a process which starts from the formation of leaves in the plant to maturity

Table:6 Effects of mixture of organic manures and time of application on soil potassium Cmolkg^{-I} during 2004/5 cropping seasons.

	2004	Time	Of	Applic			2005			
Trt/ha	0WAP	2WAP	6WAP	6WAP	Means	0WAP	2WAP	4WAP	6WAP	Means
600kgNPK	0.08	0.1	0.06	0.10		0.10	0.28	0.06	0.08	0.13
3.2tPM	0.11	0.05	0.1	0.10	0.10	0.07	0.07	0.07	0.08	0.07
450NPK+0.8tPM	0.07	0.09	0.17	0.88	0.10	0.26	0.07	0.06	0.07	0.11
300kgNPK+1.6tPM	0.080.08	0.10	0.13	0.08	0.10	0.06	0.09	0.07	0.05	0.07
150kgNPK+2.4tPM	0.10	0.31	0.07	0.08	0.14	0.26	0.34	0.08	0.08	0.19
Control	0.10	0.06	0.09	0.08	0.08	0.06	0.07	0.07	0.05	0.06
Means	0.09	0.12	0.10	0.09		0.14	0.15	0.07	0.07	
SED NPK	0.03									
SED PM	0.02									
SED NPK X PM	0.05									

SOIL EXCHANGEABLE ACIDITY.

Table: 7 shows the result of the effect of a mixture of organic and inorganic manure and time of application on soil exchangeable acidity. The result showed that application of 150kgNPK+2.4tPM of the mixture produced highest level of exchangeable acidity followed by 600kgNPK/ha application of inorganic manure which was of course significantly different from each other. The next was the control followed by 3.2t/ha PM, 300kgNPK+1.6t PM and 450kg/NPK+0.8t PM in 2004. Also time of application of 4WAP gave the highest exchangeable acidity value 1.13cmou/kg-1 followed by 2WAP 1.12cmolkgha while the least was application at 0WAP. In 2005, also application of 600kg/ha NPK alone gave the highest value of exchangeable acidity, the next was application of 450kg/haNPK+0.8tPM followed by the control. Time of application 2WAP recorded the highest value of exchangeable acidity 1.37cmol/kg-1 by 0WAP 1.31 (cmolkg^{-1}) the least was at 6WAP 1.20 cmolkg^{-1}. The differences between these values at these periods of application were not significantly different. In both years, there was no significant difference between the exchangeable acidity

values in terms of time of application. This result again is in contrast with the work of Onunka (2010) where he observed a higher level of soil exchangeable acidity at 0WAP, he attributed his result to the formation of soluble complex by the organic manure with non acid nutrient cations such as ca^{2+} and mg^{2+} thus facilitating the loss of these cations by leaching . However, in his work only organic manure was used. The decrease in the mean level of exchangeable acidity recorded in this work can be attributed to the effect of inorganic manure component of the mixture. Ayeni et al 2011 also observed significant increase $p<0.05$ in soil P^H organic matter, N, ca, mg, CEC and percent base saturation in an experiment involving a mixture of coco pod ash and poultry manure rates.

Table 7: Effect of mixture of organic and inorganic manures and time of application on soil percentage exchangeable acidityCmolkg-^{1} during 2004/5 cropping seasons.

	Time Of Applic 2004					2005				
Trt/ha	0WAP	2WAP	4WAP	6WAP	Means	0WAP	2WAP	4WAP	6WAP	Means
600kgNPK	0.72	1.20	1.62	0.96	1.12	1.46	1.73	1.36	1.30	1.47
3.2t PM	1.09	1.30	0.96	0.75	1.02	1.36	0.98	1.17	1.12	1.16
450kgNPK+0.8tPM	1.26	0.88	0.56	0.84	0.89	1.20	1.54	1.49	1.41	1.41
300kgNPK+1.6tPM	0.95	1.44	0.74	0.91	1.01	1.25	1.36	1.12	1.09	1.20
150kgNPK+2.4tPM	0.79	0.80	2.03	1.12	1.18	1.06	1.25	1.18	1.28	1.19
Control	0.88	1.13	0.85	1.30	1.o4	1.49	1.36	1.29	0.98	1.28
Means	0.09	1.12	1.13	0.98		1.31	1.37	1.26	1.20	
SED NPK	0.14						0.17			
SED PM	1.0						0.13			
SED NPK X PM	1.0						0.25			

ROOT YIELD

The result of the effect of mixture of organic manures and time of application on mean root yield of sweet potato is shown on table 8. In 2004 the result showed no statistical significance in both time of application and mixture. However 3.2t/ha (PM) organic manure gave the highest mean root yield, this was closely followed by the application of 300kg/ha NPK+1.6t/ha PM . The yield obtained at the application of 600kg/ha NPK is at variance with the works of D' Souza and Bourice (1986), (Floyd et al 1988) and Preston (1990) who obtained higher sweet potato root yield on application of a combination of organic and inorganic fertilizer at Papua New Guinea. This could be attributed to the inherent nutrient soil status. In terms of time of application 6WAP gave the highest mean root yield which was not significantly different from the yield obtained at 2WAP.

In 2005, the highest mean root yield was recorded at the application of 150kg/haNPK+2.4t/ha PM this was closely followed by 300kg/haNPK+1.6t/ha PM . This result is in agreement with the work of the above authors. They credited their result to the various factors involved such

as addition of beneficial nutrient in organic manure which are not found in inorganic manure and the improvement in the physical and biological properties of the soil. Time of application of 2WAP gave the highest yield closely followed by 6 and 4 WAP respectively. The least was recorded when inorganic manure was recorded at 0WAP. The effect of the manure mixture was highly significant ($p<0.001$) while the effect of time of application and interactions were not significant. This implies that the synergistic effect of the two nutrient material gave the best result. While inorganic fertilizer easily releases its nutrient the organic slowly releases to sustain the growth and performance of the crops through the growing season. A similar result was obtained by (Onunka et al 2003). The near uniform range of yield recorded by the time of application of 2WAP in the two year cropping season indicate that time of application of the mixture should be from 2WAP .This is implied since the ultimate aim of the farmer is optimum yield.

Table: 9. Effects of mixture of organic and inorganic manure and time of application on mean root Yield t/ha^{-1} of sweet potato during 2004 and 2005 cropping season.

	2004	Time	of	Applic			2005			
Trt/ha	0WAP	2WAP	4WAP	6WAP	Means	0WAP	2WAP	4WAP	6WAP	Means
600kgNPK	19.8	19.6	17.0	28.6	21.2	8.53	8.79	5.35	6.31/2	7.30
3.2tPM	15.6	15.9	16.0	16.7	16.1	8.11	6.09	11.17	8.24	8.40
450NPK+0.8tPM	14.6	20.6	14.6	16.0	16.41	4.04	9.08	6.06	7.84	6.75
300kgNPK+1.6tPM	15.6	17.9	14.9	24.6	8.2	8.07	9.63	8.02	9.45	8.80
150kgNPK+2.4tPM	14.1	19.9	15.7	16.0	17.3	7.78	11.17	11.23	9.08	9.82
Control	13.3	21.8	19.4	16.2	17.7	3.72	5.32	3.19	4.37	4.20
Means	13.9	18.8	15.6	20.4		6.71	8.35	7.53	7.55	
SED NPK		1.78					0.69			
SED PM		1.45					0.56			
SED NPK X PM		3.56					1.39			

CONCLUSION

The importance of combining organic and inorganic manure in crop production can not be over emphasized in view of the complementary role one plays on the other. But time is of essence to realize the deserved impact. Modern Agriculture requires that exact amount of the nutrient be applied to supply the needed nutrient at the nick of time to obtain the genetic potential of the crop. From this research work equal mixture of the two sources was found to give an economically optimum yield of the crop, when applied at between 2-4 weeks after planting and is therefore recommended

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