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EFFECT OF INTEGRATED FERTILIZER MANAGEMENT ON THE ECONOMIC PERFORMANCE OF ORANGE FLESHED SWEETPOTATO IN RAIN FOREST AGRO ECOLOGY OF NIGERIA

[1]Anedo, E.O., [2]Asawalam, D.O. and [1]Ewuziem, J.E

[1]National Root Crops Research Institute Umudike, P.M.B.7006 Umuahia Abia State
[2]Michael Okpara University of Agriculture, Umudike Abia State
Corresponding Authors' email:emmaanedo@gmail.com

Abstract
The study was conducted at the Research Farm of National Root Crops Research Institute Umudike, Nigeria. The experiment was a 5x4 factorial laid out in a randomized complete block design (RCBD). The treatment comprise of five levels of composite manure (Pig manure, cowdung and poultry manure) applied at the rate of 0, 2, 4, 6 and 8t/ha and mineral fertilizer (NPK 15:15:15) applied at the rate of 0, 200, 400 and 600kg/ha and replicated three times and data collected subjected to analysis of variance (ANOVA). Results of the study showed that application of composite manure significantly ($p<0.05$) increased number of leaves, number of branches and vine length at different sampling periods. Combined application of mineral fertilizer and composite manure significantly increased the total and marketable root yield with application of 4t/ha composite manure + 400kg/ha mineral fertilizer giving the highest total root yield of 15.90t/ha and marketable root yield of 13.97t/ha. Cost of production increased with increased rate of the treatment combinations. Application of 4t/ha composite manure + 400kg/ha mineral fertilizer gave the highest value of production (₦477,000) highest net return (₦391,370). The highest return on investment (22.02) was recorded with application of 2t/ha composite manure. From the results obtained, Sweet potato farmers will maximize profits and minimize costs with the application of 2t/ha of composite manure despite 4t/ha composite manure + 400kg/ha mineral fertilizer recording the best root yield.

Keywords: Composite, manure, mineral fertilizer, growth, root yield, economics, and orange fleshed sweetpotato

Introduction

Sweet potato varieties grown by farmers throughout Sub-Saharan Africa are white, yellow or cream-fleshed and contain little or no beta carotene. This may account for the observation that many rural dwellers, particularly children, suffer from vitamin A deficiency (Sowley *et al,* 2015). The orange-fleshed sweet potato varieties are gaining great attention as a means of mitigating common health related problems associated with vitamin A deficiency in low income households. The varieties are believed to be the least expensive source of dietary vitamin A available to poor families (Laure *et al,* 2013). This is due to the high nutritive value of beta-carotene, a precursor to vitamin A synthesis (Ukpabi *et al,* 2012). The strategy of increasing orange fleshed sweet potato consumption helps to alleviate vitamin A deficiency, which cause night blindness (Anderson *et al,* 2007).Orange-fleshed variety, rich in beta-carotene has been identified as the least expensive, year round source of dietary vitamin A and plays a vital role in boosting household nutrition (Stathers *et al.,* 2005). Sweet potato farmers in Nigeria (80%) do not apply fertilizer or apply insufficient amounts to achieve better results (EPAR, 2012). Often citing high cost or non-availability of inorganic fertilizers for not applying recommended dosage (Yeng *et al,* 2012).

The concept of "integrated nutrient management", utilizing all available organic and inorganic resources has become a dominant paradigm for improved or increased yields in small holder agricultural system of sub Saharan Africa (SSA) to ensure both efficient and economic use of scarce nutrient resources (Vanlauwe *et al,* 2001). According to Nedunchezhiyan and Reddy, (2002), sweet potato gets nutrients throughout the growing period when there is integrated use of inorganic (immediately available) and organic (slow mineralisation) source of nutrients which leads to higher yield attributes. Complimentary use of cow dung and mineral fertilizer (Asawalam and Onwudiwe, 2011), poultry manure and inorganic fertilizer (Onunka *et al,* 2003), poultry manure and agrolyser (Onunka *et al*, 2011) OBD-Plus bio fertilizer and NPK, (Ano *et al*, 2011) have been reported to increase the yield of sweet potato in South-East Nigeria. However, there is limited information on the integrated use of poultry manure, cowdung and pig manure with mineral fertilizer in sweet potato production in this area.

Materials and Methods

The experiment was conducted at the Research farm of National Root Crops Research Institute Umudike, South-East, Nigeria. Umudike is located on latitudes $05^0 29^1$N and longitude $07^0 33^1$E with an altitude of 122m above sea level. The experiment was a 5x4 factorial experiment laid out in a Randomized Complete Block Design (RCBD). The plot size measures 3m x 3m with 0.5m separating the plots and 1m separating the replicates. Treatments for the experiment were cow dung, poultry droppings, pig manure and mineral fertilizer (NPK 15:15:15). The cow dung and pig manure were sourced from the cattle and piggery units of Michael Okpara University of Agriculture, Umudike. While the poultry droppings (battery cage) were sourced from the poultry unit of NRCRI, Umudike. NPK 15:15:15 fertilizer was sourced from the open market.

Table 1: Chemical properties of the composite manure used

Chemical properties	Value
pH(H2O)	10.5
N (%)	5.39
P (%)	3.28
K (%)	3.68
Ca (%)	2.67
Mg(%)	1.95
Na (%)	2.33
OC (%)	3.00
OM (%)	5.17

Equal weights (72kg each) of the three animal manures were bulked together and applied to the plots at the rate of 2, 4, 6 and 8t/ha with 0t/ha as control. The factorial combinations were 0, 200, 400 and 600kg/ha of NPK 15:15:15 giving a total of 20 treatment combinations replicated three times. The manures were applied to the plots one week before planting, while mineral fertilizer was applied4 weeks after planting. The test crop, orange fleshed sweet potato (OFSP) variety (UMUSPO 1) was obtained from Sweetpotato programme of NRCRI, Umudike. The Sweetpotato vine cuttings (4 nodes) were planted on the crest of the ridges at a spacing of 30cm within rows and 1m between rows. The cuttings was planted 2 nodes down the soil and 2 nodes on the soil surface. All agronomic practices recommended for Sweetpotato production were carried out and data on number of leaves, number of branches, Vinelength and leave area index were collected from two tagged plants at 4,8 and 12WAP.

The storage roots were harvested at 16 weeks after planting and graded based on weights as marketable roots (>100g), unmarketable roots(<100g)(Levett,1993). Economic valuations of inputs and yields were based on the local prices. It was assumed that the different treatment cost combinations was the only source of cost variability among the treatments. Total cost of production was computed based on the prevailing market price of the manure sources and mineral fertilizer. Gross Margin was computed by subtracting the total variable cost from the total value of production. The Gross margin model used was specified as:

$$GM = TVP - TVC$$

Where:
GM = Gross Margin
TVP = Total value of production
TVC = Total variable cost

Return on investment was computed by ratio of the total value of production by the total variable cost (Karim and Elias, 1992).

$$RI = TVP / TVC$$

Results and Discussion

Effect of Composite manure and Mineral fertilizer on Growth of OFSP

Number of branches

The result of effect of composite manure and mineral fertilizer on the number of branches of OFSP at 4, 8 and 12 weeks after planting are presented in Figure 1. The results showed that composite manure significantly ($p<0.05$) increased the number of branches from 4.17-11.00, 7.33-17.67 and 13.17-24.00 at 4, 8 and 12 weeks after planting respectively. The significant increase in the number of branches could be as a result of the mineralisation of the composite manure leading to release of organic bound nutrients. The result is in line with the study of Atayese *et al.,* (2013) who observed an increase in number of branches of sweet potato with 10t/ha of poultry manure and Ambecha (2001) who reported an increase in the number of branches of sweetpotato with application of farm yard manure.

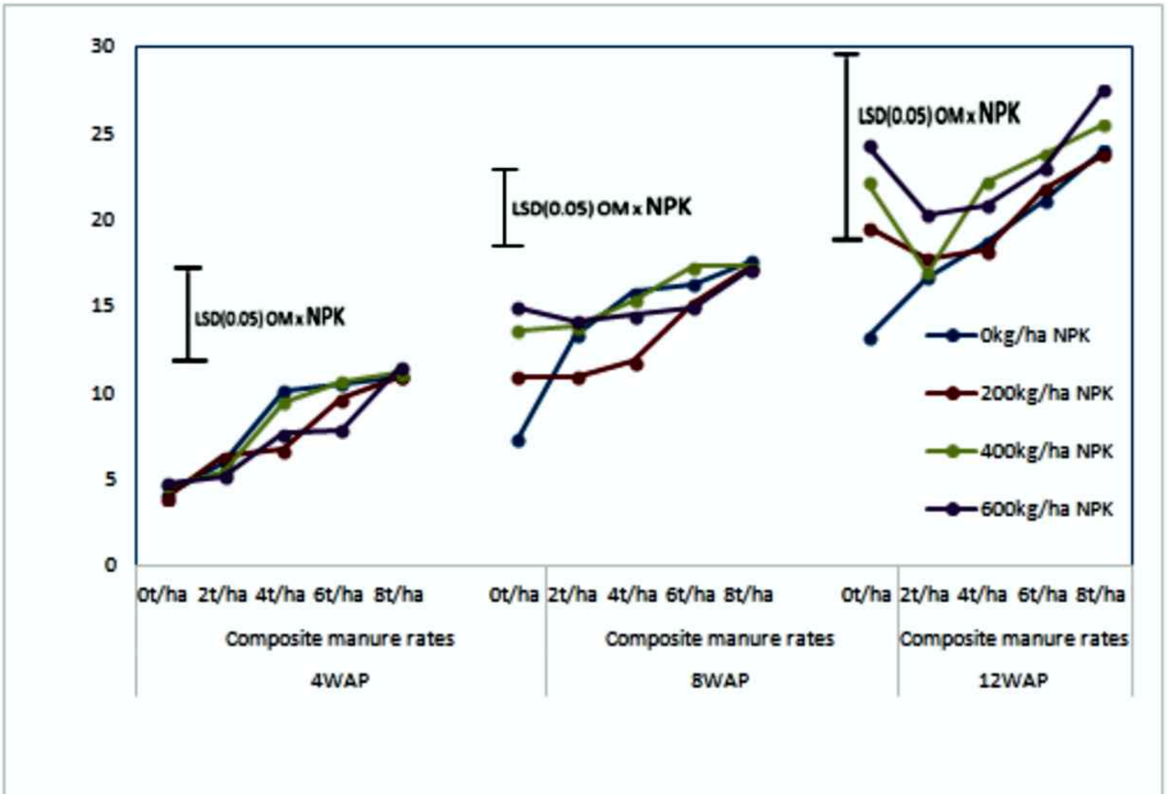

Figure 1: Effect of Composite manure and mineral fertilizer on the number of branches of OFSP at 4, 8 and 12 weeks after planting

Number of leaves

The results of the effect of composite manure and mineral fertilizer on the number of leaves of OFSP at 4, 8 and 12 weeks after planting are presented in Figure 2. Application of composite manure significantly ($p<0.05$) increased the number of leaves from 28.7-78.0, 161.5-221.8 and 219.7-303.5 at 4, 8 and 12 WAP. Application of mineral fertilizer also increased the number of leaves at 8 WAP from 161.5-236.3. The number of leaves increased with increased rate of the treatment combinations. The increase in the number of leaves might be because of mineralization of organic manure leading to release of organic bound nutrients. Also, the increase in the number of leaves with application of mineral fertilizer might be due to quick release of nutrients by mineral fertilizer. Similar results were reported by Atayese *et al.,* (2013) with application of 10t/ha poultry manure on sweet potato and Abou-Hussein *et al*., (2003) with organic fertilization in sweetpotato. El-Hlamy,(2011) reported a significant increase in the number of leaves of sweetpotato with mineral fertilizer application.

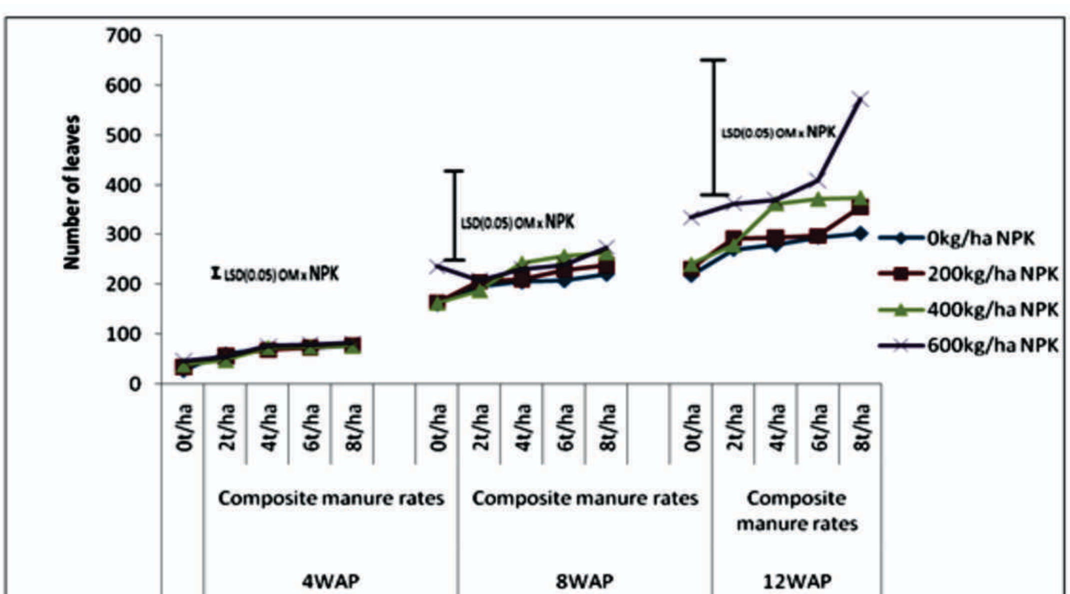

Figure 2: Number of leaves of OFSP at 4, 8 and 12 weeks after planting

Vine length

The results of the effect of Composite manure and Mineral fertilizer on vine length of OFSP at 4, 8 and 12 WAP are presented in Figure 3. Composite manure significantly ($p<0.05$) increased vine length of OFSP by a range of 51.2-88.4, 102.0-143.1 and 127.1-179.4 at 4, 8 and 12WAP. Mineral fertilizer also increased the vine length at 8 and at 12 WAP from 127-1-179.4.The results of this study is in line with the findings of Abdissa *et al., (*2012) who reported an increase the vine length of sweetpotato with application of organic manure. Also, Haliru *et al,* (2015) and El-Hlamy (2011) reported a significant increase in the vine length of sweetpotato with application of mineral fertilizer.

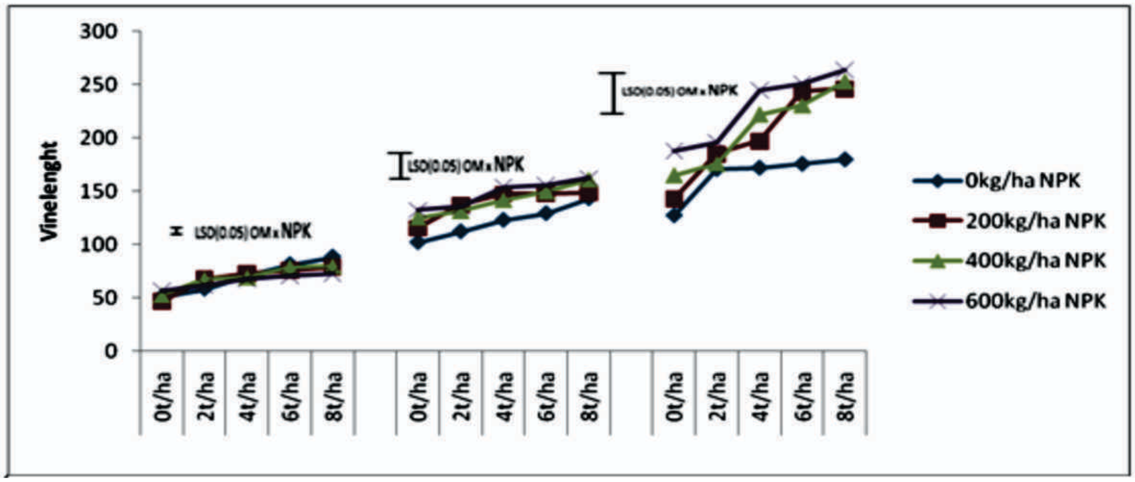

Figure 3: Vine length of OFSP at 4, 8 and 12 weeks after planting

Effect of Composite manure and Mineral fertilizer on the Root yield of OFSP

Total Root Yield

The result of the effect of composite manure and mineral fertilizer on the total root yield of OFSP is presented in Table 2.The interaction of composite manure and mineral fertilizer significantly ($p<0.05$) increased the total root yield of OFSP relative to the control. The highest mean root yield of 15.90t/ha was recorded with the application of 4t/ha organic manure + 400kg NPK. This was followed by 13.73t/ha obtained with the application of 2t/ha organic manure + 400kg NPK and 13.13t/ha with the application of 4t/ha organic manure + 200kg NPK. The higher root yield obtained with the application of composite manure and mineral fertilizer in this study might be as a result of improvement in the physico-chemical properties of the soil which led to the release of nutrients for crop uptake. Similar results were reported by Agyarkor *et al,* (2014) with incorporation of organic manure and NPK on sweetpotato yield; Akinmutimi, (2014) with application of Cocoa pod husk ash and NPK on the yield of sweetpotato; Onunka *et al,* (2012) with application of organic and inorganic manures on root yield of sweet potato; Asawalam and Onwudiwe, (2011) with complementary use of cow dung and mineral fertilizer on sweet potato; Yeng *et al* (2012) with integrated application of poultry manure and inorganic fertilizer on growth and yield of sweet potato.

Table 2: Effect of composite manure and mineral fertilizer on the total root yield of OFSP (t/ha)

Composite Manure (t/ha)						
NPK(kg/ha)	**0**	**2**	**4**	**6**	**8**	**Mean**
0	7.83	11.37	13.17	11.67	10.70	10.93
200	8.30	12.07	13.13	12.37	12.27	11.63
400	11.53	13.73	15.90	9.93	12.00	12.62
600	14.93	10.47	9.13	13.13	14.83	12.50
Mean	10.65	11.91	12.83	11.78	12.45	

LSD (0.05) organic manure=N.S

LSD (0.05) NPK=N.S

LSD (0.05)0rganic manure x NPK=4.387

Marketable Root Yield

The results of the effect of composite manure and mineral fertilizer on the marketable root yield of OFSP are presented in Table 3. The interaction of organic manure and mineral fertilizer significantly ($p<0.05$) improved the marketable root yield of OFSP relative to the control. The highest marketable root yield of 13.97t/ha was obtained with the application of 4t/ha composite manure +400kg NPK. This was followed by 12.97t/ha obtained with the application of 2t/ha composite manure and 400kgNPK and 12.67t/ha obtained with the application of 8t/ha composite manure + 600kgNPK. The improved marketable root yield obtained with the combination of composite manure and mineral fertilizer could be because of improved soil physico-chemical properties leading to the release of nutrients for the uptake by the sweet potato. The result is in line with similar results by Yeng *et al,* (2012) who obtained higher marketable root yield of sweet potato with integrated application of poultry manure and inorganic manure. Hartemink (2003) reported that poultry manure in combination with mineral fertilizer increased the marketable root yield of sweetpotato.

Table 3: Effect of composite manure and mineral fertilizer on the marketable root yield of OFSP (t/ha)

	Composite Manure (t/ha)					
NPK(kg/ha)	**0**	**2**	**4**	**6**	**8**	**Mean**
0	6.90	9.43	11.70	9.10	8.93	9.21
200	7.43	9.70	11.60	10.70	10.27	9.94
400	11.07	12.97	13.97	7.57	10.00	11.11
600	13.90	8.93	7.83	11.20	12.67	10.91
Mean	9.82	10.26	11.27	9.64	10.47	

LSD (0.05) Composite manure = N.S
LSD (0.05) NPK = N.S
LSD (0.05) Composite manure X NPK = 4.37

Economic analysis of Composite manure and Mineral fertilizer in the production of OFSP

Cost of production of OFSP with the use of composite manure and mineral fertilizer

The cost considerations of the different treatments indicates that the treatment with the highest levels of both inorganic fertilizer and the composite manure (600kg/ha of NPK 15:15:15 + 8t/ha of composite manure) had the highest addition to the total cost of production in both years (Table 4). This is expected because increased addition of any input will increase the cost of production. Variations among treatments were attributed mainly to mineral fertilizer and manure costs. Similar result was obtained by Lales (2008) with application of different levels of organic and inorganic fertilizer in lowland rice.

Table 4: Cost of production of OFSP with the use of composite manure and mineral fertilizer (₦)

	Composite manure rates				
NPK(kg/ha)	**0**	**2**	**4**	**6**	**8**
0	0	14,814.8	29,629.6	44,444.4	59,259.3
200	28000	42,814.8	57,629	72,444.4	87,259.3
400	56,000	70,814.8	85,629.6	100,444.4	115,259.3
600	84,000	98,814.8	113,629.6	128,444.4	143,259.3

Total value of production (Revenue)

The treatment plots that received 400kg/ha NPK 15:15:15 in combination with 4t/ha of composite manure gave the highest total value of production (₦477,000) while the control plots had the least (₦234,900) (Table 5). This result showed that integrated nutrient management does not only improve the yield of crops but also leads to increase in farmer's revenue. Agyarko *et al* (2014) obtained similar result with application of 3t/ha poultry manure + 100kg NPK in sweetpotato

Table 5: Total value of production (Revenue) (₦)

	Composite manure rates				
NPK(kg/ha)	0	2	4	6	8
0	234,900	341,100	395,100	350,100	321,000
200	249,000	362,100	393,900	371,100	368,100
400	345,900	411,900	477,000	297,900	360,00
600	447,900	314,100	273,900	393,900	444,900

Net return

The net returns of the treatment combinations was computed to show what an OFSP farmer is expected to gain if he/she applies any of the treatment combinations to production activity. From the result presented in Table 6, the plots that received 4t/ha of composite manure + 400kg/ha of NPK 15:15:15 gave the highest net return (₦391,370) whereas the least net return was recorded with plots that were treated with 4t/ha of composite manure + 600kg/ha of NPK 15:15:15(₦160,270.4). This shows huge financial burden inorganic fertilizers place on the farmer. Similar result was observed by Lales (2008) with application of organic and inorganic manure in lowland rice. The study observed that net return decreased as the level of mineral fertilizer in combination with organic manure increased. According to Deshmisk *et al,* (2010), a good combination of organic and inorganic sources of nutrients might be helpful to obtain a good economic return with good soil health.

Table 6: Net return of OFSP production

	Composite manure rates				
NPK(kg/ha)	0	2	4	6	8
0	234,900	326,285.2	365,470.4	305,655.6	261,740.7
200	221,000	319,285.2	336,271	298,655.6	280,840.7
400	289,900	341,085.2	391,370.4	197,455.6	244,740.7
600	363,900	215,285.2	160,270.4	265,455.6	301,640.7

Return on investment

The return on investment showed a different but clearer economic picture (Table 7). The highest return on investment was recorded with plots that received only 2t/ha of composite manure (22.02) only. However, the least return on investment (1.41) was recorded with the plot that received 4t/ha composite manure + 600kg/ha of NPK 15:15:15. This analysis is important because this determines where the farmer would want to stay to make more gain at minimal cost. Karim and Elias (1992) noted that farmers always try to maximize their returns up to the point where returns on investment are highest as capital is scarce. Tolessa and Friessen (2001) reported that application of 25% recommended inorganic fertilizer with enriched farmyard manure led to higher marginal rate of returns in maize, indicating that the integrated approach can enable the farmers save up to 75% of commercial fertilizers.

Table 7: Return on investment

	Composite manure rates				
NPK(kg/ha)	0	2	4	6	8
0	0	22.02	12.33	6.88	4.42
200	7.89	7.46	5.84	4.12	3.22
400	5.18	4.82	4.57	1.97	2.12
600	4.33	2.18	1.41	2.07	2.11

Conclusion

This study showed that application of desired level of integrated nutrients (combinations of organic and inorganic manures) is economical and holds the key to enhanced growth and root yield of OFSP in the rainforest agro-ecology of Nigeria. Composite manure showed better enhanced growth parameters at different sampling periods. Combined application of composite manure and mineral fertilizer significantly ($p<0.05$) increased both the total and marketable root yield of OFSP. Results of the economic analysis showed that application of 4t/ha composite manure +400kg/ha mineral fertilizer gave the highest value of production(Revenue) and net return even though, the highest return on investment was recorded with plots that received 2t/ha of composite manure only. It is therefore recommended that sweetpotato farmers in the study area should place more emphasis on the use of composite manure at the rate of 2t/ha for maximum profit at minimum cost..

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