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Keywords: *growth, maize, moringa leaf, NPK, poultry manure, yield.*

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EFFECTOFMORINGALEAVESPOULTRYMANUREANDNPKFERTILIZERSONGROWTHANDYIELDOFMAIZEZEAMAYSLINILORINSOUTHERNGUINEASAVANNAHOFNIGERIA

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Abstract- A field experiment was conducted in 2016 and 2017 planting seasons at the Teaching and Research Farm of Kwara State University, Malete, Nigeria to assess the growth and yield response of maize plant to organic and inorganic fertilizer*.* The study comprised of 6 treatments viz; Control, 100 % NPK 15-15-15, 100 % Moringa leaves (MO), 100 % Poultry manure (PM), 50% Moringa leaves (MO) + 50% NPK and 50% Moringa leaves (MO) + 50% Poultry manure (PM). All the treatments except the control were applied at the rate of 60 kg N/ha. The experiment was laid out in a randomized complete block design (RCBD) with 3 replications. Results showed that application of Moringa leaves with NPK at 4, 8 and 12 WAP significantly ($p < 0.05$) increased the growth parameters and grain yield of maize when compared to application of NPK, poultry manure and moringa leaves alone including the control treatment. The highest grain yield (4.5t /ha) was obtained from MO+NPK while the grain yield (3.6 t/ha) were obtained with NPK during 2016 cropping season. The Moringa leaf with NPK had a significant ($p < 0.05$) influence on grain yields of maize during second cropping than NPK alone in 2017. The treatment MO+NPK and NPK alone produced maize grain yield by 4.4 t/ha and3.9 t/ha respectively. Therefore, the use of MO+NPK at 60 kg N/ha was judged more economic than NPK, PM and PM +MO in the studied area.

Keywords: growth, maize, moringa leaf, NPK, poultry manure, yield.

I. Introduction

Maize (*Zea mays* L.) is an annual cereal crop commonly cultivated in most parts of Nigeria. It is a major source of food and livelihood for millions of people in many countries of the world (Ogunsumi *et al.,* 2005). Maize grains are useful raw material in industries for the production of medicines and different food recipes (Otitoju *et al*., 2016). Maize has a multipurpose advantage as every part of it such as the leaves, stalks, tassels and cobs are useful (IITA, 2011). In Nigeria, the increasing rate of demand for maize for different purposes had not been met with the supply from local production (Daramola and Taiwo, 2008). One of the problems of crop production in the tropics is that tropical soils have low fertility status (Agbede, 2010). The soils are highly weathered and leached, low in organic matter and available nutrients, thus leading to low productivity within few years of cultivation (Soremi *et al*., 2017). Applying inorganic fertilizer is one of the widely accepted ways of increasing soil nutrients both in the temperate and tropical zones of the world. However, long term studies have shown that there is a limit to which inorganic fertilizer can sustain the productivity of intensely cultivated soil. This is because of problem of decrease in yield with time, enhancement of soil acidity, leaching losses, and degradation of soil physical and organic matter status(Ojeniyi, 2000).

Research has shown that organic based fertilizers are less leached into ground water than the chemical fertilizer (Sridhar and Adeoye, 2003). As a result of this fact, the use of organic based fertilizer has found favour in boosting crop production in Nigeria, because it is cheap and less likely to pollute the ground water as much as chemical fertilizer. It improves soil fertility status as well as increasing the income of farmers via increase in yield. Thus, there is an increase in studies on organic wastes as alternative fertilizers. Organic wastes provide a continuous decomposing substrate and consequent gradual input of soil organic matter, thereby increasing soil nutrients and improving the soil physical properties.

Animal manure is known to be effective in maintenance of adequate supply of organic matter in soil, with improvement in soil physical and chemical condition and enhanced crop performance (Ikpe and Powel, 2002).Poultry, cattle, sheep and pig manure has been found to improve soil fertility and crop yield. Adeniyan and Ojeniyi, (2005); Ojeniyi and Adegboyega, (2003) reported that addition of poultry and cattle manure to soil lead to increase in soil PH, Organic Carbon, Nitrogen, Phosphorus, Calcium, Potassium, Magnesium, Sodium and CEC. Research on moringa application as fertilizer has been reported to increase the growth, yield and quality of crops. Several re-

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searches have indicated that *M. oleifera* is a highly valued plant with multipurpose effects (Fuglie, 2000; Yang *et al*., 2006; Anwar *et al*., 2007; Adebayo *et al*., 2011)]. Increase in grain yield of maize has been reported by Mvumi *et al*. (2013). *Moringa oleifera* have been investigated to ascertain its effect on growth and yield of crops and thus can be promoted among farmers as a possible supplement or substitute to inorganic fertilizers (Phiri, 2010).

Complementary use of organic and inorganic fertilizers has been proved to be a sound soil fertility management strategy (Law-Ogbomo *et al*., 2011). Organic fertilizer fortified with inorganic materials may be formulated to replenish the soil and improve plant fertilization. It releases nutrients in soil in the form that plants can easily absorb and it can activate soil micro-organisms and increase microbes, which will help the decomposition processes of organic matter. This will promote higher plant growth, healthier crops and better fruit yield. It reduces the needs of chemical fertilizer, which will lead to lower production cost and indirectly increases income (Olowoake, 2014).

There is now a growing demand for sound and ecologically compatible and environment friendly techniques in agriculture, capable of providing enough food for the increasing human population; retaining soil quality and improving the quality and quantity of agricultural produce (Russo, 2012).

However, there is scanty information on the application of poultry manure, moringa, and its complimentary use with inorganic fertilizer that would give the best result in terms of growth performance and yield of maize. This study therefore aims at investigating the effect of different combination of organic and inorganic fertilizers on the growth and yield of maize and to compare the economic use of poultry manure, Moringa leaves, its combination with mineral fertilizer and NPK fertilizer.

II. Materials and Methods

a) Study location

The study was conducted at the experimental plot of Kwara State University, Malete (08^{0} 42 ′48.5″N and 04^{o}26′17.9″E), Ilorin, Nigeria, southern guinea savanna zone of Nigeria in 2016 and 2017 respectively. The region has temperature that varies between 33∘C and 34∘C, annual rainfall in the region is about 1200mm and during the period, with a dry spell from December to March. The Kwara State University land area forms part of the South-western region of Nigerian basement complex, a region of basement recurrence and plutonism during the Pan-African orogeny (Olowoake, 2017).

b) Soil analysis

Soil samples from the study area were analyzed prior to experimentation after collection with the aid of auger from each block. The samples were bulked, air-dried and crushed to pass through a 2mm sieve. Soil analyses were carried out using procedure described by (Okalebo, 2002).Particle size distribution was determined by hydrometer method using calgon solution as dispersing agent. The soil pH was measured with a glass pH electrode after 1.1 soil/ water ratio suspension. The organic carbon content was determined by the modified wet oxidation method of Wilkey and Black and converted to organic matter by multiplying by 1.724. Total nitrogen was determined by the micro-Kjeldahl digestion and distillation method. Available phosphorus was determined by the Bray 1Acid Fluoride solution. Exchangeable cations were extracted with 1.1 ml Ammonium acetate at pH 7. Na and K were measured with flame photometer while Ca and Mg were measured with atomic absorption spectrophotometer. Cation exchange capacity was measured by Ammonium acetate technique.

c) Land preparation and field method

The experimental site was cleared manually and the size of each sub plot was 3.0 X 3.0 (9 m2), with an inter-plot space of 0.5 m.). The experimental design was laid out in a randomized complete block design (RCBD) with three replications. The treatments used were:

1. Control
2. 100 % NPK 15-15-15
3. 100 % Moringa leaves (MO)
4. 100 % Poultry manure (PM)
5. 50% Moringa leaves (MO) + 50% NPK
6. 50% Moringa leaves (MO) + 50% Poultry manure (PM)

The chemical composition of moringa leaves (MO) and poultry manure used in the study is given in in Table 1. All the treatments except the control were applied at the rate of 60 kg N/ha as recommended by Aduloju and Abdulmalik (2013) for the optimum growth of maize.

Table 1: Proximate analysis of moringa leaves and poultry manure

Nutrient element	N (%)	P(%)	K(%)	OC(%)	Ca(%)	Mg(%)	Fe(%)	Zn(%)
Moringa leaves	2.56	0.22	1.13	68.9	0.84	0.29	201.0	31.45
Poultry manure	1.14	0.41	2.06	62.5	1.83	0.93	3560.0	32.85

The fertilizers were applied to the variety of BR9928 DMR –SR (Yellow, Downy Mildew Streak Resistance) maize. The planting distance was 75 cm x 25 cm at two plants / stand. However, maize plant was later thinned to one after seedling emergence. The organic fertilizer sources were applied two weeks before planting to allow for their mineralization while the mineral fertilizer was applied two weeks after planting. Collection of data commenced from 4, followed by 8 weeks after planting till the twelfth weeks. Maize was harvested fresh at 12 WAP. Growth and yield parameters measured were; plant height, stem girth, number of leaves, leaves area, and grain yield. Plant height was measured with a meter rule at the distance from soil level to the terminal bud, leaf area determination was derived from the length and breadth measurement of the longest leaf per plant and a correction factor value of 0.75 were used to multiply the value following the procedure of Okonmah, (2012). Number of leaves was by visual counting of the leaves, plant girth was measured with vernier calipers at 3 cm above soil level. The yield was determined by measuring cob weight, dry grain weight of 100 grains. Data collected were subjected to Statistical Analysis System (SAS) for Analysis of variance (ANOVA) and the treatments were compared at 5 % level of significance using the Duncan's Multiple Range Test (DMRT). Net income of maize under different treatments was used to compare the economics of the treatments.

III. Results and Discussion

Table 1 shows the mineral content of Moringa leaves and poultry manure. From the analysis, there is an indication that both the poultry manure and leaves of Moringa have high content of macro- and micro-elements.

The initial soil physico-chemical properties of the studied area are shown in Table 2.The soil is of sandy loam textural class with 69.4% sand, 24.4% silt and 6.2% clay. Slightly acidic with pH of 6.5. The pH of most agricultural soils in tropics has been reported to range from 5.0 to 6.8 (Udo and Ogunwale, (1977).The organic matter content as well as the total nitrogen and available phosphorus are low, indicating that the soil is will respond positively to fertilizers applied to improve maize productivity.

In 2016, maize plant height was significantly influenced by application of moringa leaves when combined with NPK fertilizer. At 4, 8 and 12 WAP, maize plant in the MOR+NPK treatment was taller than those of other treatments by 11-45%, 12-55% and 8-31%, respectively. The control treatment consistently produced the shortest plant height. In 2017, Maize plant height also differed significantly ($P < 0.05$) among the fertilizer treatments (Table 3). Percentage differences observed in maize plant height in 2016 at the different sampling intervals were also maintained in 2017. Likewise, the application of MOR+NPK treatment was better than the use of NPK (15:15:15) alone. This is in line with the results of Olowoake *et al*. (2015) who reported that the combinations of organic and mineral fertilizer perform better on plant height than when each of them is solely used.

Table 2: Physico-chemical properties of experimental soil

Parameters	Soil test value
pH(H_2O)	6.5
EC (dS/.m)	0.3
Org.C(gk/g)	8.76
Total N(g/kg)	0.7
P (mg/kg)	9.7
Exchangeable bases c mol/kg	
Mg	4.54
Ca	2.34
Na	16.19
K	0.41
Extractable micronutrients	
Cu	45.5
Fe	35,75
Mn	70.5
Zn	377.5
Textural class %	
Sand	69.4
Silt	24.4
Clay	6.2
Textural class	Sandy loam

Table 3: Maize plant height (cm) as influenced by fertilizer types in 2016 and 2017 cropping seasons

Treatment (WAP)	Weeks 4	After 8	Planting 12
		2016	
Control	20.8d	43.1d	89.9d
MOR	33.9b	85.5b	111.3b
PM	25.5c	59.1c	108.7c
MOR+NPK	37.9a	96.8a	130.8a
MOR+PM	31.9b	63.1b	99.4c
NPK	30.0b	65.2b	119.7b
		2017	
Control	10.29c	50.0d	63.5d
MOR	16.4b	61.3c	66.0c
PM	18.0a	68.5c	73.0b
MOR+NPK	18.7a	94.0a	104.0a
MOR+PM	17.2b	81.9b	90.5a
NPK	16.6b	60.3c	77.0b

Means having the same letter along the columns indicate no significant difference using Duncan's multiple range test at 5% probability level

Legend:
MOR- Moringa leaves,
PM- Poultry manure,
MOR+NPK- Moringa leaves +NPK
MOR+PM- Poultry manure +NPK

In 2016, the number of leaves per plant differed significantly ($P<$ 0.05) among the different fertilizer treatments (Table 4). At 4 WAP, NPK treatment had 3-19% more number of leaves per plant than others while at 8 and 12 WAP, MOR+NPK had 6-26% and 12-18% number of leaves than others. All the fertilized plots had higher number of leaves per plant than the control treatment. The number of leaves per plant also differed significantly ($P<$ 0.05) among the fertilizer treatments in 2017 (Table 4). At 4 WAP, there were no significant differences ($P<$ 0.05) on number of leaves for plot treated with MOR+NPK and NPK. Likewise, Sole application of NPK fertilizer was not statistically better than the combined use of moringa leaves and NPK in terms of number of leaves. However, at 12 WAP, the higher number of leaves produced from organomineral MOR+NPK over the NPK throughout the growing period could be due to sustaining release of nutrients from the former over the latter (Ogundare *et al*., 2012; Ndaeyo *et al*., 2013).

Table 4: Number of leaves of maize plant as influenced by fertilizer types in 2016 and 2017 cropping seasons

Treatment	Weeks 4	After 8	Planting (WAP) 12
		2016	
Control	5.9c	8.2d	9.7c
MOR	6.8b	10.4b	11.0b
PM	6.4b	8.7c	10.5b
MOR+NPK	7.1a	11.1a	11.9a
MOR+PM	6.6b	9.9b	11.3b
NPK	7.3a	9.9b	11.0b
		2017	
Control	5.0b	9.0c	10.0d
MOR	5.5a	11.5b	13.0b
PM	6.0a	12.0a	12.0c
MOR+NPK	6.5a	13.0a	14.0a
MOR+PM	6.0a	11.6b	12.5b
NPK	6.0a	11.0b	12.0b

Means having the same letter along the columns indicate no significant difference using Duncan's multiple range test at 5% probability level.

Legend:
MOR- Moringa leaves,
PM- Poultry manure,
MOR+NPK- Moringa leaves +NPK
MOR+PM- Poultry manure +NPK

In 2016, maize plant stem girth at 4, 8 and 12 WAP differed significantly (Table 5) among the different fertilizer treatments. Stem girth in the MOR+NPK plot was bigger than in other treatments at 4, 8 and 12 WAP by 14-40%,14- 42% and8-39%respectively. The smallest stem girth was produced by the control treatment. In 2017, maize plant stem girth differed significantly ($p<0.05$) among fertilizer treatments in (Table 5) with the trend observed in 2016 maintained in 2017. The application of MOR+NPK resulted in the production of maize plant with bigger stem girth while the control consistently had the smallest stem girth. The significance increases ($p<0.05$) in stem girth of all the treatments compared with control attest to the ability of these treatments in supplying plant nutrients. The increase in stem girth had been claimed to be as a result of better nutrient mineralization with time of application(Gobron, 2009).

Table 5: Stem girth of maize plant (mm) as influenced by fertilizer types in 2016 and 2017 cropping seasons

Treatment	Weeks 4	After 8	Planting (WAP) 12
		2016	
Control	4.3d	7.7d	8.3d
MOR	6.2b	10.1c	10.8 c
PM	5.4c	11.0b	11.3b
MOR+NPK	7.2a	13.2a	13.7a
MOR+PM	5.9b	10.0c	10.4c
NPK	5.3b	11.4b	12.6b
		2017	
Control	4.0d	7.5d	8.0d
MOR	5.5c	11.5c	12.0c
PM	6.0b	12.0b	12.5c
MOR+NPK	7.0a	13.8a	15.0a
MOR+PM	6.3b	12.1b	13.1b
NPK	6.0b	12.0b	13.6b

Means having the same letter along the columns indicate no significant difference using Duncan's multiple range test at 5% probability level.

Legend:
MOR- Moringa leaves,
PM- Poultry manure,
MOR+NPK- Moringa leaves +NPK
MOR+PM- Poultry manure +NPK

Table 6 shows that at 4, 8 and 12 WAP, the leaf area of maize plant differed significantly($p<0.05$) among the different fertilizer treatments in 2016. The leaf area in the MOR+NPK plot was larger than other treatments at 4, 8 and 12 WAP by 9-56%, 13-56% and 6- 42% respectively. The control treatment produced the smallest leaf area. Maize plant leaf area was significantly ($p<0.05$) influenced by the fertilizer treatments in 2017 (Table 6). The MOR+NPK treatment produced the widest leaves and exhibited the same pattern observed in 2016 while the control treatment had the smallest leaf size. Generally, the MOR+NPK treatment produced bigger leaves area than mineral fertilizer (NPK). This implies that, higher availability of N, P and K were important for leaf growth of maize. This result is similar to the findings of Gobron, (2009). Increasing NPK fertilizer rate probably increased the photosynthetic activity and leaf area. The values of maize plant leaves area were observed to below in the entire plot without any fertilizer treatment when compared to moringa leaves enriched with either poultry manure or NPK fertilizer treatments. This might be as a result of low nutrients status of the soil especially N and P.

Table 6: Leaves area of maize plant (mm) as influenced by fertilizer types in 2016 and 2017 cropping seasons

Treatment	Weeks After Planting (WAP) 4	8	12
		2016	
Control	65.9e	85.4e	147.6e
MOR	136.3b	167.8b	193.0c
PM	78.7d	96.8d	164.9d
MOR+NPK	149.1a	192.1a	254.9a
MOR+PM	123.7c	130.7c	154.2d
NPK	119.7c	164.1c	239.8b
		2017	
Control	48.9d	116.8e	150.0d
MOR	67.6c	125.6c	168.9c
PM	110.7a	160.3b	190.0b
MOR+NPK	106.9a	192.2a	202.4a
MOR+PM	76.5c	126.0c	187.1b
NPK	106.3b	123.4d	174.5c

Means having the same letter along the columns indicate no significant difference using Duncan's multiple range test at 5% probability level.

Legend:
MOR- Moringa leaves,
PM- Poultry manure,
MOR+NPK- Moringa leaves +NPK
MOR+PM- Poultry manure +NPK

Figure 1 shows that, the maize grain yield differed significantly ($p<0.05$) among the different fertilizer treatments in 2016 and 2017. The MOR+NPK treatment produced the highest total grain yield (4.5 t/ha and 4.4 t/ha in 2016 and 2017 respectively) while the control had the least grain yield (1.5 t/ha and1.7 t/ha, in 2016 and 2017 respectively). The MOR+NPK treatment produced 20–67% and 11-61%more grain yield than other treatments in 2016 and 2017, respectively. There was no significant ($p<0.05$) difference between grain yield produced from the MOR+ PM and NPK in 2016 and 2017, respectively. The maize plants without fertilizer treatment had the lowest yield which could have been partly due to deficiency of nutrients as revealed by low nutrient status of the soil from the initial physic-chemical analysis. This agrees with statement by FAO, (2013) that increment in maize production occurred with higher levels of fertilizer application. The higher grain yield produced from combination of moringa leaves and mineral fertilizer was similar to the works of Olowoake and Ojo (2014); Nwaogu, (2013); Ogunlade *et al*., 2011 who reported that the combinations of organic and mineral fertilizer perform better on the yield of Amaranthus caudatus and maize, than when each of them is solely used.

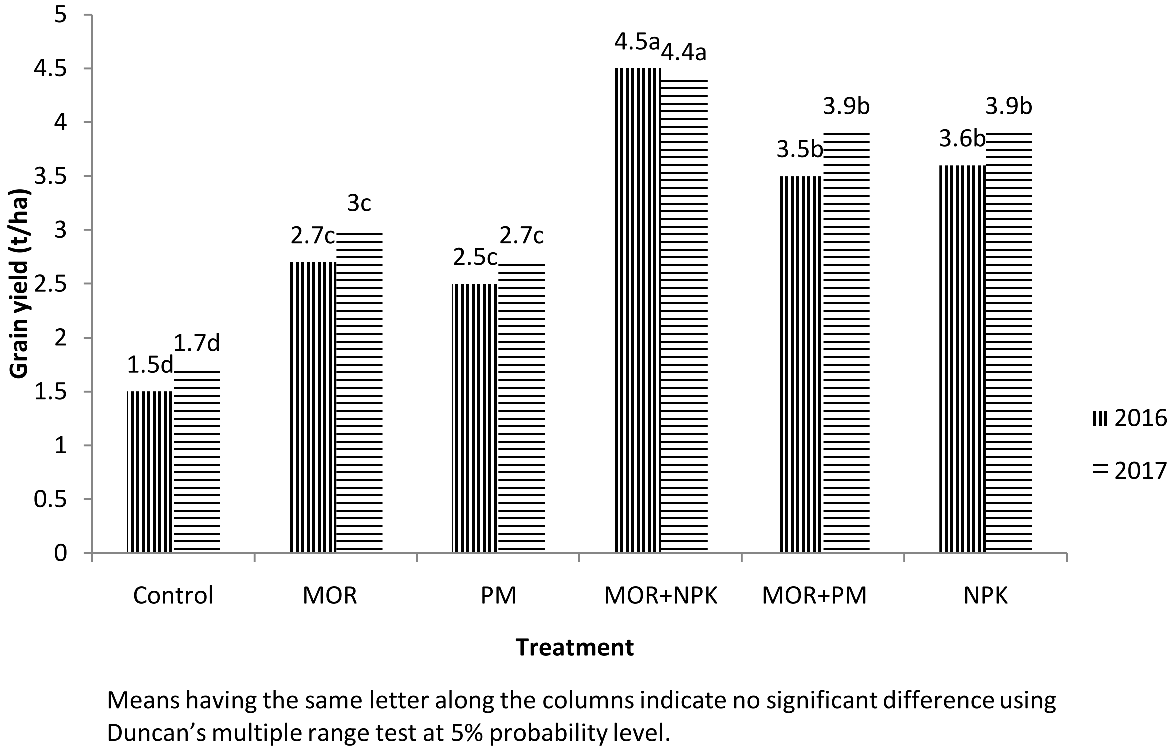

Fig. 1: Maize Grain yield (t/ha) as influenced by fertilizer types in 2016 and 2017 cropping seasons

Legend:
MOR- Moringa leaves,
PM- Poultry manure,
MOR+NPK- Moringa leaves +NPK
MOR+PM- Poultry manure +NPK

The effectiveness of any production is eventually estimated on the basis of its economic returns. Table 7 showed that higher net benefit (₦143, 500) was obtained with the application of MOR+NPK followed by the net benefit (₦ 117,000) obtained with NPK and minimum net benefit (₦ 28,000) was recorded in control. The economic returns analysis between 2016 and 2017 indicated higher netrevenues on the maize plot with MOR+NPK treatments than other plots. The supply of a more balance proportion of essential nutrients by NPK and moringa leaves could account for its highest return. According to Kombat (2015), balanced and adequate fertilizer application is essential for increasing crop yields and net returns, whiles ensuring sustainability.

Table 7: Estimates of cost and returns of maize under different treatments in 2016 and 2017

Treatment	Mean yield (t /ha)	Mean revenue per maize treatment₦	Variable cost ₦	Fixed cost ₦	Total cost ₦	Net farm income ₦
Control	1.6	64,000	28,000	8,000	36.000	28,000
MOR	2.9	114,000	44,000	8,000	52,000	62,000
PM	2.6	104,000	31,000	8,000	39,000	73,000
MOR+NPK	4.5	178,000	34,500	8,000	42,500	143,500
MOR+PM	3.7	148,000	33,000	8,000	41,000	115,000
NPK	3.8	150,000	33,000	8,000	33,ooo	117,000

Average 1 USD is approximately ₦306.3 (as at December 2017)

IV. Conclusion

This study showed that moringa leaves supplemented with NPK at 60 kg N/ha gave the best performance in all the growth and yield parameters. The study has also demonstrated that application of NPK alone performed better than the poultry manure and moringa alone in terms of grain yield. However the use of organic moringa leaves in combination with mineral fertilizer (MOR+NPK) can sustain maize production.

Also, it was more economical to apply the combination of organic and inorganic fertilizer for maize production in Ilorin, guinea savannah zone of Nigeria.

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