RESPONSE OF CASSAVA VARIETY TMS/98/0505 TO POTASSIUM FERTILIZATION AND TIME OF HARVEST IN SOUTH EASTERN NIGERIA.

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ABSTRACT

Two field experiments were used to study the response of a low cyanide cassava variety TMS/98/0505 to potassium fertilizer and time of harvest in a tropical ultisol in south eastern Nigeria in 2005/06 and 2006/07. In each year, a split plot design was adopted for the experiment with treatments arranged in a randomized complete block design (RCBD). The main plot treatments were five rates of potassium (0, 50, 100, 150 and 200 (Kg/ha) while the sub-plot treatments were five times of harvest (6, 8, 10, 12 and 14 months after planting (MAP). Potassium application significantly increased plant height and storage root dry matter yield but had no effect on number of storage roots per plant. Plant height was increased with application of potassium up to 150 Kg K/ha while storage root dry matter yield increased when potassium was applied up to 50 Kg K/ha. Optimum storage root dry matter yield was obtained at 12 MAP. Both fresh root and dry matter yields were significantly low at 6 MAP. Except for plant height, there were generally no statistically significant effect of potassium fertilizer and time of harvest interactions on cassava crop.

Keywords: Potassium, Time of harvest, TMS/98/0505, Storage root yield.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is grown in a wide range of agro-ecological zones and is a staple food for many people in the lowland regions of tropical Africa (Hahn, 1989). About 67% of cassava grown in Africa is confined to the humid and sub-humid regions of West Africa with Nigeria currently the highest producer with over 40 million metric tones per annum (CBN, 2005). Cassava provides food for more than 500 million people world wide (CIAT, 2001) and it is the second most important food in the African diets. The large amounts of carbohydrates accumulated in its roots make cassava an important source of energy and nutrients. Apart from being the major source of carbohydrate for most Nigerians, it has other diverse uses in pharmaceutical, confectionery and livestock industries (Eke-Okoro and Dixon, 2000). Cassava leaves are eaten in some parts of Nigeria and other African countries like Congo, Sierra Leone, Tanzania, Zaire and Zambia and they are rich in proteins, vitamins and minerals.

Research efforts by International Institute of Tropical Agriculture (IITA) and the National Root Crop Research Institute (NRCRI), Nigeria have recently resulted in the development and release of five cassava varieties, including TMS/98/0505. The TMS/98/0505 variety is characterized by multiple pest resistance, profuse branching, low cyanide content, high yield potential and is good for animal feed and has both culinary and industrial value (Nnodu and Dixon 1998; Dixon *et al*. 2005). The rapid branching and closed canopy architecture of the variety at 2-3 months after planting bestows on it a good competitive ability against weeds. According to Doll (1977), labour costs the highest for cassava production; of which weeding operations alone account for about 25 to 55 percent of the cost and take up to about 55 percent of time spent on its production (Anon, 1976).

As for any other crop, to maintain soil productivity and sustain high yields, nutrients removed in the harvested products of cassava should be replaced in the form of fertilizer. Among tropical root crops, cassava has the highest ratio of potassium to nitrogen in its harvested tuber and extracts the largest amount of potassium from soil (Suyamto, 1998). Typical nitrogen, phosphorus, potassium, calcium and magnesium removals per tonne of cassava root are 4.91, 1.08, 5.83, 1.83 and 0.79 Kg/ha, respectively. Despite this large nutrient demand, cassava is often grown on marginal lands with low fertility and consequently low average root yields. Cassava is efficient in phosphorus utilization as a result of the association of its roots with soil mycorrhiza (Sharpley *et al*. 1992; Howeler *et al*. 2000) and responds to potassium in potassium deficient soils (Obigbesan, 1977; Kang, 1984; Howeler *et al*. 2000). Potassium increases the rate of photosynthesis, plays special role in carbohydrate synthesis ans translocation (Hahn and Hozyo, 1984; Hahn, 1977). The ultisols in southeastern Nigeria are low in potassium (Unamba-Opara, 1985) and, therefore, require potassium fertilization for good cassava yields (Maduakor, 1997).

The time of harvest for cassava depends on the clone, rainfall, soils, temperature regime and socio-economic factors (Nweke *et al*. 1994). Githunguri *et al*. (1998) obtained the highest yield in cassava at 8 MAP and indicated that root cyanogenic potential increases with crop age while Janssems (2002) noted that cassava can be left for upwards of 18-21 months before harvest. Ezedinma *et al*. (1980) reported that yields of stakes and commercial roots of cassava showed significant increases up to about 12 month and declined thereafter. Ngendahayo and Dixon (2001) stressed the need to determine the optimum time of harvest for cassava genotypes in different agroecologies of Nigeria.

The objective of this present study was to determine the effect of potassium fertilization and time of harvest on growth and yield of TMS/98/0505 cassava variety.

MATERIALS AND METHODS

The experiment was conducted between 2005 and 2007 in the Eastern farm of the Michael Okpara University of Agriculture, Umudike, farm to determine the effect of Potassium (K) fertilizer and different times of harvest on the growth and productivity of cassava variety TMS/98/0505. Umudike is located on latitude 05^o 29` N and 07 $^o$ 33` E and an elevation of 122 m above sea level. The soil is texturally classified as sandy loam; and classified as an ultisol.

Land which was under one year fallow at the time the experiments commenced were disc ploughed on the 17 August and ridged 1 m apart on the 18 August, 2005. In 2006, the land was disc ploughed on 7 May, harrowed 9 May and ridged 11 May. The soil was sampled (20 cm) for analysis on 12 August, 2005 and 7 May, 2006. The experiment was a split plot arranged in a Randomized Complete Block Design (RCBD) with three replications. Each plot (sub-plot) measured 4m x 2 m (8 m^2).The main plot treatments were five potassium rates (0, 50, 100, 150 and 200 Kg K/ha) while the sub-plot treatments were five times of harvest (6, 8, 10, 12 and 14 months after planting (MAP)). Potassium as muriate of potash was applied at various rates 4 WAP on the appropriate plots.

Cassava variety TMS/98/0505 stem cuttings of 25 cm length were planted 1 m apart along the crest of ridges on 19 August 2005 and 12 May, 2006. The plants were spaced at 1 m x 1 m to give a plant population of 10,000 plants/ha. Supply of vacant stands was done two weeks after planting (WAP). At one MAP, each plot received a blanket application of 60 Kg N/ha as Urea and 20 Kg P_2O_5/ha as Single Super Phosphate (Howeler et al. 2000); at the same time the various potassium fertilizer levels were applied to appropriate plots. A mixture of primextra and Fusilade pre-emergence herbicides were applied on the ridges at 5 litres/ha and 4 litres/ha respectively using a 20-L knapsack sprayer (Eke-Okoro *et al*., 2005). Hoe weeding was done once at 2 MAP.

Records were taken on Plant height (m), number of storage roots/plant, storage roots weight (Kg/plant), fresh storage roots yield (t/ha) and dry matter yield (t/ha), fresh cassava roots were chopped, packaged in an envelope and oven-dried for 72 hours at 70^o C and weighed to obtain dry weight and converted to ton/ha. The data were subjected to analysis of variance using Genstat statistical package (2003) discovery edition.

RESULTS

The soils of the experimental sites for the 2005/06 and 2006/07 were texturally classified as sandy clay loam (Table 1). The soil of the 2005/06 experiment was moderate in organic matter, nitrogen, phosphorus and potassium while that of the 2006/07 experiment was lower in organic matter, nitrogen and potassium. The sites were both acidic with pH (H_20) of 5.20 in 2005 and 5.12 in 2006. Total rainfalls of the site were 2051.8, 2038.3 and 2420.7 mm in 2005, 2006 and 2007, respectively.

Plant height was significantly affected by potassium level (Table 2). Application of potassium from 100 Kg K/ha to 150 Kg K/ha increased plant height where as below 100 Kg K/ha no increase was observed. There was also an increase in plant height with successive increase in crop age up to 12 months after planting. Plant height was significantly reduced by 9.9% with delay in time of harvest from 12 to 14 MAP. Interactions of potassium fertilizer and time of harvest were significant. The highest plant height of 2.5m was obtained when potassium was applied at 150 Kg K/ha and roots harvested at 12 MAP. Shortest plants occurred at 6 or 8 MAP, irrespective of potassium fertilizer rates.

In all situations, the number of storage roots per plant was not significantly affected by the application of potassium fertilizer (Table 3). In 2005/06, the effect of time of harvest was not consistent on number of tubers, with significantly more tubers produced at 8 MAP than at other periods of harvest. However, in 2006/07, the number of tubers increased with delay in time of harvest from 6 or 8 to 10 MAP, beyond which significant decreases occurred at 14 MAP. Interaction of potassium and time of harvest did not significantly affect the number of tubers per plant.

In both years, potassium application did not produce any significant difference on storage root weight per plant (Table 4). On average, fresh root weight increased significantly with delay in date of harvest up to 12 MAP. Delaying time of harvest to 14 MAP resulted in 17 % reduction in fresh root weight of tubers compared to 12 MAP in 2005/06. The weight of fresh tubers was not significantly affected by interactions between potassium and time of harvest.

In 2006/07, application of 100 Kg K/ha gave a significant higher fresh storage root yield than the control (no potassium application) (Table 5). Cases where potassium was applied irrespective of the rates gave statistical similar fresh storage root yield. In 2005/06, fresh tuber yield increased with delayed harvest up to 10 MAP, beyond which statistical difference was not established. However, in 2006/07, fresh root yield increased significantly with delay in time of harvest up to 12 MAP. Delaying harvest to 14 MAP did not further increase fresh storage root yield when compared with 12 MAP. K-fertilizer and time of harvest interactions were not significant. As mean over the two cropping seasons, fresh storage root yield at 10 MAP did not statistically differ from the yield at 12 and 14 MAP but was significantly higher than the yield at 6 and 8 MAP.

Application of potassium at higher levels of 150 Kg K/ha significantly increased the dry storage root weight over where no K or lower rates of K were applied especially in 2006/07 (Table 7). Increasing potassium to 200 Kg K/ha did not result in yield advantage compared to either 50 or 150 Kg K/ha in both years. Time of harvest significantly improved dry tuber weight up to 12 MAP while delaying harvest to 14 MAP caused a reduction in dry weight when compared with 12 MAP. Interactions were significant in 2006/07 with highest dry weight of roots obtained at 12 MAP and applying potassium at 150 Kg K/ha.

Application of potassium significantly affected storage root dry matter yield in 2006/07 0nly (Table 8). Storage root dry matter yield in 2006/07 increased significantly with application of potassium up to 100 Kg K/ha compared with no potassium application. In 2005/06, storage root dry matter yield increased significantly with delayed harvesting up to 10 MAP, beyond which no further improvement occurred. However, in 2006/07, storage root dry matter increased significantly up to12 MAP. Storage root yield were lower in 2006/07 in which the crop experienced drought at 7MAP. On consideration of storage root dry matter as mean over two cropping seasons, the effect of time of harvest was such that dry matter production at 12 MAP was similar with that at 14 MAP but significantly higher than the dry matter yield at 6, 8 or 10 MAP (Table 9). Potassium application increased storage root dry matter yield up to 50 Kg K/ha while interactions between potassium and time of harvest were not significant.

DISCUSSION

The responses of cassava morphological attribute of plant height and yield to potassium varied. Application of 150 Kg K/ha gave the highest plant height while application of 50 Kg K/ha was optimum for storage root dry matter yields. Response of cassava to potassium was also reported by earlier workers (Kang, 1984; Obigbesan and Fayemi, 1976; Obigbesan, 1977; Maduakor, 1977). Beneficial effects of potassium application have mostly been attributed to the fact that the element increases the activities of starch synthetase which results to high yield (Murata and Akazawa, 1968 and 1969), especially if there are inadequate native supplies of the nutrient. While working on sweet potato, Tsuno and Fujise (1965) noted that potassium exerted the greatest chemical influence on yield by accelerating the translocation of photosynthate from the leaves to the tuberous roots for bulking and also increase sink capacity and photosynthetic rate. Application of 50 Kg K/ha appeared adequate for obtaining high fresh storage root and dry matter yields while application of up to 200 Kg K/ha did not evince any other yield benefits. Suyamto (1998) obtained similar results, in which 60 Kg k_2O/ha (49.8 Kg K/ha) was recommended for cassava grown in Java, Indonesia. FFD (2002) recommended 75 Kg K/ha for cassava, when the native soil potassium is between 0 and 0.15 cmol/Kg. In the study reported here, the native soil potassium level was higher, being 0.25 cmol/Kg in 2005/06 and 0.19 cmol/Kg in 2006/07.

Yield responses of cassava in different ecological zones have been reported. Ngeve (1985) reported that yields of cassava continued to increase until 14 months after which they stabilized; Githunguri *et al*. (1998) obtained the highest yield at 8 MAP in the south guinea savanna (Mokwa); Alleman and Dugmore, (2004) reported significant yield increases in seven out of eight varieties when harvest was delayed to between 15 to 21 MAP; Nweke *et al.* (1994) had indicated that harvesting time for cassava depends on the clone, rainfall, soils, temperature regime and socio-economic factors. On the average, 12 MAP appeared to be the optimum time of harvest for storage root dry matter yield, with no important additional responses beyond this period. Generally, beyond 10 MAP yields stabilized, probably because remobilization of starch into sugar may have begun to provide energy for respiration and fresh shoot growth at this period. Githunguri *et al*. (1998) reported that plant age may trigger cessation of assimilate translocation to the roots. The substantially low fresh storage root and dry matter yields obtained at 6 MAP confirms earlier reports (Daphne, 1979; Ngeve 1985; Alleman and Dugmore, 2004) that a growing season of 6 months does not permit the realization of the yield potentials of cassava. The average storage root yield of 35.8 t/ha obtained with potassium fertilizer application at 50 Kg K/ha was higher than the 23.5 t/ha obtained by Suyamto (1998) at a similar fertilizer rate of 49.8 Kg K/ha. In the same vein, the average fresh storage root yields of 40.8 t/ha obtained 12 MAP was higher than the highest average yield of 28.7 t/ha obtained by Eke-Okoro *et al.* (2001) with TMS 30572 variety at 12 MAP.

Storage root yields were generally higher in the 2005/06 experiment due partly because of the higher soil fertility (nitrogen and potassium levels) in that year and partly because of drought experienced by the 2006/07 crop in December, 2006 and January 2007. The later (2006/07 crop) experienced water stress as from 7 MAP. Water stress during root and tuber formation reduced cassava significantly while that after seven months of the planting had no influence on yield (El-Sharkawy *et al*., 1998; Agbaje and Akinlosotu., 2004)

CONCLUSION

The study showed that application of potassium increased cassava plant height, storage root yield and dry matter yield. The application of potassium fertilizer at the higher rate of 150 Kg K/ha significantly increased plant height while the application of a 50 Kg K/ha increased storage root dry matter yields. The use of 50 Kg K/ha potassium rate proved satisfactory for fresh storage root and dry matter yields and is recommended. Delay in time of harvest up to 12 MAP significantly increased plant height and storage root dry matter yield. Fresh storage root yields increased up to 10 MAP after which it stabilized. For high storage root yield, harvest should be scheduled as from 10 MAP.

Table 1: Soil and rainfall data of the site during the experimental period.

Physical characteristics	Year 2005/06	Year 2006/07	Chemical characteristics	Year 2005/06	Year 2006/07
Sand (%)	64.80	66.10	pH (H_2O)	5.20	5.12
Silt (%)	7.50	8.70	Organic matter	2.95	2.60
Clay (%)	26.50	25.40	% Nitrogen	0.108	0.096
Texture	Sandy clay loam		Potassium (cmol/Kg)	0.25	0.19
			Av. Phosphorus (cmol/Kg)	14.10	15.20

Rainfall (mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Mean
2005	17.3	126.7	64.0	141.3	222.4	264.4	277.0	225.0	336.7	323.0	45.4	8.6	2051.8	171.0
2006	76.6	81.9	131.9	136.0	202.8	237.3	303.4	133.7	483.1	237.4	14.2	0	2038.3	169.9
2007	0	62.9	35.5	78.4	444.9	354.0	187.6	464.8	319.9	335.6	112.1	25.0	2420.7	201.7

Source: Meteorology Unit, National Root Crop Research Institute, Umudike.

Table 2: Effect of potassium and time of harvest on plant height (m) in 2005/06.

K-Level (Kg/ha)	Time of harvest (MAP) 6	8	10	12	14	Mean
0	1.18	1.34	1.43	1.35	1.62	1.36
50	1.20	1.32	1.49	1.35	1.46	1.36
100	1.18	1.33	1.51	1.36	1.52	1.38
150	1.26	1.34	1.53	2.47	1.57	1.63
200	1.24	1.43	1.52	2.00	1.52	1.67
Mean	1.21	1.35	1.50	1.71	1.54	

LSD $_{(0.05)}$ for potassium (K) means = 0.12;
LSD $_{(0.05)}$ for time of harvest (T) means = 0.12;
LSD $_{(0.05)}$ for K x T = 0.26

Table 3: Effect of potassium and time of harvest on number of storage roots/Plant.

K-Level (Kg/ha)	Time of Harvest (MAP) 6	8	10	12	14	Means
2005/2006						
0	8.47	9.53	6.57	6.10	7.90	7.71
50	7.37	10.70	7.77	6.80	7.87	8.10
100	6.70	11.30	8.33	6.33	8.67	8.27
150	8.33	9.67	6.43	5.77	7.33	7.51
200	9.23	10.43	9.13	6.80	7.33	8.59
Means	8.02	10.33	7.65	6.36	7.82	
2006/2007						
0	6.00	6.43	8.10	6.20	6.13	6.57
50	5.77	5.87	7.70	6.87	6.23	6.49
100	7.33	6.33	7.10	6.57	7.00	6.87
150	5.00	5.47	6.10	6.80	5.80	5.83
200	6.10	6.00	6.33	6.90	6.43	6.35
Means	6.04	6.02	7.07	6.67	6.32	

	2005/06	2006/07
LSD $_{(0.05)}$ for potassium (K) means =	NS	NS
LSD $_{(0.05)}$ for time of harvest (T) means =	1.21	0.94
LSD $_{(0.05)}$ for K x T means =	NS	NS

Table 4: Effect of potassium and time of harvest on fresh storage root weight (Kg/plant) in 2006 and 2007.

K-Level (Kg/ha)	Time of Harvest (MAP) 6	8	10	12	14	Means
2005/2006						
0	0.24	0.39	0.61	0.78	0.55	0.52
50	0.23	0.45	0.63	0.81	0.84	0.59
100	0.31	0.43	0.51	0.75	0.59	0.52
150	0.25	0.49	0.84	0.81	0.68	0.62
200	0.22	0.48	0.75	0.94	0.75	0.63
Means	0.25	0.45	0.67	0.82	0.68	
2006/2007						
0	0.30	0.29	0.35	0.38	0.35	0.33
50	0.35	0.33	0.29	0.41	0.45	0.37
100	0.34	0.28	0.32	0.46	0.44	0.37
150	0.35	0.38	0.43	0.47	0.58	0.44
200	0.27	0.35	0.37	0.42	0.48	0.38
Means	0.32	0.33	0.35	0.43	0.46	

	2005/06	2006/07
LSD $_{(0.05)}$ for potassium (K) means =	NS	NS
LSD $_{(0.05)}$ for time of harvest (T) means =	0.08	0.05
LSD $_{(0.05)}$ for K x T means =	NS	NS

Table 5: Effect of potassium and time of harvest on fresh storage root yield (tons/ha).

K-Level (Kg/ha)	Time of Harvest (MAP) 6	8	10	12	14	Means
2005/2006						
0	20.40	37.80	40.50	49.30	43.00	38.20
50	16.90	49.30	50.90	58.40	65.30	48.20
100	19.90	49.80	42.20	47.50	51.50	42.20
150	22.00	46.30	53.10	45.50	50.50	43.50
200	21.00	49.60	68.90	65.20	55.40	52.00
Means	20.10	46.60	51.10	53.20	53.10	
2006/2007						
0	17.03	20.06	25.47	16.77	15.67	20.53
50	19.06	19.40	18.40	19.06	20.03	23.42
100	21.96	22.65	22.92	25.65	23.99	25.56
150	22.84	27.97	30.22	31.68	29.32	25.38
200	21.75	26.99	30.78	33.76	31.16	24.03
Means	19.00	19.19	23.44	28.41	28.89	

	2005/06	2006/07
LSD $_{(0.05)}$ for potassium (K) means =	NS	NS
LSD $_{(0.05)}$ for time of harvest (T) means =	7.75	2.40
LSD $_{(0.05)}$ for K x T means=	NS	5.58

Table 6: Effect of potassium and time of harvest on mean fresh storage root Yield (t/ha)

K-Level (Kg/ha)	Time of Harvest (MAP) 6	8	10	12	14	Means
0	18.80	28.46	31.23	36.07	32.35	29.38
50	18.70	34.36	36.78	43.20	46.16	35.80
100	22.71	34.11	31.75	38.86	41.13	33.71
150	19.36	32.69	39.36	38.50	42.11	34.40
200	18.35	34.81	46.45	47.36	43.26	38.04
Means	19.54	32.88	37.11	40.80	41.00	

LSD $_{(0.05)}$ for potassium (K) means = NS
LSD $_{(0.05)}$ for time of harvest (T) means = 3.95
LSD $_{(0.05)}$ for K x T means = NS

Table 7: Effect of potassium and time of harvest on storage root dry weight (Kg)/plant.

K-Level (Kg/ha)	Time of Harvest (MAP) 6	8	10	12	14	Means
2005/06						
0	0.061	0.114	0.174	0.225	0.161	0.159
50	0.066	0.145	0.186	0.239	0.253	0.178
100	0.089	0.125	0.146	0.210	0.176	0.149
150	0.077	0.157	0.247	0.252	0.230	0.193
200	0.060	0.146	0.231	0.291	0.248	0.195
Mean	0.071	0.138	0.197	0.243	0.214	
2006/07						
0	0.081	0.11 3	0.106	0.117	0.077	0.099
50	0.086	0.108	0.087	0.126	0.106	0.102
100	0.113	0.084	0.125	0.159	0.128	0.122
150	0.145	0.195	0.180	0.209	0.194	0.185
200	0.135	0.164	0.166	0.227	0.202	0.179
Means	0.112	0.133	0.133	0.168	0.141	

	2005/06	2006/07
LSD $_{(0.05)}$ for potassium (K) means =	0.037	0.024
LSD $_{(0.05)}$ for time of harvest (T) means =	0.026	0.016
LSD $_{(0.05)}$ for K x T means =	NS	0.038

Table 8: Effect of potassium and time of harvest on storage root dry matter yield (tons/ha).

K-Level (Kg/ha)	Time of Harvest (MAP) 6	8	10	12	14	Means
2005/06						
0	5.12	11.34	11.74	14.25	12.59	11.01
50	4.72	15.56	14.75	16.95	19.54	14.30
100	5.66	14.33	11.72	13.15	15.22	12.02
150	6.35	14.91	18.76	14.18	17.00	14.24
200	5.63	14.78	21.19	20.19	19.23	16.20
Means	5.50	14.18	15.63	15.75	16.72	
2006/07						
0	4.76	5.61	9.52	8.98	8.27	7.43
50	6.47	6.38	7.01	11.17	10.24	8.25
100	7.19	5.66	8.87	11.81	11.64	9.03
150	5.51	6.72	9.98	14.17	13.23	9.89
200	4.76	6.35	8.14	13.61	13.04	9.18
Means	5.74	6.14	8.66	11.95	11.28	

	2005/06	2006/07
LSD $_{(0.05)}$ for potassium (K) means =	NS	1.42
LSD $_{(0.05)}$ for time of harvest (T) means =	2.20	1.38
LSD $_{(0.05)}$ for K x T means =	NS	NS

Table 9: Effect of potassium and time of harvest on mean storage root dry matter yield (t/ha)

K-Level	Time of Harvest (MAP)					
(Kg/ha)	6	8	10	12	14	Means
0	4.94	8.47	10.63	11.61	10.43	9.22
50	5.60	10.89	10.96	14.06	14.89	11.28
100	6.79	9.99	10.29	12.49	13.43	10.60
150	5.93	11.01	14.28	14.27	15.07	12.11
200	5.19	10.57	14.66	16.89	16.14	12.69
Means	5.56	10.18	12.16	13.86	13.99	

LSD $_{(0.05)}$ for potassium (K) means = 2.25
LSD $_{(0.05)}$ for time of harvest (T) means = 1.23
LSD $_{(0.05)}$ for (K x T) means = NS

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