The productivity of pure and mixed grass–legume pastures in the Northern Guinea Savanna zone of Nigeria

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Abstract

Buffel grass (*Cenchrus ciliaris* cv. Biloela), green panic (*Panicum maximum* var. trichoglume), Caribbean stylo (*Stylosanthes hamata* cv. Verano) and Townsville stylo (*S. humilis* cv. Paterson) in pure stands or grass–legume combinations were established from seed and evaluated for dry matter (DM) yield and crude protein (CP) during the growing seasons of 1977 and 1978. Caribbean stylo or Caribbean stylo–grass mixtures had a greater yield potential than Townsville stylo, but differences between buffel grass and green panic were small and inconsistent.

The highest DM yields of 3.83 t/ha and 4.97 t/ha in the first and second years, respectively, resulted from Caribbean stylo–green panic swards. However, averaged over all harvesting dates, Caribbean stylo–buffel grass mixtures produced the largest yields of 2.38 and 3.94 t/ha in 1977 and 1978, respectively.

Crude protein (CP) concentration varied from 18.22–5.94% in the legumes and 7.43–2.37% in the grasses. On the basis of CP yield, about 95 days after sowing (1977) and 90 days of regrowth (1978) would be recommended for conducting hay harvest and livestock grazing on all swards. Beyond these periods, most of the swards deteriorated to mere foggages which would necessitate supplementation, were they to be used for hay or livestock grazing.

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Introduction

The Guinea Savanna zone of Nigeria has potential for a viable livestock industry but this requires highly productive sown pastures and sound husbandry systems (Haggar 1969). The importance of legumes in increasing pasture productivity in the tropics and subtropics has long been recognised (Bryan 1962; Horrell and Court 1965; Jones *et al.* 1967).

Since the early 1950s, several introduced pasture grasses and legumes have been screened at Shika, but selection of promising materials has relied mainly on yield demonstrated in pure cultures (Blair-Rains 1963; Haggar 1971). While the use of fertiliser-N on pure grass pastures may be justified in the high rainfall zones of Nigeria with long growing seasons, the establishment of compatible grass–legume mixtures would be more economical under the limited rainfall, range conditions of the Northern Guinea Savanna (Haggar 1971; Akinola 1974).

The present study therefore aimed to evaluate the growth of 2 grasses [buffel grass (*Cenchrus ciliaris* cv. Biloela) and green panic (*Panicum maximum* var. trichoglume)] and 2 tropical legumes [Caribbean stylo (*Stylosanthes hamata* cv. Verano) and Townsville stylo (*S. humilis* cv. Paterson)] in pure stands and grass–legume mixtures at Shika.

Materials and methods

The experiment was conducted at the National Animal Production Research Institute, Shika in the Northern Guinea Savanna zone of northern Nigeria (11°12′N, 7°33′E) during the 1977 and 1978 growing seasons. The area has a monsoonal climate and is characterised by a total annual rainfall of 1000–1250 mm, most of which falls during May–October (Kowal and Knabe 1972). Mean daily temperature during the rains is 24.8°C and mean relative humidity 72%. A cool,

dry period with mean minimum and maximum daily temperatures of 14°C and 30°C, respectively, and about 21% mean relative humidity follows during November–February. This period is followed by a hot, dry period with mean minimum and maximum daily temperatures of 21°C and 36°C, respectively, and about 37% mean relative humidity during March–April–May (Kowal and Knabe 1972).

The experimental site had been fallow for almost 20 years. Prior to clearing in June 1977, the top soil (0–15 cm) was sampled and analysed for physico-chemical characteristics (AOAC 1970). The soil had 9% clay, 9% silt, 82% sand; 5.6 pH; 0.010% total N; 117 ppm total P; 3.23 meq/100 g Ca^{2+}; 0.113 meq/100 g Mg^{2+}; and 0.095 meq/100 g K^{+}. The site was brush-cut, ploughed and harrowed twice between July 7–14, 1977. Before sowing on July 21, the ground was raked and levelled to obtain a good seedbed and 32 plots (8 × 4 m each) laid out. A randomised complete block design consisting of 8 treatments (2 grasses, 2 legumes and 4 grass–legume combinations) replicated 4 times was used. Single superphosphate was applied uniformly at 18 kg/ha P in order to enhance legume production.

The legume seeds were treated with hot water at 80°C for 10 minutes, a day before sowing, to improve germination. Seeds were broadcast according to the following treatments: pure swards — Townsville stylo, Caribbean stylo, buffel grass, green panic; and mixed swards — Townsville stylo–buffel grass; Townsville stylo–green panic; Caribbean stylo–buffel grass; and Caribbean stylo–green panic. On the basis of germinability, Townsville stylo and green panic seeds were sown at the rate of 10 kg/ha and Caribbean stylo and buffel grass at 5 kg/ha. Rates for each component were halved when sowing grass–legume mixtures.

The plants were sampled for DM yield in the year of establishment (1977) at 67, 95, 139 and 199 days after sowing. In the second year (1978), yield samples of regrowth were taken at 90, 125 and 217 days after cutting to a uniform height of 15 cm above ground level on April 1, 1978.

On each sampling date, plant samples were harvested from 2 randomly located 0.36 m^2 areas from each plot at a height of 15 cm above ground level. Total fresh yield was recorded in the field and subsamples collected. These were hand-sorted into sown grass, legume and weed components. These components were weighed fresh, subsampled and oven-dried at 80°C to a constant weight for determining DM yield. The dried samples were ground using a Christy and Norris laboratory mill, fitted with a 1 mm mesh sieve. Crude protein (CP) percentage was determined on a DM basis using the standard Kjeldahl method (AOAC 1970). The DM yield and CP data were subjected to analysis of variance and the means were compared using Duncan's New Multiple Range Test (Steele and Torrie 1960).

Results

Climatic conditions

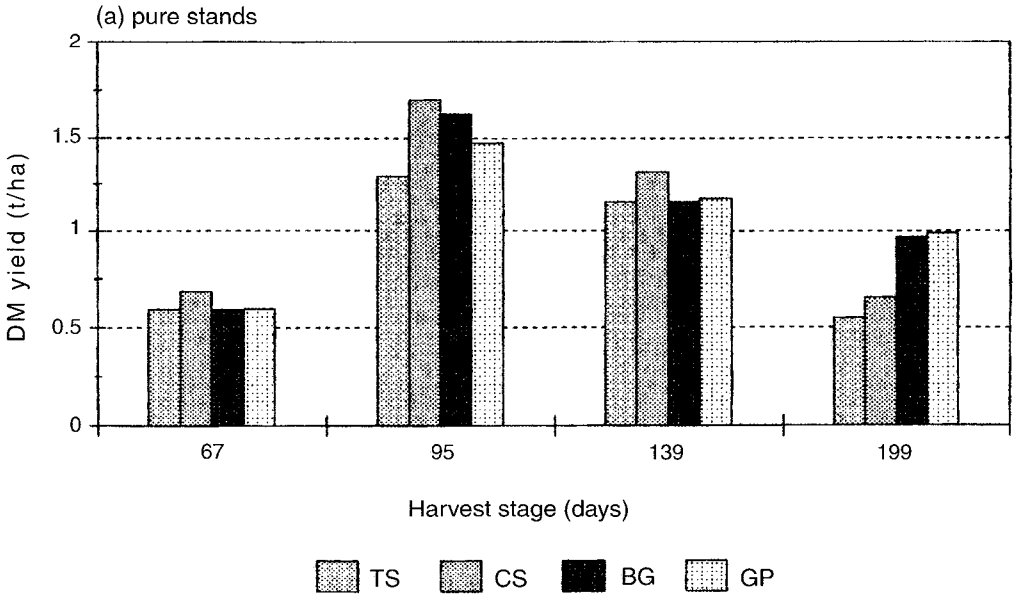
The total annual rainfall figures for 1977 and 1978 were 776 mm and 1205 mm, respectively, with that in 1978 more evenly spread. During the growing season (May–September), the average daily maximum and minimum temperatures were 29.9°C and 19.9°C (averaged over both years), respectively, without striking changes between months.

Dry matter yields

Changes in dry matter yields of pure stands and mixed swards over time are shown in Figures 1(a) and 1(b) and Figures 2(a) and 2(b). Maximum DM yields for different treatments for 1977 and 1978 are shown in Table 1. Treatment differences were highly significant ($P < 0.001$), as was the treatment × harvest date interaction ($P < 0.001$). The highest DM yields from the sown species were recorded at the sampling 95 days after sowing in the establishment year (1977) and at 90 days after cutting in the second year (Table 1). Averaged over all treatments, the lowest yields occurred at 67 days after sowing in 1977.

Dry matter yields of mixtures exceeded those of pure grass or legume swards ($P < 0.05$). However, with the exception of Townsville stylo, yields of pure cultures and of the individual grass or legume components of mixed swards did not differ significantly (Table 1).

Although differences in yield between pure stands within harvest dates were not always statistically significant, Caribbean stylo produced the highest DM yields in both years except at 199 days after sowing in 1977, when both buffel grass and green panic produced higher yields than Verano, primarily due to leaf loss in the legume.



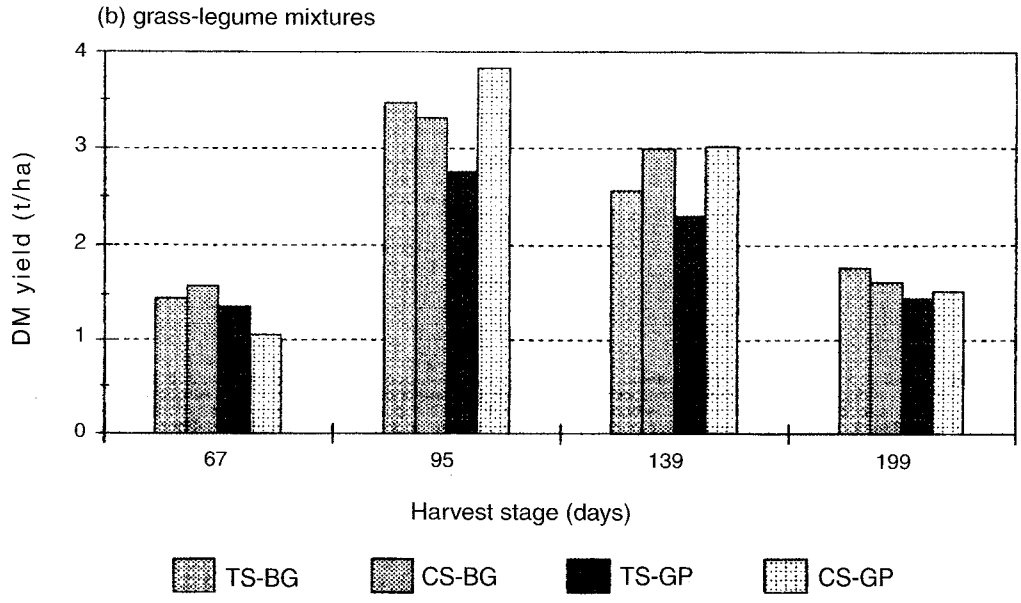


Figure 1. Dry matter production (t/ha) of grasses, legumes and mixed grass-legume swards during 1977 growing season. TS = Townsville stylo; CS = Caribbean stylo; BG = buffel grass; GP = green panic.

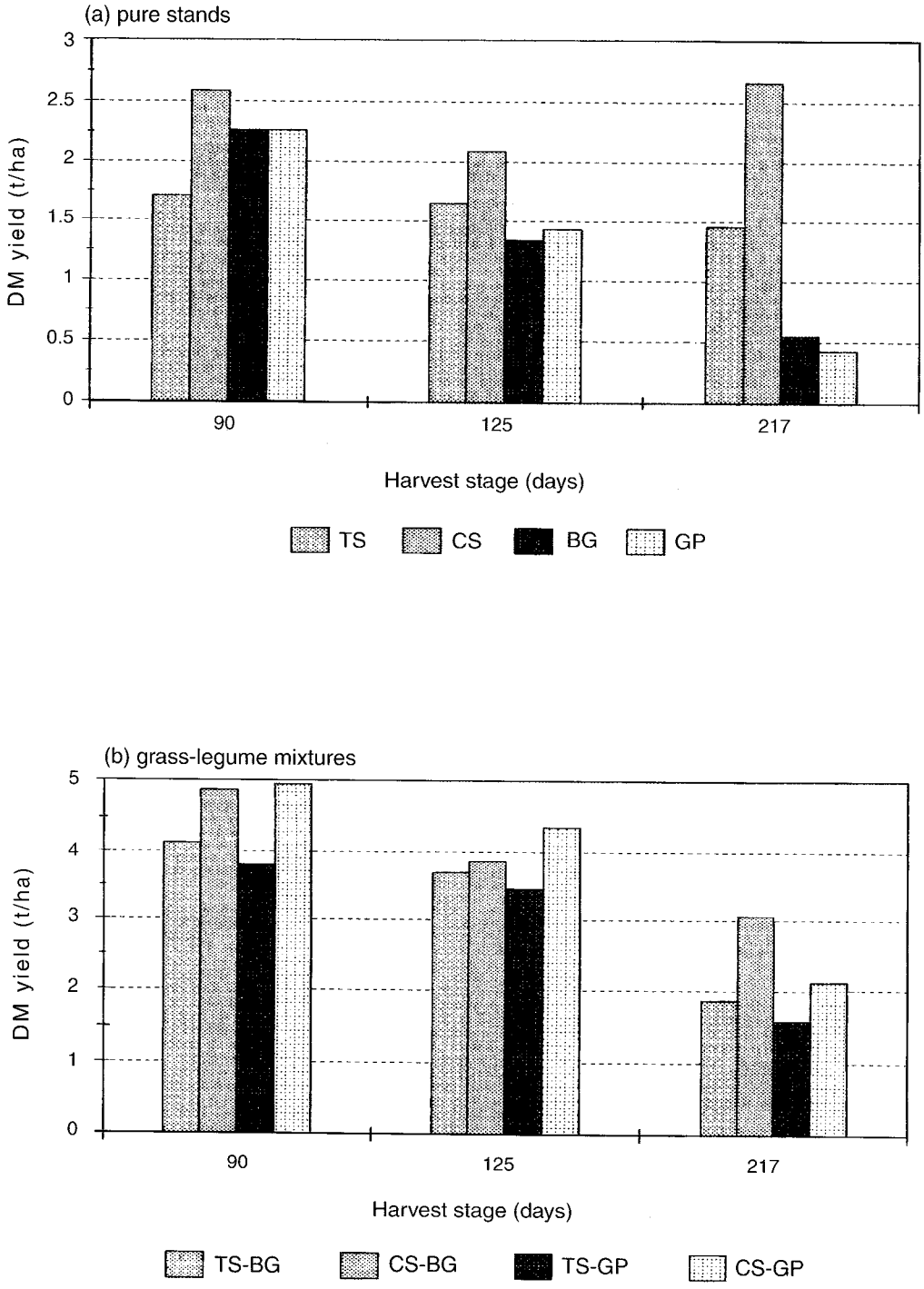


Figure 2. Dry matter production (t/ha) of grasses, legumes and mixed grass-legume swards during 1978 growing season. TS = Townsville stylo; CS = Caribbean stylo; BG = buffel grass; GP = green panic.

Townsville stylo was generally inferior to all other sown species.

Mixed Caribbean stylo–green panic swards produced the highest DM yields of 3.83 t/ha and 4.97 t/ha in the first and second years, respectively. Overall, Townsville stylo-based mixtures resulted in lower production levels than those based on Caribbean stylo, although this result was not consistent across all harvests. However, Townsville stylo–green panic was the only pasture that was significantly different from other treatments (Table 1).

Weed dry matter yields

The extent of weed competition was extremely variable depending on the treatment, sward age and year (Table 1). Maximum weed DM yield generally occurred on day 95 in the establishment year and day 90 in the second year in mixed and in some pure swards. From these dates, there was a gradual decline in weed DM yield up to the end of the growing season, even though this trend was not always consistent in plots containing pure swards. For example, plots containing pure grasses had their lowest weed DM yields at day 125 and not at the end of the growing season when the last sampling was done.

Weed infestation was higher in the plots containing Caribbean stylo than in those containing Townsville stylo in 1977, but mixed grass–legume swards still had a high content of the sown species (data not shown), at the end of the 1978 growing season.

Crude protein concentration

Variations in CP concentration among the species are presented in Table 2. Highly significant differences ($P < 0.01$) existed among treatments and

Table 1. Maximum dry matter yields (t/ha) of components of pure grass and legume swards and grass–legume mixtures during 1977 and 1978 growing seasons.

Treatments	1977 (95 d after sowing)				1978 (90 d regrowth)			
	Grass	Legume	Total sown spp.	Weeds	Grass	Legume	Total sown spp.	Weeds
Pure swards								
TS[1]	—	1.29	1.29 e[2]	1.03 c	—	1.71 b	1.71 d	1.99
CS	—	1.70	1.70 d	1.37 bc	—	2.59 ab	2.59 c	2.21
BG	1.62	—	1.62 d	1.21 c	2.26	—	2.26 cd	2.48
GP	1.47	—	1.47 de	1.06 c	2.26	—	2.26 cd	1.91
Grass–legume mixtures								
TS–BG	1.75	1.74	3.49 ab	1.38 bc	2.12	2.00 ab	4.12 ab	2.40
CS–BG	1.63	1.67	3.30 b	1.91 a	2.46	2.42 ab	4.88 a	2.64
TS–GP	1.44	1.32	2.76 c	1.12 c	2.28	1.62 b	3.90 b	2.00
CS–GP	1.98	1.84	3.82 a	1.75 ab	2.26	2.71 a	4.97 a	2.02

[1]TS = Townsville stylo; CS = Caribbean stylo; BG = buffel grass; GP = green panic.
[2]Means within a column followed by the same letter do not differ significantly ($P > 0.05$).

Table 2. The effect of age on crude protein concentration (%) of grasses and legumes during 1977 and 1978 growing seasons.

Treatments	Days after sowing (1977)					Days of regrowth (1978)			
	67	95	139	199	Mean	90	125	217	Mean
TS[1]	18.22 a[2]	13.78 a	8.19 a	6.61 a	11.70 a	16.87 a	16.24 a	10.69 a	14.30 a
CS	14.92 b	12.56 a	7.97 a	5.94 a	10.35 a	16.44 a	13.42 b	9.65 b	13.17 b
BG	7.43 c	5.42 b	2.92 b	2.37 b	4.53 b	5.54 b	4.18 c	3.98 c	4.57 c
GP	6.05 c	4.38 b	3.41 b	3.01 b	4.21 b	4.84 c	4.00 c	4.00 c	4.28 c

[1]TS = Townsville stylo; CS = Caribbean stylo; BG = Buffel grass; GP = Green panic.
[2]Means within a column followed by the same letter do not differ significantly ($P > 0.05$).

harvest dates. The treatment × harvest date interaction was also significant ($P < 0.01$). Per cent CP declined from the first to the last harvest regardless of treatment in both years, and the legumes contained more CP than the grasses. A pure legume stand tended to have higher CP concentration than the same legume in association with a grass (data not shown), with the reverse appearing to be true for the grass. CP levels in Townsville stylo were higher than in Caribbean stylo, and although the average for buffel grass exceeded that for green panic, CP concentration of green panic fell less rapidly with age. Overall, CP concentration in legumes varied from 18.22% in Townsville stylo (at 67 days in year 1) to 5.94% in Caribbean stylo (after 199 days in year 1) and for grasses from 7.43–2.37% in buffel grass in year 1. The legumes contributed substantially to the overall CP concentration of the grass–legume mixtures. Since weed infestation is a problem in these pastures, the practice should be to graze the pasture heavily early in the season in order to minimise the problem.

Discussion

Most agronomic investigations on the 4 species selected for this study have been conducted in northern Australia. In a review by McCown *et al.* (1984), the climatic and soil conditions of Australia and Africa were compared and they suggested that many parallels exist between the 2 continents. They concluded that the tropical climate in northern Australia is similar to that of Africa's Guinea and Sudan zones within which Shika is located.

Data from our study suggested that Caribbean stylo was the most productive in pure stands and more compatible with either of the grasses than Townsville stylo. This supports the earlier findings of Burt *et al.* (1974) and Edye *et al.* (1975) in northern Australia. It performed well, increasing yield and quality, which should lead to improved animal performance. Plots of pure Caribbean stylo or Caribbean stylo–grass mixtures tended to be more weed tolerant than those containing Townsville stylo.

In contrast to the situation with the legumes, there was no significant difference in yield between green panic and buffel grass. This contrasts with the earlier report by Coaldrake and Russell (1969) that buffel grass succeeded better than green panic when they were broadcast on to the ash covering newly burned brigalow land in northern Australia. Nevertheless, from the present study, buffel grass would seem to be a more appropriate companion grass than green panic. It might be reasoned that the pure grass swards, in general, required the addition of N to increase their vigour and curtail weed interference (Chheda and Akinola 1971).

The highest yield of 3.83 t/ha recorded in the establishment year of our study was much lower (33, 28 and 24 per cent of DM yield) than recorded earlier for signal grass (*Brachiaria decumbens*) mixed with Townsville stylo, perennial stylo (*S. guianensis* cv. Schofield) and densely planted pure signal grass at Shika (Akinola 1977), primarily due to the lower fertility of soils used in the present investigation.

The higher DM yields obtained in the second year could be attributed partly to better rainfall distribution and partly to improvement in the soil nutrient status. Contributing to the latter would have been the decaying of plant parts especially leaves, nodules and roots. Although Caribbean stylo behaved as a biennial plant on good soils at Shika, plants died during the dry season following the year of establishment in this study and both legumes survived only by means of seedling recruitment. A fall in yield following a period of peak production occurred in both years. In the establishment year, this was most likely due to the onset of drought, whereas the decline in the second year probably resulted from strong weed competition above and below ground. The decline in yield between the maximum values and the final harvest seems very large, particularly for the grasses. This may be a function of the cutting height of 15 cm, where a lot of lodged material is below the cutting height.

According to Milford and Minson (1965), when hay from tropical swards contains less than 7 per cent CP, intake of DM is lowered. Crude protein concentration of grasses, particularly in association with legumes, approached 7 per cent only during the early stages of growth, even though a review on green panic by Butterworth (1967) showed a range in CP of 4–14 per cent for grass cut at different stages of growth. However, CP of pure legume swards exceeded 7 per cent up to 139 days (early December) in 1977 and 217 days (early November) in 1978. The importance of growing legume-based pastures was obvious;

the grass–legume swards produced more forage of higher quality than the pure grass swards and would provide a productive diet for a longer period.

The data indicate that the most appropriate times to harvest for maximum CP yield were about 95 days after sowing in 1977 and 90 days of regrowth in 1978. Pure legume and mixed grass–legume swards maintained comparatively large quantities of nutritious forage suitable for hay making up to 217 days of regrowth (early November) in 1978. Crude protein data would suggest that pure grass pastures would provide a submaintenance diet almost throughout. However, these figures represent the analysed whole plant samples, and the ability of animals to select leaf material would ensure adequate nutrition at least for liveweight maintenance for a considerable period.

Since both DM and CP yields peaked in the first 3 months and then declined rapidly, pastures should either be grazed early in the growing season or conserved as hay in order to maximise the benefits.

Indications from this study were that, because of its considerable yield potential, Caribbean stylo alone or in mixtures with grass, particularly buffel grass, seems promising for use in pastures in the Northern Guinea Savanna zone of Nigeria. However, our study was too short to adequately assess these species for persistence and grass–legume compatibility. Further research is needed to determine the compatibility of Caribbean stylo with other promising sown grasses or when oversown into stands of productive native grasses such as *Andropogon gayanus*. Since undefoliated swards are not likely to be a good guide to performance under grazing, the species should be tested under grazing conditions before it is recommended for use for improved animal production in this ecological zone. Also, longer term studies under grazing are required to establish the stability of mixed pastures over time.

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