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Underplanting oil palm with cocoa in Ghana

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Abstract. Mature oil palms at the Oil Palm Research Institute at Kusi, Ghana were underplanted with cocoa to study the feasibility of mixed cropping of the two crops under West African conditions. The oil palm trees used in this trial were planted in 1970 and had achieved maximum canopy formation. Three triangular spacings of the oil palms used were 8.7, 9.9 and 10.5 m. The cocoa was underplanted in June 1988 at a spacing of 2.4 m triangular using mixed hybrids. There were no significant differences in oil palm yield between plots with cocoa and the controls. There was no appreciable damage to the cocoa trees from falling palm fronds and fruits during harvesting or pruning. Cocoa seedling growth and yield were significantly better under the oil palm spaced at 9.9 or 10.5 m triangular than under oil palm spaced at 8.7 m triangular.

Introduction

Although widely practised in tropical regions, intercropping has previously been considered to be an underdeveloped agricultural practice. However in spite of the emphasis of research and development on monocropping, intercropping remains widespread and in many situations represents a more efficient use of natural resources [Fordham, 1983]. Mixed cropping can serve as an insurance against crop failure, makes more efficient use of labour and improves both land use efficiency and the income earning capacity of the farmer. The main disadvantages of mixed cropping are that yields from the individual crops are usually below yields from monocultures owing to inherent competition for light, water and nutrients, and farm maintenance operations may be difficult to mechanize.

While oil palm (*Elaeis guineensis*) has normally been cultivated as a monocrop without shade due to its high light requirements [Hartley, 1966], cocoa (*Theobroma cacao*) is usually cultivated under thinned forest tree shade in Ghana [Wood, 1985]. During the establishment of these tree crops farmers traditionally intercrop with food crops such as plantain, maize, cassava, cocoyam, pepper and many other annual crops, as a cultural practice for income to offset part of initial tree crop development outlay or as a source of food sustenance to the farmer. However as the canopy of the tree crops closes, such intercropping is no longer feasible. Tree-crop intercropping with, for example, cocoa and coconuts has been carried out in many countries [Leach et al., 1974; Ramadasan et al., 1978; Shepherd et al., 1977]. There have also

been several attempts to intercrop cocoa with oil palms, rubber, areca palm and nutmeg [Mossu, 1992]. When planted at their normal density, all these crops produce too much shade for the cocoa trees which adversely effect cocoa pod production. A successful intercropping system should be both sustaining and complementary.

One major characteristic of a cocoa/oil palm intercropping is that these two crops have different labour calendars which do not interfere with each other. Thus in Ghana, whilst the peak yield and high labour requirements for oil palm occur between February and July, that for cocoa is between September to March. Cocoa/oil palm intercropping has been found biologically compatible [Egbe and Adenikinju, 1990] and cocoa is grown in combination with other tree crops such as oil palm, citrus and kola in Nigeria. In Ghana, cocoa and oil palm could be seen growing in association on farmers, farms. However, information on the net benefits in a cocoa/oil palm intercropping under Ghanaian conditions is lacking.

The objective of this study was to test the possibility of growing cocoa as an under plant in mature oil palm plantation in Ghana.

Materials and methods

The experiment site was at the Oil Palm Research Institute at Kusi in the eastern region of Ghana, known to be climatically suitable for both cocoa and oil palm cultivation. The soils derived from forest ochrosols are mainly silty to clayey loam, deep (over 1.8 m), moderately well drained and slightly acidic (pH 4.6–6.0) occurring on a gently sloping topography. The Institute lies on longitude W.001.45, latitude N.06.00 and about 150 m a.s.l. The total annual (January to December) and total dry season (November to February) rainfall as well as the mean daily temperature figures for Kusi, Ghana from 1986 to 1993 are shown in Fig. 1. The oil palms used in this study were originally part of an experiment which was set up in 1970 and aimed at determining under environmental conditions prevalent in Ghana, the effect of various triangular spacing combined with double (hexagonal) spacing up to the second or third year production on yield. The original experiment was replicated four times and occupied a total area of 16 ha with Deli O × P ex OPRC as the planting materials. Three triangular spacings of oil palm i.e. 8.7, 9.9 and 10.5 m which had achieved maximum canopy formation were selected for this study. Six-month-old recommended mixed hybrid cocoa seedlings were underplanted in May 1988 in all plots at a single spacing of 2.4 m (8 feet) triangular giving a plant population of 1975 trees per hectare. Three control (sole) plots of pure oil palm with no cocoa were included at the three densities mentioned above. A randomised block design with four replicates and occupying 0.17 ha per treatment per replicate was used. A schematic arrangement of the cocoa and oil palm are shown in Fig. 2.

Weed control was carried out four times a year by high slashing with

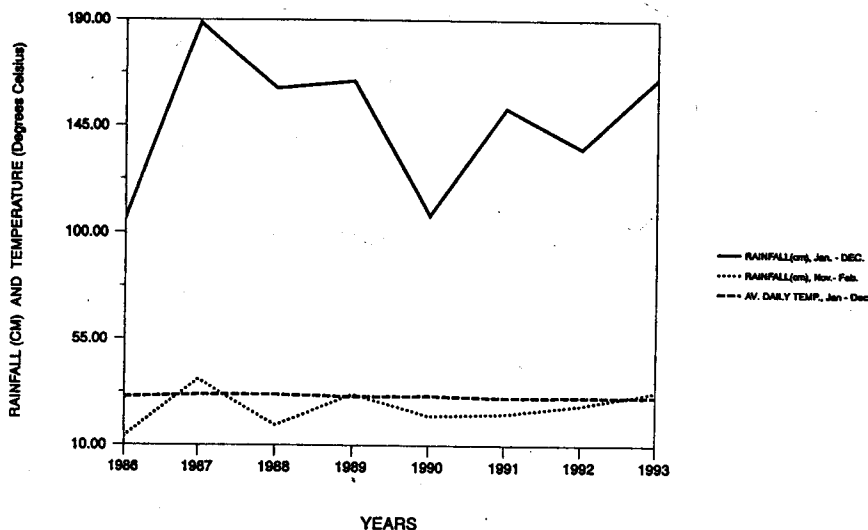


Fig. 1. Oil palm research institute (Kusi) – climate data – 1986–1993; total annual, total dry season rainfall (CM) and mean daily temperature ('degrees' celsius).

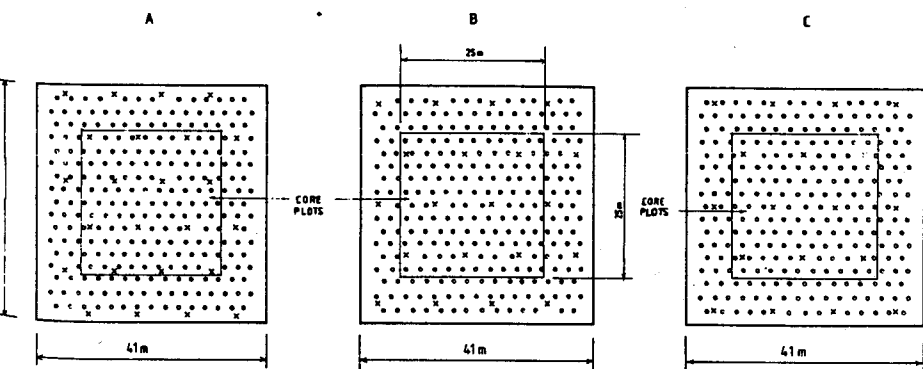


Fig. 2. Schematic arrangements of cocoa (o) and oil palm (x) in the underplanting trial. (A) Oil palm at 8.7 m triangular; (B) Oil palm at 9.9 m triangular; (C) Oil palm at 10.5 m triangular. Scale 1:500 m.

cutlass. The oil palm was fertilized once a year in September/October with NPK 15-15-15 at a rate of 120 kg/ha. There was no deliberate attempt to fertilize the cocoa. Growth measurements of the cocoa (girth and height) were carried out at three monthly intervals starting at six months after transplanting till two years old when the plants had started flowering. As a routine management practice basal chupon as well as climbers and dead branches were periodically removed from the cocoa. The skirt of the cocoa canopy was raised

as and when necessary by pruning the lower branches to enhance better ventilation and to facilitate easy movement of labour for farm operations.

Records were taken on percentage of cocoa trees that flowered at two years and on the number of healthy pods, rodent damage as well as black pods caused by *Phytophthora palmivora*. There was no routine spraying against fungal attack, however capsid pockets were periodically treated. The assessment of damage on the cocoa was done immediately after each harvesting of the palm fruits by counting the number of cocoa trees which were affected by either the bunches or falling fronds. Harvesting of the cocoa was done at monthly intervals from September to January. On each occasion, the pods were sorted out into healthy, diseased, as well as rodent-damaged, to facilitate data collection. The peak of oil palm harvesting was normally between

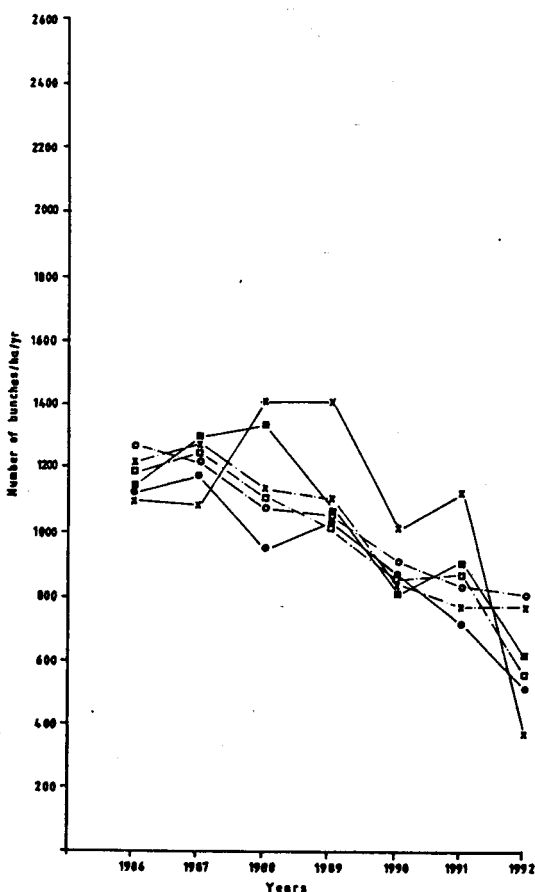


Fig. 3. Oil palm yield (no. of bunches/ha) in cocoa/Oil palm intercropping trial. 8.7 m Δ control (- x -); 8.7 m Δ underplanted (- x -); 9.9 m Δ control (- o -); 9.9 m Δ underplanted (- ● -); 10.5 m Δ control (- □ -); 10.5 m Δ underplanted (- ■ -).

February and July each year and data were collected on the number of bunches as well as total weight of bunches per treatment.

Results

The yield of the oil palm defined by number of bunches and total weight of bunches per ha from 1986 to 1992 are shown in Figs. 3 and 4, respectively. There were no significant differences in oil palm yield (total bunch number and total bunch weight) between plots with cocoa and the controls at all spacings of the oil palm. The oil palm at 8.7 m underplanted with cocoa showed very large fluctuations in bunch number (1400 to 400), (Fig. 3) which was not observed for the 9.9 m and 10.5 m treatments despite the general decline in yield over the period. There was also a general decline in the total weight of bunches over the period. Data on girth and height measurement of

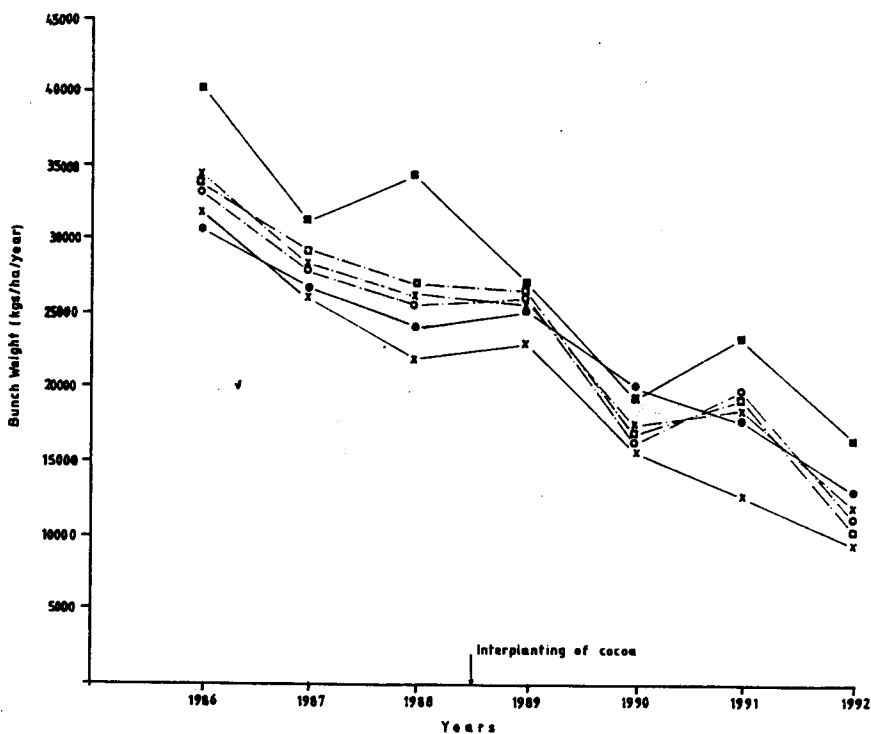


Fig. 4. Oil palm yield (total bunch weight; kg/ha) in cocoa/oil palm intercropping trial. 8.7 m Δ control (- x -); 8.7 m Δ underplanted (- x -); 9.9 m Δ control (- o -); 9.9 m Δ underplanted (- ● -); 10.5 m Δ control (- □ -); 10.5 m Δ underplanted (- ■ -).

the cocoa from November 1988 to May 1990 showed similar trend and hence only data for the girth are presented in Fig. 5.

It was observed that as the spacing of the oil palm increased the cocoa size was significantly greater ($p \leq 0.05$). Two years after planting, about 80% of the cocoa planted under 10.5 m and 9.9 m spaced oil palm flowered as against only 25% in those planted under 8.7 m shade (Table 1).

In terms of healthy pods, cocoa planted under 10.5 m spaced oil palms produced higher number of pods than cocoa planted under 9.9 m oil palm which in turn produced much higher number than that planted under 8.7 m oil palms. This data could not be statistically analysed because of the few treatments producing pods at this stage. The second, third and fourth year yield records presented in Table 2 follow a pattern similar to that observed in the first year.

The levels of rodent damage and the incidence of black pod disease were negligible in all plots in the second harvest (1991-92). However in the third

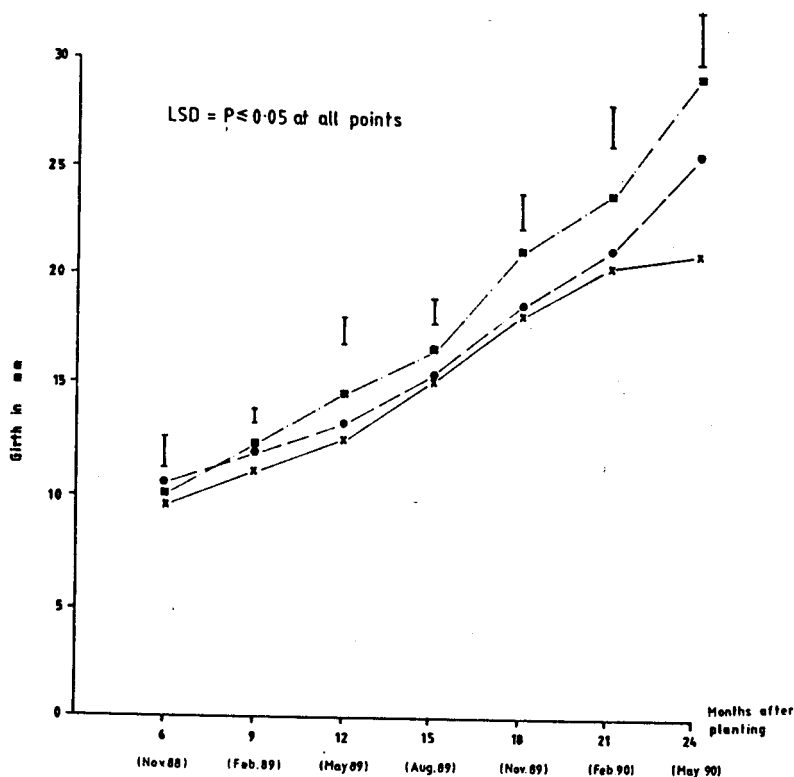


Fig. 5. Mean girth development of cocoa for the period 1988-1990 in a cocoa/oil palm intercropping trial. Cocoa Planted under 8.7 m Δ oil palm (- x -); Cocoa Planted under 9.9 m Δ oil palm (- ● -); Cocoa Planted under 10.5 m Δ oil palm (- ■ -).

Table 1. Percentage of cocoa trees flowering at 2 years after planting (in 1990) and yield of healthy pods during the first harvest (1990–91).

Spacing of oil palm	Percentage of trees flowering/plot	Number of healthy pods/plot
8.7 m triangular	25.3	21 (12.4 kg dry beans/ha)
9.9 m triangular	80.1	63 (37.3 kg dry beans/ha)
10.5 m triangular	82.5	107 (63.4 kg dry beans/ha)

* Pod numbers from core plots of 0.063 ha. Dry beans estimated from pod value of 27 (i.e. 27 cocoa pods gives 1 kg dry cocoa beans).

Table 2. Yield^a of healthy pods in cocoa underplanted in oil palm plantation from 1991 to 1994.

Spacing of oil palm	1991–92	1992–93	1993–94
8.7 m triangular	66 pods/plot (39.1 kg dry beans/ha)	123 pods/plot (72.9 kg dry beans/ha)	234 pods/plot (138.6 kg dry beans/ha)
9.9 m triangular	272 pods/plot (161.2 kg dry beans/ha)	524 pods/plot (310.5 kg dry beans/ha)	406 pods/plot (240.7 kg dry beans/ha)
10.5 m triangular	394 pods/plot (233.5 kg dry beans/ha)	858 pods/plot (508.4 kg dry beans/ha)	1346 pods/plot (795.9 kg dry beans/ha)
SED (6 df)	180.6	245.5	220.0

* Pod numbers from core plots of 0.063 ha. Dry beans estimated from pod value of 27 (i.e. 27 cocoa pods gives 1 kg dry cocoa beans).

year (1992–93), the percentages of rodent damaged pods under 8.7 m, 9.9 m and 10.5 m palm were 9.40, 1.47 and 1.35, respectively, whilst the percentages of black pods were 18.80, 12.70 and 8.26, respectively. The levels of rodent damage and blackpod infestation again dropped remarkably in the fourth year (1993–94) (Table 3).

Data on the number of cocoa trees damaged by palm fruits and fronds during harvesting and normal pruning from 1990 to 1993 are presented in Table 4. The results indicate that as the canopy of the cocoa developed, the number of cocoa trees damaged by palm fruits and palm fronds increased in all treatments. This damage was higher under 10.5 m and 9.9 m palm spacings (where cocoa canopy was well developed) than under 8.7 m spacing over the period 1990 to 1993.

Insect damage to the cocoa was not serious under the shade provided by the palm trees. The visual assessment of weed cover also indicated that weed regrowth was fastest, in the order, under 10.5 m (control), 9.9 m (control), 8.7 m (control), 8.7 m (underplanted) followed by 9.9 m (underplanted) and 10.5 m (underplanted).

normally grown under thinned forest shade. This shade could be provided by the oil palm as observed in this study. As there were no significant differences in the oil palm yield the additional yield from the cocoa could be taken as 'bonus' and therefore indicates that there is a benefit in underplanting oil palm with cocoa. Under peasant farmer system, lower yields from the cocoa attributed to the haphazard spatial arrangement of the intercrops were recorded [Egbe and Adenikinju, 1990]. However in this study the growth and yield of the cocoa under the oil palm at 9.9 m or 10.5 m triangular is comparable to that of any pure stand of cocoa of the same age. In Ghana a national average of 212 kg/ha of dried cocoa beans was reported in the early 1960s [Cunningham and Arnold, 1962] and it has not changed much till today (about 280 kg/ha) although higher yield of 3.9 tons/ha has been achieved on experimental plots [Adomako, 1990]. Similar observation has been made in Brazil where it has been reported that the performance of the cocoa growth in combination with hevea is comparable to that of average cocoa crop in the locality (650 kg dry beans/ha) but lower than that of cocoa stands in improved management (about 2.5 tons/ha) [Alvim and Nair, 1986].

Damage caused by palm fruits and fronds over the experimental period was not appreciable and suggests that this may point to a compatible package. Rodent damage and black pod attack on the cocoa was not alarming at low oil palm densities thus supporting the use of widely spaced palms for this underplanting package. The spacing of the cocoa (2.4 m triangular) could be a factor which encouraged the spread of the black pod disease and rodent attack. The cocoa density was rather high and probably needs to be reduced. With a spacing of 3×3 m or 3 m triangular, these problems may have been less. In a similar study but with different spatial arrangement of the cocoa and oil palm no significant differences in growth and development of cocoa seedlings and in the level of *Phytophthora palmivora* infestation and pod damage by mammals were observed [Kolade, 1986].

In intercropping systems with cocoa and kola or *T. ivorensis*, the surface feeding roots of the two crops were apparently in mutual competition [Egbe and Adenikinju, 1990]. However with the restricted fibrous roots of the oil palm [Hartley, 1966] and the extensive superficial feeding roots of the cocoa [Wood, 1985] there appears to be no adverse effect between oil palm and cocoa when they are interplanted. Thus in similar studies carried out elsewhere, cocoa production in cocoa/kola and cocoa/*Termilaria ivorensis* mixtures was however lower than in sole crop, while cocoa production in the cocoa/oil palm mixture was higher [Beets, 1978; Egbe and Adenikinju, 1990; Nair, 1984; Norman, 1974]. Whilst the closest spacing of the oil palm produced a higher number of bunches, the yield in this treatment was inferior to the widely spaced palms which produced very heavy bunches to compensate for the relatively few number of bunches produced. The yield trend of the oil palms over the period 1986 to 1992 was similar to that observed from 1975 to 1985. The decline in the oil palm yields over the period 1988 to 1992 cannot be attributed to the presence of the cocoa as this decline was observed

in the control plots as well. Estate copra production has been reported not to be affected by the introduction of cocoa as an intercrop in coconut plantation [Shepherd et al., 1977]. A study of the oil palm yield from 1975 to 1987 reveals that though the yields fluctuate from year to year, there was a general decrease in yields as the trees advanced in years. This trend agrees with observation made by Hartley, [1966]. Shepherd et al. [1977] also observed fluctuations in copra yield in a cocoa/coconut intercropping which they ascribed to climatic and physiological factors rather than to the cocoa intercrop. Williams and Hsu [1970], also observed that under environmentally good, moderate or marginal conditions, oil palm yield defined by fresh fruit bunch (FFB) from the 4th to 25th year after planting ranges from 12.5 to 22.5, 11.5 to 20 and 7.5 to 15 tons per/ha, respectively, under Malaysian conditions. This trend is not too different from the oil palm yields observed in this study. Interplanting oil palm with cocoa in 'hollow square' pattern is reported to yield higher fresh fruit bunches than in 'avenue planting' pattern or in pure stands of oil palm [Onwubuga and Iremiren, 1980]. The mean FFB yields over a six-year period observed by these workers were 4860.7, 5496.0 and 5967.9 kg/ha/annum for pure oil palm, avenue pattern and hollow square pattern of cocoa/oil palm intercropping, respectively. The palm trees used in this study were about 18 years old and getting to the end of their economic life but since the higher yields of the cocoa in the widely spaced palms did not appear to affect the oil palm yields it could be suggested that the introduction of cocoa into the oil palm improved land-use efficiency.

The planting of cocoa as an intercrop with oil palm is recommended when the palm trunks are about 2 m high (i.e. about 7–8 years old) [Vanderwegen, 1952]. In this study the cocoa was planted rather late. To fully evaluate the potential benefit of the intercrop system, it would be interesting to investigate the performance of the cocoa and oil palm from the early stages of their vegetative growth through their productive life. This arrangement appears to be a more compatible package as both cocoa and oil palm have similar economic life span (25 years) and hence at the time of felling the oil palm the cocoa could be grubbed out and the two crops replanted.

Conclusion

Underplanting oil palm with cocoa improves land usage, when planted in the right component proportions and is capable of broadening the resource base of the farmer. The oil palm should however be planted at a wider spacing of about 10.5 m triangular for optimal cocoa performance to be obtained than the usual spacing of 8.7 m triangular.

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