RESEARCH ARTICLE

Oil Palm- Cocoa based Cropping System for Economic Viability and Sustainability

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ABSTRACT

A study was undertaken on Oil Palm- Cocoa based Cropping System for sustainability in West Godavari district of Andhra Pradesh. The study was conducted based on primary data collection through personal interview method using pre-tested interview schedules with a sample size of 60 farmers each in oil palm, coconut, oil palm + cocoa and coconut + cocoa belongs to six Mandals in West Godavari district of Andhra Pradesh as respondents.

Data collected on cost of establishment, maintenance, economic yields, employment generation, light infiltration, nutrient availability in different cropping systems, tabulated, analysed using the techniques for economic viability and sustainability of oil palm-cocoa cropping system. Information.

There was an increasing trend of fresh fruit bunch (FFB) yield of oil palm, organic carbon and could be utilized 22.4% of the soil mass beyond the active root zone of palms effectively. Although highest gross returns were recorded in Oil Palm + Cocoa (Rs. 248735) cropping system, the net returns were not significantly different between Coconut + Cocoa (Rs. 85254) and Oil Palm + Cocoa (Rs. 85191) cropping systems. Oil palm intercropped with cocoa recorded higher IRR (32%), BCR (1.56) and NPV (Rs. 160237) than 28%, 1.51 and Rs. 121873 respectively in mono crop of oil palm.

Further, there was no significant difference in payback period in mono crop of oil palm and in gardens intercropped with cocoa. Higher employment generation in oil palm + cocoa cropping system (431days/year) followed by coconut + cocoa system (385 mandays) compared to monocropping of oil palm (93 mandays) and coconut (81 mandays).

Key words: cropping system, sustainability, economic viability, cocoa, oil palm

INTRODUCTION:

Oil palm (*Elaeis guineensis* Jacq.), a perennial oil yielding crop with an average yield of 4-6 t of oil/ha/year is being cultivated in 3.17 lakh ha in India out of which 1.56 lakh hectares is in Andhra Pradesh only (DAC, 2018). A total potential area of 1.93 million ha in 18 states of India has been identified for growing oil palm (DOPR, 2012). The economic life span of the crop is 30 years. Normally it is planted in hexagonal system with 9 m spacing. During the juvenile and adult phase of the plantation, lot of inter space is available as the growing palms do not cover the full land area. Intercrops like vegetables, dwarf banana, maize, tobacco, chilli, turmeric, ginger, pineapple and flowers are recommended in oil palm plantations during juvenile phase to generate additional income.

Cocoa, botanically known as *Theobroma cacao* L. a tropical crop is native to Amazon basin and spread to other countries within 15^0 on either side of the Equator including Mexico, Central America, Caribbean Islands, South America, West Africa and South East Asia where the conditions for growing were ideal. West Africa dominates the world production today followed by South East Asia. Cocoa, the chocolate tree, is the most popular inter/mixed crop grown in coconut and areca gardens in South India. The cultivation of cocoa is gaining momentum and at present 82940 ha is under cocoa in India with 28205 ha in Tamil Nadu followed by 24156 ha is in Andhra Pradesh (DCCD, 2018).

Currently India is producing 18920 t of cocoa annually, importing about 70% of its need and the demand is increasing @ 15% annually. Andhra Pradesh ranks first in production and productivity of Cocoa in India with 7700 t and 800 kg/ha respectively.

Cocoa is the most popular inter/mixed crop grown in coconut and areca gardens in South India. Looking at the benefits of cocoa as an intercrop some farmers have started cultivating cocoa in oil palm plantations in West Godavari district of Andhra Pradesh. Like coconut and areca gardens, there is a potential for cocoa cultivation in oil palm plantations of India. This not only helps in effective utilization of inter spaces of palm plantation but also provide additional income to famers, in addition to adding lot of organic matter/litter to the main crop. Cocoa intercropping has been reported to be biologically compatible (Egbe and Adenikinju, 1990) and physiologically adaptive in oil palm plantations.

In Ghana, cocoa and oil palm could be seen growing in farmers' farms. There is a symbiotic association between oil palm and cocoa. Oil palm provides shade to cocoa which is a shade tolerant crop requiring 40-70 per cent light for better yield. Cocoa adds lots of organic matter and nutrients through leaf fall. The main reason for intercropping cocoa with coconuts or oil palm is that such systems utilize the land more efficiently than the monocrop systems.

Since mature cocoa requires some protective shade, it is logical that planting shade trees producing economic crops would improve the viability of a planting. However, they should not be too competitive for light, water and nutrition. In this regard, coconut is superior to oil palm.

Cocoa being shade tolerant crop and having remunerative prices identified as most suitable and sustainable intercrop in these palms. Sustainability is the use of natural resources or the application of a practice or technology in a manner in which the long-term net impact on natural resources is not negative (Vepa et al. 2004). From an agronomic point of view, an evenly spaced shade is better than shade trees planted in avenues.

Cocoa grows well in the interspaces between coconut trees that otherwise is unused land. Cocoa is less labour intensive compared to many other horticultural crops. This enables a farmer to earn additional income without much investment on inputs and labour and without an investment on land.

Another very important aspect of cocoa is that it is a perennial crop that lasts for 30-50 years continuously yielding the farmer additional income throughout the year. It is also one of the supports of agro-based industry in India. Cocoa beans are the primary raw material for confectioneries, beverages, chocolates and other edible products.

Keeping this in view, a study has been undertaken for comprehensive information with respect to sustainability of oil palm-cocoa cropping system and cost benefit ratio.

MATERIALS AND METHODS

Present study was carried out during 2016 and 2017 in West Godavari District of Andhra Pradesh, India with cocoa as intercrop in oil palm gardens. Among the 133 oil palm growing districts in the country, West Godavari district in Andhra Pradesh stands first in area, production and productivity with 62537ha, 7.47lakh MT and 18MT respectively. Hence, six mandals namely Pedavegi, Denduluru, Kamavarapu Kota, Dwaraka Tirumala, Jangareddygudem and T.Narsapuram in the district of West Godavari were selected and collected the data on different components to study the sustainability of oil palm-cocoa cropping system.

To undertake this study a survey has been conducted in West Godavari district of Andhra Pradesh where cocoa is cultivating as intercrop in oil palm and coconut gardens on a large scale. The study has been conducted based on primary data collection through personal interview method using pre-tested interview schedule with sample size of 60 farmers each in oil palm, coconut, oil palm + cocoa and coconut +cocoa belongs to six Mandals in West Godavari district of Andhra Pradesh as respondents as respondents and collected the data on different components to study the sustainability of the system. Information on cost of establishment, maintenance including fixed and variable costs, economic yields, employment generation, light infiltration data in different cropping systems were collected, soil samples were collected and analysed to study the nutrient availability. Data tabulated and analysed, techniques for evaluating economic viability and sustainability of oil palm-cocoa cropping system were employed.

RESULTS AND DISCUSSION

Economic yields under different cropping systems (n = 60)

The data presented in Table 1, revealed that there was an increasing trend of fresh fruit bunch (FFB) yield of oil palm compared to the mono crop with the

introduction of cocoa. However, the difference was not statistically significant (Table 1.) In case of coconut, the cocoa gave significantly higher yield (121%) with just about 18% higher population.

SOIL CHARACTERISTICS IN DIFFERENT CROPPING SYSTEMS AND ROOT SYSTEM

It has been observed that the active roots of an adult oil palm / coconut palms are concentrated laterally within a radius of 2-2.5m from the palm base. Thus in monocrop of oil palm/coconut about 22.4% of the soil mass is effectively utilized. Hence, the remaining 77.6% land could be utilized effectively by identifying suitable intercrop in these palms (Table 2.). Similarly 85% of the roots of oil palm are concentrated between 0 – 50cm depth. As the nutrient and moisture gradient is towards the centre of the palms, high nutrient use efficiency (NUE) and water use efficiency (WUE) could be achieved by raising intercrops outside the radius of the oil palm root zone. Further because of shade under the palms, the evaporation is very much reduced. Therefore, intercrop allows a better retention of water in the soil for a longer period. Improvement of soil fertility takes place as there is a gradual build up of organic matter in the soil by the addition of leaf litter and pruned material and by incorporation of these residues. Chowdappa (2015) also reported that in a pure stand of coconut only about 25% of the soil mass is actually utilized by the coconut and proper utilization of the remaining 75% of land could be utilized for intercropping ot farm diversification.

To study the soil properties and nutrient availability in different cropping systems, soil samples were collected from the selected gardens and analysed for pH, EC, OC, available P and K in all the systems. All the parameters were found non-significant in different cropping systems. pH, EC and Organic carbon were in the range of 7.21 to 7.31, 0.18 to 0.21 dS/m, 0.78 to 1.04% and NPK were in the range of 231-261, 51.8-76.10, 222.16 to 267.90 kg/ha respectively in different cropping systems (Table 3). Soil reaction has been recorded as normal in all cropping systems, EC and OC were low, available phosphorous was high and available potassium was medium. Although there was an increase in organic carbon in oil palm and coconut gardens intercropped with cocoa, it was found statistically non- significant.

COST OF CULTIVATION IN DIFFERENT CROPPING SYSTEMS

Although the yield level fairly gives an indication of any crop's performance either pure or as an intercrop, the cost and returns implications have an additional dimension that will indicate the profitability of otherwise of such cropping system(s). It is with this aim that the cost of cultivation of the four cropping systems (oil palm and coconut pure and with cocoa) were studied in the sample farms. The cropping system wise sample farm data on cost of cultivation is presented in Table 4. It may be mentioned that the establishment cost refers to the cost of cropping system till the planting of the main crop i.e., oil palm and coconut. The gross

Table 1: Comparison of Pure *vs* Mixed cropping systems in study area

Cropping System	Average age of main crop (years)	Average age of cocoa (years)	Crop stand of main crop (ha)	Crop stand of cocoa (ha)	Economic yield of main crop (ha)	Yield of cocoa beans (kg/ha)
Oil palm	12	—	142	—	23.19 t/ha	—
Coconut	22	—	140	—	26521 nuts	—
Oil palm + Cocoa	13	6	142	378	23.69 t/ha	381.0
Coconut + Cocoa	26	8	139	445	26625 nuts	841.6

Table 2: Pattern of land utilization by a mono-cropping system

S. No.	Feature	Area (m^2)	
		Oil palm (Spacing $9m^3$)	Coconut (spacing $7.5m^2$)
1.	Land area available /palm	70.15	56.25
2.	Area of maximum concentration of roots/palm	15.71	12.57
3.	Area effectively utilized by roots/palm	22.39 %	22.34 %

Table 3. Soil characteristics in different cropping systems

Cropping System	PH	E.C (ds/M)	O.C (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Ca (Meq/100g)
Oil palm	7.29	0.19	0.99	257.22	76.10	267.90	1.72
Coconut	7.31	0.18	0.90	253.74	51.80	264.22	1.86
Oil palm + Cocoa	7.25	0.18	1.04	260.87	64.14	224.16	1.89
Coconut + Cocoa	7.21	0.21	0.94	231.08	54.47	225.13	1.63
Mean	7.27	0.19	0.97	250.73	61.63	245.35	1.77
S.Em	0.11	0.01	0.05	12.94	6.50	24.34	0.14
C.D (0.05)	N.S	N.S	N.S	N.S	N.S	N.S	N.S
C.V	3.68	13.06	13.69	12.64	25.82	24.30	19.93

Table 4. Cost of cultivation and Returns different cropping systems (Rs./ year)

Cropping system	Name of the Mandal	Establishment Cost(Rs./ha)	Gross Expenditure* (Rs./ha)	Gross Returns (Rs./ha)	Net Returns (Rs./ha)
Oil Palm	Pedavegi	10039.00	96901.25	166945.00	70043.75
Oil Palm	Denduluru	10222.50	122013.73	175051.00	53037.28
Oil Palm	K.Kota	9925.00	109348.75	181420.00	72071.25
Oil Palm	D.Tirumala	16024.25	98408.25	177174.00	78765.75
Oil Palm	J.R.Gudem	14641.75	128162.00	186245.00	58083.00
Oil Palm	T.Narasapuram	6978.13	92846.25	187210.00	94363.75
12 years		**8661.15**	**107946.70**	**179007.50**	**71060.80**
Coconut	Pedavegi	3628.50	46155.00	77250.00	31095.00
Coconut	Denduluru	7893.50	72641.25	92725.00	20083.75
Coconut	K. Kota	3964.75	54666.50	89637.50	34971.00
Coconut	D.Tirumala	4571.75	59797.50	89365.00	29567.50
Coconut	J.R.Gudem	4846.25	57492.75	80850.00	23357.25
Coconut	T.Narasapuram	2757.50	37404.75	87668.75	50264.00
22 years		**4550.38**	**54692.96**	**86249.38**	**31556.42**
Oil Palm + Cocoa	Pedavegi	11500.75	168704.00	242915.00	74211.00
Oil Palm + Cocoa	Denduluru	13581.00	156349.75	251840.00	95490.25
Oil Palm + Cocoa	K.Kota	12635.63	169696.00	255348.75	85652.75
Oil Palm + Cocoa	D.Tirumala	13852.50	135764.50	235906.25	100141.75
Oil Palm + Cocoa	J.R.Gudem	16250.75	189082.00	249025.00	59943.00
Oil Palm + Cocoa	T.Narasapuram	15515.90	161668.75	257376.25	95707.50
13 years		**13889.42**	**163544.17**	**248735.21**	**85191.04**
Coconut + Cocoa	Pedavegi	14735.00	139295.25	229912.50	90617.25
Coconut + Cocoa	Denduluru	15573.50	138833.00	246825.00	107992.00
Coconut + Cocoa	K.Kota	15174.50	152695.25	187922.50	35227.25
Coconut + Cocoa	D.Tirumala	15389.00	139045.75	207825.00	68779.25
Coconut + Cocoa	J.R.Gudem	12602.25	163271.75	251379.38	88107.63
Coconut + Cocoa	T.Narasapuram	6754.50	123200.00	244001.25	120801.25
26 years		**13371.46**	**142723.50**	**227977.60**	**85254.10**
C.D at (5%)		3015	13325	16693	21331
C.V(%)		22.7	9.2	7.3	25.4

*Gross Expenditure includes maintenance/ production costs + establishment cost

expenditure refers to the annual average costs of cultivating the cropping system for the average age of the cropping systems. Thus this gross expenditure reflects the total costs of a particular cropping system. Net returns obtained by deducting gross expenditure from gross returns.

Among the four cropping systems, the establishment cost was the lowest in coconut (Rs. 4550), while it was the highest in Oil Palm + Cocoa system (Rs. 13889). Similarly, the maintenance/ production cost for the average aged plantation was the lowest (Rs. 54693), while highest cost was in Oil Palm + Cocoa plantation (Rs. 163544). On the other hand the highest gross returns was in the case of Oil Palm + Cocoa (Rs. 248735) followed by Coconut + Cocoa, pure Oil Palm and Coconut pure stand. The net returns were the highest in Coconut + Cocoa system followed by Oil Palm + Cocoa system. Although highest gross returns were recorded in Oil Palm + Cocoa (Rs. 248735) cropping system, the net returns were not significantly different between Coconut + Cocoa (Rs. 85254) and Oil Palm + Cocoa (Rs. 85191) cropping systems. Amoah *et al*.,(1995) reported that 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 space at 8.7 m triangular.

ESTIMATES OF SUSTAINABILITY

The costs and returns are not the only measures to assess the profitability from investment made on oil palm orchards. Before selecting any enterprise, it is necessary to examine the viability and sustainability of that enterprise (Srilatha, 2015). There are several appraisal techniques for evaluating economic viability and sustainability of oil palm orchards. Among them, employment generation, net present value (NPV), benefit:cost ratio (BCR) and internal rate of return (IRR) were employed to evaluate economic feasibility of investment on oil palm orchards and sustainability of the cropping system with cocoa as intercrop. In the present study the costs and returns were discounted at 12% to estimate the net present value.

BENEFIT-COST RATIO:

A benefit-cost ratio (BCR)/Profitability Index Rate is an indicator, used in the formal discipline of cost-benefit analysis that attempts to summarize the overall value for money of a project or proposal. Cost of cultivation is significantly different from each other. Gross annual expenditure on mono-cropping of oil palm (Rs. 107947) is much higher than coconut (Rs.54693) cultivation. Similarly when oil palm is intercropped with

Table 5: Year wise income from different cropping systems (Rs./ha)

Age of the garden(Years)	Cropping System			
	Oil Palm	Oil Palm + Cocoa	Coconut	Coconut+Cocoa
0	-29464	-36595	-21329	-21383
1	-24065	-26818	-19418	-14210
2	-24095	-24828	-20048	-14601
3	-4733	-13265	-16888	-9161
4	3157	19357	28764	-2033
5	22296	60570	27380	-341
6	52504	80298	31394	11788
7	63712	98744	39934	20788
8	79097	98751	39460	29129
9	108807	117047	42284	41191
10	95749	90227	55223	38917
11	97487	80909	64156	43221
12	112202	87867	79880	46569
13	113688	88787	98931	44478
14	85017	79052	95805	60784
15	77661	93286	111945	58953
16	83421	96519	107539	68626

17	92683	79826	114173	67001
18	69663	86415	99040	65472
19	117530	71822	95418	66808
20	95140	66986	105738	62556
21		72354	70662	86814
22		100057	90391	76745
23		90854	99149	69462
24		166982	108371	91425
25		140614	121248	98359
26			145115	114786
27			153027	97331
28			157628	104464
29			229564	90527
30			187562	146797
31			276300	162330
32			574293	

cocoa the cost of expenditure was Rs.163544 as compared to coconut intercropped with cocoa (Rs..142724). Although the gross expenditure and gross returns were more in oil palm + cocoa cropping system compared to coconut+cocoa, the net returns did not differ significantly. This may be due to higher yield of cocoa in coconut (Table 2). Hence, the cost benefit ratio in different systems did not differ significantly (Table 6). B:C ratio was in the range of 1.51 to 2.21 in different cropping systems after taking into consideration of establishment cost. The benefit-cost ratios were 1.51, 2.21, 1.56 and 1.72 at 12 per cent discount rates in oil palm, coconut, oil palm+cocoa and coconut+cocoa cropping systems respectively proves that a rupee invested in oil palm orchard would fetch Rs.1.51 in mono-cropping of oil palm and Rs. 1.56 in oil palm+cocoa cropping system indicates the profitability and economic viability of oil palm cultivation.

NET PRESENT VALUE (NPV):

Net Present Value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows. NPV is used in capital budgeting to analyze the profitability of a projected investment or project. The data on NPV in different cropping systems shows that the NPV in oil palm + cocoa cropping system is higher (Rs.160237) than monocrop of oil palm (Rs.121873). While in coconut the NPV was recorded higher (Rs.197263) in monocrop of coconut than in coconut+cocoa (Rs.129058) at 12 per cent discount rate. The high positive net present worth at 12 per cent discount rate indicates its sustainability and viability for investment. Srilatha (2015) also reported that even at discount rate of 24 per cent, the oil palm cultivation was economically viable. This also indicates that oil palm+ cocoa cropping system is better than coconut + cocoa cropping system (Table 6).

INTERNAL RATE OF RETURN (IRR)

Internal rate of return is a metric used in capital budgeting measuring the profitability of potential investments. IRR is the value of the discount rate that makes the net present value (NPV) of all cash flows from a particular project equals to zero. Internal rate of return in different cropping systems under study also shows similar results as like NPV. Oil palm intercropped with cocoa recorded higher IRR (32%) than monocrop of oil palm (28%), while coconut intercropped with cocoa recorded lower IRR (26%) than monocrop of coconut (35%). This indicates that oil palm intercropped with cocoa is a better option for investment (Table 6). Further the IRR was found to be much higher than the bank rate of interest on long term loans and hence the oil palm and oil palm cocoa cropping systems are economically viable and sustainable. The IRR of 39.19 per cent was reported by Srilatha (2015) in monocropping of oil palm in Nellore District of Andhra Pradesh which is much higher than interest charged by banks on agricultural loans.

PAYBACK PERIOD

Payback period was in the range of 7.8 to 10.3 years in different cropping systems. In gardens of oil palm intercropped with cocoa, payback period was less (7.1 years) as compared to 10.3 years in coconut with cocoa.

Table 6.: Estimates of sustainability (@ 12% discount rate)

Crop		No. of Plants(ha)		Age (Years)		IRR (%)	NPV (Rs.)	B:C Ratio	Pay Back Period (Years)
		O.P/ CN	Cocoa	O.P/ CN	Cocoa				
Oil Palm	**Average**	142	NA	12	NA	28	121873	1.51	7.1
	Range	125-150	NA	8 to 21	NA	7 to 54	3227 - 235286	1.01 - 2.13	6 to 11
Coconut	**Average**	140	NA	22	NA	35	197263	2.21	9.0
	Range	125-150	NA	9 to 33	NA	13 to 61	15587 - 383647	1.07 - 3.89	5 to 17
Oil Palm	**Average**	139	378	13 6	32	160237	1.56	8.0	
+ Cocoa	**Range**	125-150	275-563	8 to 26	5 to 14	17 to 51	70068 -301306	1.21 - 2.08	6 to 14
Coconut	**Average**	134	445	26	8	26	129058	1.72	10.3
+ Cocoa	**Range**	125-150	250-625	11 to 32	5 to 14	16 to 41	60003 - 269926	1.22 - 2.66	7 to 15

Table 7: Employment generation in different cropping systems (man days)

System	Establishment stage (0 and 1st Year) (ha/year)	Annual maintenance (ha)	Harvesting, collection, transport etc. (ha/year)	Total Mandays
Oil palm	10	54	30	93
Coconut	9	72	16	81
Oil palm + Cocoa	81	126	224	431
Coconut + Cocoa	69	136	181	385

The results indicate that in oil palm + cocoa cropping system's payback the entire expenditure could be realised in about two years earlier than coconut+cocoa cropping system (Table 6). In the gardens wherever intercrop with cocoa has been planted between 1st and 8th year old oil palm (juvenile stage and yield stabilizing period) the yields of cocoa were comparatively low. However, the payback period did not get affected in oil palm and oil palm+cocoa cropping system because of stabilized FFB yields and prices of oil palm. In the gardens wherever the payback period of oil palm completed before planting cocoa as intercrop its payback period has been recorded as two years after planting the intercrop.

EMPLOYMENT GENERATION

Sustainability by definition means 'the use of natural resources or the application of a practice or technology in a manner in which the long-term net impact on natural resource is not negative'. The other common definition is 'the use of any resource by the next generation to the same degree as that of the present generation. Oil palm has been promoted as small holders irrigated crop in India. Mono-cropping of oil palm has been facing lot of up and downs during the last 25 years in India due to its unstable pricing pattern. Diversification of existing mono-cropping aims to provide the alternative avenues available for enhancing the income in a sustainable way. Since the oil palm canopy covers entire land area during adult stage, taking up of intercrop which is feasible under the shade is important. Further, Oil palm in India is dominated by small and marginal holders who constitute 59.5% of farm households and most of the high yielding oil palm plantations are owned by them. Availability of sufficient manpower within the family, capable of hard work, and full time devotion for farming are considered to be strengths of small farms in India. If these small holders get round the year employment in their gardens due to intercropping with suitable perennial crop in oil palm and get periodic income for their lively hood in a sustainable mode is a boon to oil palm farmers. Varghese and Nampothiri (1998) reported that under rainfed conditions labour requirement for maintenance of one hectare of oil palm requires 150 man days.

From the data it is clear that mono-cropping of oil palm generates less employment (93 man days) in a year than the gardens intercropped with cocoa (431 man

days). Similarly in coconut + cocoa system (385 man days) generated more employment than coconut (81 man days) mono-cropping (Table 7.). Further, oil palm+ cocoa creates employment round the year as oil palm and cocoa are being harvested periodically round the year.

LIGHT INFILTRATION IN DIFFERENT CROPPING SYSTEMS.

Solar energy utilization is high in oil palm due to its large canopy and the light falls on the ground is less than coconut palms. However, the amount of sunlight available for intercrops varies with the age of the palms. Solar radiation is not fully intercepted in oil palm and coconut at their juvenile phase and in the adult phase. Therefore intercrops can possibly utilizing the available sunlight effectively during juvenile stage and during adult stage of the palms.

Light infiltration data has been recorded in all the systems using quantum sensor. Light infiltration data in different cropping systems was recorded and they were in the range of 12.21% to 35.68%. It has been observed from the data that the light infiltration rate in adult oil palm plantations and coconut gardens are to the tune of 15 to 36%. During the peak bright period of the day 84.96% of the light has actually intercepted in oil palm as compared 64.32% in coconut. The remaining 15.06% in oil palm and 35.68% in coconut is available for the intercrop. In the oil palm+cocoa and coconut+cocoa cropping systems light infiltration above the canopy of cocoa was recorded as 17.26 and 29.04% respectively, indicates that the quantum of light infiltrate in coconut+cocoa cropping system is more than that in oil palm+cocoa cropping system(Table 8.). Although the spacing in oil palm (9m hexgonal) is more than in coconut (7.5m^2), the less infiltration rate in oil palm+cocoa cropping system may be due to larger canopy size and hexagonal method of planting in oil palm. Further, the light infiltration below the oil palm and coconut is less than in oil palm+cocoa(12.21%) and coconut+cocoa(16.34%) cropping systems (Table 9.). This may be due to inter crop with cocoa might have created congenial micro climate to oil palm and coconut to build up good canopy. Hence, the cocoa yields in coconut are higher than in oil palm due to availability of more sunlight to cocoa. Egbe and Adenikinju (1990) reported that heavy shade and root competition depressed the yields of cocoa intercropped

Table 8: Light interception in monocrop of oil palm and coconut

S.No.		Below oil palm	Below Coconut	Above Cocoa	
				Oil palm + Cocoa system	Coconut + Cocoa system
1.	Light interception (%) (10.30hrs – 13.30hrs)	15.06	35.68	17.26	29.04
2.	Open light (µ mol m^{-2} s^{-1})	1070.64	1069.67	1064.50	1058.70

Table 9: Light Infiltration in different cropping systems

Name of the Mandal	Cropping system											
	Oil Palm		Coconut		Oil Palm + Cocoa				Coconut + Cocoa			
	Open Light	Light Infiltration%	Open Light	Light Infiltration%	Open Light	Light Infiltration (%)			Open Light	Light Infiltration (%)		
	(µ mol m^{-2} s^{-1})	Below Oil Palm	(µ mol m^{-2} s^{-1})	Below Coconut	(µ mol m^{-2} s^{-1})	Above Cocoa	Below Cocoa	Below Oil Palm	(µ mol m^{-2} s^{-1})	Above Cocoa	Below Cocoa	Below Coconut
Pedavegi	1066.00	12.61	1018.45	38.57	1071.15	15.62	1.42	11.95	1031.95	22.56	2.07	15.27
Denduluru	1088.08	15.96	1097.60	27.18	1075.75	15.35	1.40	12.98	1046.90	23.08	1.51	17.50
K.Kota	1040.28	14.32	1050.15	32.69	1065.90	20.02	2.09	14.08	1109.38	33.49	2.09	14.32
D. Tirumala	1134.38	14.99	1090.80	26.36	1078.90	17.30	1.35	11.01	1068.70	26.82	1.39	16.97
J. Gudem	1045.35	11.20	1068.05	48.13	1038.43	17.06	2.63	10.07	1058.90	35.58	3.22	16.77
T. Narasapuram	1043.93	21.25	1098.78	41.14	1056.88	18.24	3.67	13.14	1036.40	32.71	2.80	17.20
Mean	1069.67	15.06	1070.64	35.68	1064.50	17.26	2.09	12.21	1058.70	29.04	2.18	16.34%

with *Cola nitida* or *Terminalia. ivorensis* compared with oil palm *(Elaeis guineensis*). *They recorded c*ocoa yields of 718 kg dry beans/ha when grown alone, 1199 kg when grown with oil palm, 611 and 699 kg when grown in single and double rows between *C. nitida* and 207 kg when grown between *T. ivorensis.* Although the amount of sunlight available for intercrops varies with the age of the palm, adult oil palm gardens (10 years old) could be effectively utilized for cultivation of cocoa as intercrop.

CONCLUSION

The present investigation on 'Oil Palm- Cocoa based cropping system for sustainable productivity' was conducted to study the effect of cocoa an intercrop in oil palm and cocoa yield, nutrient availability and estimate the benefit cost ratio of the system. Primary data on cost of cultivation, employment generation, economic yield and light infiltration in gardens of oil palm, coconut, oil palm+cocoa and coconut+cocoa cropping systems. Soil samples were collected and analysed for various soil characteristics. The data collected were subjected to conventional analysis and worked out costs and returns in different cropping systems. Discounted cash flow techniques viz., NPV, BCR and IRR were used to analyse the profitability and viability of oil palm orchards. From the data it was observed that only 22.4% of the soil mass is utilized by oil palm and the remaining 77.6% land could be utilized effectively for intercrop in oil palm and coconut palms. Mono-cropping of oil palm generates less employment (93 mandays) in a year than the gardens intercropped with cocoa (431mandays). Increasing trend of soil organic carbon was recorded in oil palm and coconut gardens intercropped with cocoa.

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