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# International Journal of Oil Palm

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REVIEW ARTICLE

# The oil extraction rate (OER) in relation to cultivation of oil palm in India - A Critical Review

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**ABSTRACT**

Palm oil will continue to dominate the vegetable oil scenario as a major source of edible, non edible and industrial vegetable oil in the country. For sustainable production of vegetable oils, the oil palm is best source to deliver. To meet the vegetable oil demand, India adopted two pronged strategies of cultivating oil palm which is the highest oil yielding crop and importing edible palm oil is the major share. Irrigated oil palm in India is grown in 16 states in an area of 3.31 lakh ha with imported and indigenous planting material producing about 3.0 lakhs tons of crude palm oil. There are about 26 processing units in the country with total processing capacity of 584 tons/hr. Average fresh fruit bunch (FFB) yield level ranges from 15 to 20 ton/ ha/ year under normal management conditions, whereas some progressive farmers are harvesting 30 to 40 t/ ha/ year. No doubt that oil palm is a paying crop to the farmers. The average OER percentage is near about 17.5. Many factors are involved in realizing low OER and it is difficult to comprehend them individually. An attempt was made to review the OER percentage in the major oil palm growing states of the country and possible ways and means to increase the OER are discussed in this article.

**Key words:** Oil palm, oil extraction rate, India, crude palm oil (CPO)

## INTRODUCTION

India is one of the major oilseeds growing, consuming, and importing country in the world. Oils play an important role in the Indian agricultural economy next to the food grains. The traditional oil seeds of our country *viz.,* groundnut, sesame, rape-seed, mustard, sunflower, safflower, soybean *etc.* are cultivated in an area of about 27 million ha in the country, could produce about 20.3 million tonnes of oil seeds with an average yield of 757 kg/ha (Rethinam, 2018). Vegetable oil consumption has increased considerably and resulted in continuous demand-supply-gap for edible oils which is being met by imports of vegetable oil to the level of 10.5 million tons and the demand will be 23.10 million metric tons Rethinam (2014). Having realised the efficiency of a high value perennial crop like oil palm which can produce one ton of crude palm oil in 0.22 ha of land; could give an average crude palm oil (CPO) yield of 4-6 t/ ha/ year and 0.4 to 0.6 t of palm kernel oil (PKO). The crop was introduced as irrigated small holder's crop in 1990[s] and demonstrations in farmers' fields and field performance in different states in small and marginal farmer's gardens have shown that oil palm can be successfully grown as an irrigated crop in the country.

A potential area of 19, 33,715 ha has been assessed suitable for cultivation of oil palm in 18 states of the country by a competent team constituted by Government of India. Reasonably good plantations established in the identified agro-climatic zones/ regions indicate the wide adaptability of the crop under irrigated conditions in India. There are also ample opportunities for raising inter/ mixed cropping at various stages of palm plantations.

## CURRENT AREA UNDER OIL PALM CULTIVATION IN DIFFERENT STATES

Oil palm was first commercially planted during the year 1960 in the forest lands of Kerala and later in Little Andaman Islands. Currently oil palm is grown in an area of 3, 17,161 ha in 14 states identified as an irrigated crop with largest area is in Andhra Pradesh. In

Kerala and Mizoram, it is largely grown as a rain-fed crop. In general, the planting material *viz.,* the tenera hybrids in the oil palm growing states has both indigenous genetic material sourced from the seed gardens in Andhra Pradesh, Kerala and Karnataka established by using the parental source available at Palode, besides the tenera sprouts imported from Costa de Rica, Papua New Guinea, IRHO and Thailand. The dura and pisifera imported from Nigeria during 1975 and nurtured at ICAR-CPCRI Regional Station, Palode formed the indigenous sources for production of tenera hybrids.

## TREND IN FFB PRODUCTION IN DIFFERENT STATES OF INDIA

### Andhra Pradesh (including Telangana)

Andhra Pradesh, the major oil palm belt in the country endowed with good soil and quality irrigation water, emerged as the most suitable environment for cultivation of oil palm in India under irrigated condition. Among the major soil groups of Andhra Pradesh, red soils (Alfisols) occupy 65 per cent of the area and oil palm cultivation is concentrated in these soil conditions. Andhra Pradesh receives heavy tropical rains during June to September and October. The summer months are spread over February, March through June. In this weather condition successful gardens are maintained by farmers yielding 25 to 30 t FFB/ ha. Recent estimates compiled by Rethinam (2018) for the years 2005-06 to 2015-16 indicated that the combined states of Andhra Pradesh and Telangana accounted for 1, 72,429 ha of oil palm cultivation, produce 89.16 % FFB yield in the country, out of a total production of 12,82,823 tons. The FFB is processed in 13 oil palm mills.

1) For judging the FFB production in the major oil palm growing state of Andhra Pradesh the data obtained from West Godavari district is presented in Fig 1.The data shows a regular trend in the yield depicting two cycles of production, the main cycle starting from May to October when 60 per cent of yields are received in the processing mills and another cycle from November to April.

With little variation, the trend in FFB yield between months and between years is similar and the yield progressively increased over years (Fig. 2). During this period the palm oil mills are activity linked to grading, processing and oil extraction from mesocarp and kernel incidentally producing large quantities of EFB, mesocarp fiber and palm oil mill effluent (POME).

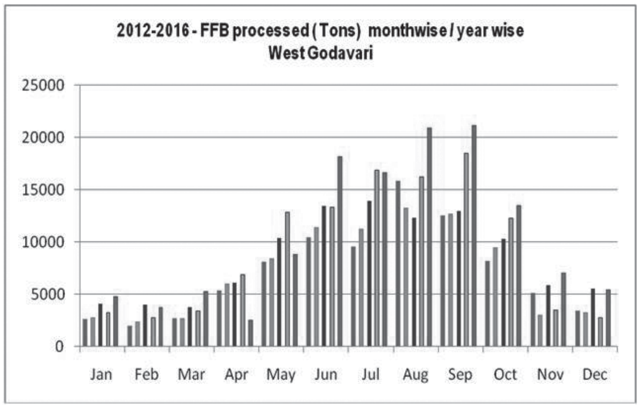


Fig.1: Trend in FFB receipts at different months during 2012-16 in West Godavari District, Andhra Pradesh (Y axis FFB in tons)

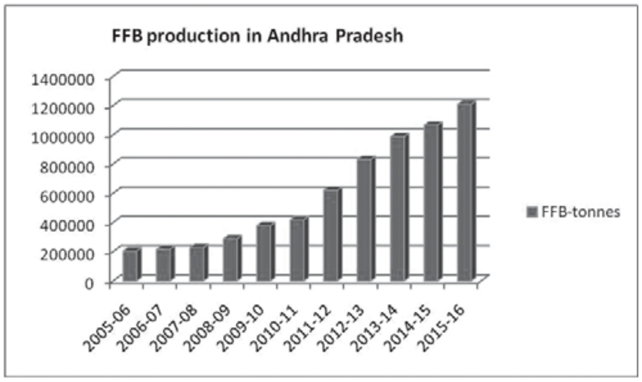


Fig. 2: Progressive increase in FFB yields in Andhra Pradesh

The variation in FFB yield of palms within a season and more pronounced between seasons is very much apparent in Andhra Pradesh plantations. Corley and Tinker (2003) suggested that such phenomenon is mainly due to fluctuation in bunch number which is determined many months before anthesis, long before the demand for assimilates become significant. During lean months of November to April, the bunch sink is reduced and the extra dry matter may be allowed / partitioned to vegetative dry matter production. Probably this may lead to more reserves of assimilates in the system which will influence the required energy for production of FFBs during the peak season. Since bunch production has been indicated as source limited, it is necessary that the palms may be fertilized adequately avoiding leaching losses in the rainy months especially in states which receive rains from south-west monsoon. Palms generally assumed to be irrigated based on Pan Evaporation data and considering the canopy radius.

Normally under good management, oil palm yield more or less stabilizes after 7th year of yielding and remains so with little variation up to 18-20 years and continues to yield unless otherwise replanted for obvious reasons. The FFB production increased over years due to (i) oil palm gardens planted earlier are maturing towards higher productivity and (ii) more newly planted gardens are entering to active reproductive phase.

**Tamil Nadu:** Currently oil palm is cultivated in 3374 hectares though the reassessed potential area is 2, 05,000 ha. Most of the oil palm plantation is raised on deep red soils classified as Inceptisols and Alfisols. The normal annual rainfall in Tamil Nadu is about 945 mm of which 48% is through the North East Monsoon and 32% through the South West Monsoon. The state is entirely dependent on rains for recharging its water resources; monsoon failures may lead to drought conditions. The pattern of FFB yields in Tamil Nadu agro-climatic conditions and seasonal variation in FFB yields is similar to that observed in Andhra Pradesh. The month of May to October can be considered as active FFB yielding phase in Tamil Nadu plantations also (Fig. 3).

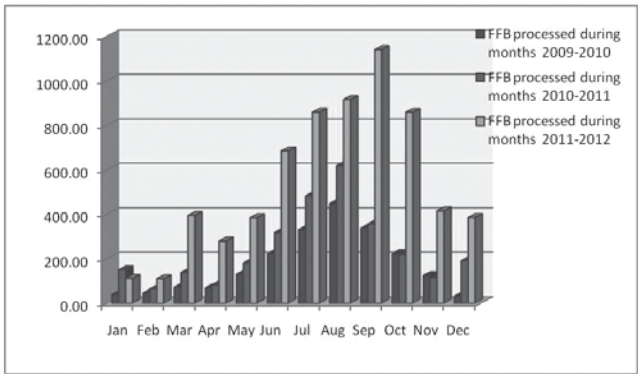


Fig. 3: FFB processed at different months during 009-10 to 2011-2012 in Tamil Nadu (Y axis FFB in Tons)

**Karnataka:** Karnataka has a history of planting oil palm with initiatives by the department officials on a commercial scale during 1990-91 under DBT and OPDP programme. Under a reassessed potential of 2, 60,000 ha, Karnataka has a planted an area of 50,156 ha (Rethinam, 2018). Karnataka is predominantly a red soil region and excellent plantations are raised in deep red soils. Karnataka has the FFB processing facility in four palm oil mills with the biggest facility is at Shimoga.

**Kerala:** Kerala, where oil palm is mostly under rain-fed conditions is managed by Oil Palm India Limited (OPIL) and United Oil Palm Planters and Extractors is cultivated in an area of 5, 776 ha out of 6, 500 ha potential area identified. Soils of Kerala are mostly acidic red soils classified as inceptisols and ultisols and support a good growth of palm plantation raised under rain-fed conditions. June to September receive the south west monsoon rains, leaving a dry period from October to May with occasional summer showers. Need based irrigation is a must for maintaining the productivity.

**Mizoram:** Oil palm cultivation started in Mizoram in the early 2000 and the present planted area is around 20,377 ha distributed in Kolasib, Lungle, lawngtlai, Mamit, Serchip, Aizwal and Saiha with assistance from ISOPOM, OPAE (RKVV) and NMOOP schemes. Mizoram is a mountainous track with highly acidic soils rich in available nitrogen and potash. Phosphorus appears to be the most limiting nutrient for growth. In general Mizoram hills receive an annual rainfall of 2500 mm concentrated in six months, leaving the rest of the period dry.

## OIL EXTRACTION RATE (OER) AND ITS ESTIMATION

The OER is a measure of efficiency of entire palm oil production process, which is expressed as a percentage of CPO (Crude Palm Oil) extracted to the total weight of FFB processed. It is considered as a critical measure of (i) the efficiency of field plantation in producing FFB with high O/B ratio (ii) harvesting it efficiently, and (iii) efficiency of the plantation mill. Chang (2003) expressed that OER is a management tool to assess the quantity of FFB processed for an area of planted oil palm. In determining oil to bunch ratio in the laboratory, a representative FFB is selected from the harvested produce and dissected to its various components such as fruit-lets, spike-lets, mesocarp, nut, kernel and stalk etc before each component is subjected to physical and chemical characteristics. Alverado and Sterling (1998) opined that the bunches processed at the mill are highly heterogeneous and those analyzed at the laboratory during the study were chosen for their homogeneity. They concluded from their five years study (1990 to 1995) that proportion of fruit to bunch is the main factor in the oil content per bunch.

The NIFOR method as described by Black et al. (1963) is reported to be in general use for nearly 40 years (Corley and Tinker 2003) though some variations are introduced for estimating parameters like wet mesocarp to fruit ratio (WM/F), dry mesocarp to wet mesocarp (DM/WM) followed by estimation of oil to dry mesocarp (O/DM). Oil to bunch (O/B) is calculated from O/B = (O/DM) x (DM/WM) x (WM/F). According to Chan (1981), oil loss from mill processing averaged about 8% of the oil recovered. A factor of

0.855 is routinely used by IRHO (Institut Recherche pour les Huile et Oleagineux) to account for field and mill losses when converting laboratory O/B to mill OER. Multiplying the O/B by 0.855 gave 19.3% OER which agreed closely with the mill estimates. The standard field manual gives a clear understanding of the procedures for oil extraction from oil palm bunches and a review of the methods was done by Rao et al. (1983). Nurul and Ismail (2010) employed near infra red (NIR) scanning spectrometer for quick determination of actual oil content in oil palm fruit bunch. Pamornnak et al. (2013) proposed a technique to determine oil extraction rate of palm fruit based on the dielectric constant measurement at microwave frequency. The technique can achieves accuracy of 95.63% for OER determination.

The major palm oil producing nation, Malaysia has reported variation in OER (19.7% compared to 20.2% in the previous year) and also indicated possible reasons for the same (Kushira et al. 2017). The average OER declined, mainly due to prolonged dry weather arising from *El Nino* effect causing inferior FFB quality. The OER in Peninsular Malaysia, Sabah and Sarawak declined by 2.8%, 2.4% and 0.2% to 19.21%, 20.60% and 19.98%, respectively. Reports on the performance of oil palm in Thailand indicated that while FFB yields per hectare and per year have increased significantly despite fluctuations over the last twenty years, the overall OER in Thailand decreased by more than 2% from 1990-1994 to 2005- 2009 (Source: unpublished data, OAE 2010). In Philippines, pricing of oil palm is highly dependent on the world market and current exchange rates. Local rates are guided by the pricing formula: (Jo Villanueva 2017; Sawit 2011): (A x B) +(C x D) - P750/MT x 85%. Some norms for OER and KER are proposed as guiding factors in price formulations. Where: A=selling price/t of CPO: B-the OER based on average OER in the mill or few new planting (based on ± 1 below provided the crop quality does not exceed the limit as indicated in schedule B). C= the selling price per ton of Kernels of VAT: D= the average Kernel Extraction Rate of KER. PORLA, Malaysia had given the basic extraction rate in Malaysia

**Table 1: The basic extraction rate for kernel based on the age of palm for tenera (DxP) progeny,Malaysia, (<3 to 18 years)**

| Age of palm | Peninsula | | Sabah/ Sarawak | |
|---|---|---|---|---|
| | Extraction rate | | Extraction rate | |
| | Oil (%) | Kernel (%) | Oil (%) | Kernel (%) |
| < 3 | 14-15 | 4.0-4.2 | 15-16 | 3.5-3.9 |
| 3-< 4 | 15-16 | 4.2-4.5 | 16-17 | 3.9-4.2 |
| 4-< 5 | 16-17 | 4.5-4.8 | 17-18 | 4.2-4.5 |
| 5-< 6 | 17-18 | 4.8-5.0 | 18-19 | 4.5-4.8 |
| 6-< 7 | 18-19 | 5.0-5.5 | 19-20 | 4.8-5.0 |
| 7-< 8 | 19-20 | 5.0-5.5 | 20-21 | 4.8-5.0 |
| 8-< 18 | 20 | 5.0-5.5 | 21 | 4.8-5.0 |
| 18 & above | 19-20 | 5.0-5.5 | 10-21 | 4.8-5.0 |

**Table 2: Basic extraction rate for kernel based on the age of palm for tenera (DxP) progeny, Malaysia (<5-25 years)**

| Bunch weight (kg) | Peninsula | | Sabah/ Sarawak | |
|---|---|---|---|---|
| | Extraction rate | | Extraction rate | |
| | Oil (%) | Kernel (%) | Oil (%) | Kernel (%) |
| < 5 | 14-15 | 4.0-4.2 | 15-16 | 3.5-3.9 |
| 5-< 6 | 15-16 | 4.2-4.5 | 16-17 | 3.9-4.2 |
| 6-< 7 | 16-17 | 4.5-4.8 | 17-18 | 4.2-4.5 |
| 7-< 8 | 17-18 | 4.8-5.0 | 18-19 | 4.5-4.8 |
| 8-< 9 | 18-19 | 5.0-5.5 | 19-20 | 4.8-5.0 |
| 9-<10 | 19-20 | 5.0-5.5 | 20-21 | 4.8-5.0 |
| 10-< 25 | 20 | 5.0-5.5 | 21 | 4.8-5.0 |
| 25 & above | 19-20 | 5.0-5.5 | 19-21 | 4.8-5.0 |

(Source: FFB grading manual, PORLA, Malaysia) given in table 1 and 2, indicated that with the age of the palm the bunch weight increase and the extraction rate is also increasing.

## THE OIL EXTRACTION RATE (OER) IN INDIAN OIL PALM PLANTATIONS

A brief account of OER obtained from the states of Andhra Pradesh, Karnataka, Kerala, and Mizoram is discussed below.

**Andhra Pradesh**: The monthly OER reported from palm oil mill in West Godavari district recorded for different months in 10 years from 2007-'08 to 2016-'17 was examined to study the pattern of yield and the OER realized over months and between years. The data can also be examined for the peak and lean season of FFB yield (Table 3, 4, 5 and Fig. 4).

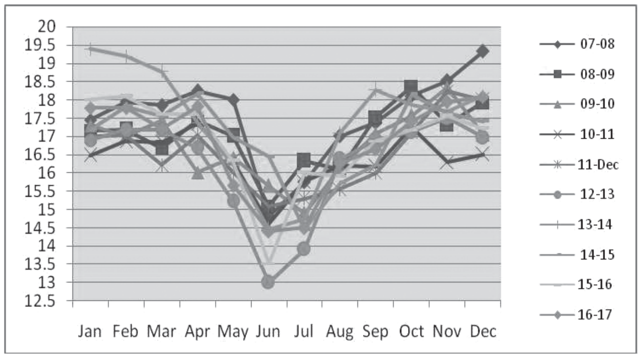


Fig. 4: Trend in OER % in different months of a year (2007-2008 to 2016-2017) West Godavari, A.P.

The trend in OER in a year over months is presented in Fig.4 clearly indicates seasonal variation in OER particularly a reduction in OER during the peak season of FFB yield. The 10 year data on OER realized in West Godavari oil palm plantations revealed the following

**Table 3: Pattern of OER realized over Ten years during Peak season of FFB yield.**

| Month/ year | 07-'08 | 08-09 | 09-10 | 10-11 | 11-12 | 12-13 | 13-14 | 14-15 | 15-16 | 16-17 | Average OER % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| May | 18.01 | 17.01 | 16.42 | 16.33 | 16.03 | 15.22 | 16.22 | 16.98 | 16.33 | 15.66 | 16.421 |
| Jun | 14.82 | 15.09 | 15.65 | 14.61 | 15.09 | 13.01 | 14.47 | 16.44 | 13.52 | 14.41 | 14.711 |
| Jul | 15.75 | 16.33 | 14.89 | 15.77 | 15.3 | 13.92 | 14.73 | 14.46 | 16.00 | 14.5 | 15.165 |
| Aug | 17.01 | 16.11 | 16.16 | 16.19 | 15.56 | 16.38 | 17.1 | 15.73 | 15.92 | 16.27 | 16.243 |
| Sep | 17.38 | 17.53 | 17.08 | 16.18 | 16.00 | 16.91 | 18.27 | 16.22 | 16.87 | 16.65 | 16.909 |
| Oct | 18.11 | 18.36 | 17.57 | 17.27 | 17.11 | 17.13 | 17.86 | 18.15 | 17.18 | 17.42 | 17.616 |
| Average | 16.847 | 16.74 | 16.295 | 16.0583 | 15.848 | 15.428 | 16.442 | 16.33 | 15.97 | 15.818 | 16.18 |

**Table 4: Pattern of OER realized over years during Lean season of FFB yield**

| Month/ year | 07-'08 | 08-09 | 09-10 | 10-11 | 11-12 | 12-13 | 13-14 | 14-15 | 15-16 | 16-17 | Average OER % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 17.45 | 17.95 | 17.15 | 17.3 | 16.48 | 17.00 | 16.90 | 19.39 | 17.19 | 18.01 | 17.48 |
| Feb | 17.45 | 17.95 | 17.19 | 17.01 | 16.87 | 17.04 | 17.17 | 19.19 | 17.82 | 18.09 | 17.58 |
| Mar | 17.85 | 17.85 | 17.01 | 17.44 | 16.83 | 16.22 | 16.68 | 18.77 | 17.55 | 17.6 | 17.34 |
| Apr | 18.25 | 18.25 | 16.87 | 16.02 | 17.35 | 17.02 | 18.17 | 17.38 | 18.17 | 17.62 | 17.58 |
| Sep | 17.28 | 17.53 | 17.04 | 16.18 | 16.00 | 16.91 | 16.87 | 16.22 | 16.87 | 16.65 | 16.87 |
| Oct | 18.11 | 18.36 | 17.17 | 17.27 | 17.11 | 17.13 | 17.18 | '18.15 | 17.18 | 17.42 | 17.65 |
| Nov | 18.52 | 17.33 | 19.19 | 17.27 | 18.23 | 17.5 | 17.56 | 17.64 | 17.56 | 17.95 | 17.80 |
| Dec | 19.33 | 17.93 | 18.09 | 16.51 | 18.00 | 16.97 | 17.21 | 17.42 | 17.21 | 18.08 | 17.66 |
| Average | 18.04 | 17.89 | 17.58 | 16.87 | 17.60 | 16.97 | 17.44 | 18.02 | 17.44 | 17.68 | 17.50 |

**Table 5: Difference in mean OER content during the lean period and Peak period of FFB Yield (2007-'08 to 2016-'17)**

| Sl. No. | Average OER | |
|---|---|---|
| 1 | Lean period : November to April | 17.50 |
| 2 | Peak period : May to October | 16.18 |
| 3 | Difference | 1.32 |

(i) seasonal variation in OER between peak and lean months of FFB yield to the tune of 1.32 % (Table 5) (ii) OER for the same month in different years varied from 14.711 to 17.66 and between years over months the OER was recorded as 16.39 to 17.53. (iii) The consolidated average for 10 years over months and years is recorded as 16.851 and (iv) The resultant variation in OER is below expectations under the given soil conditions, irrigation, nutrition and cultural management. (v) West Godavari plantations record low OER compared to East Godavari oil palm plantations (Fig 5). One of the reasons for low OER may be due to the fact that FFB from different age groups are processed and difference in the major soil groups on which oil palm is cultivated.

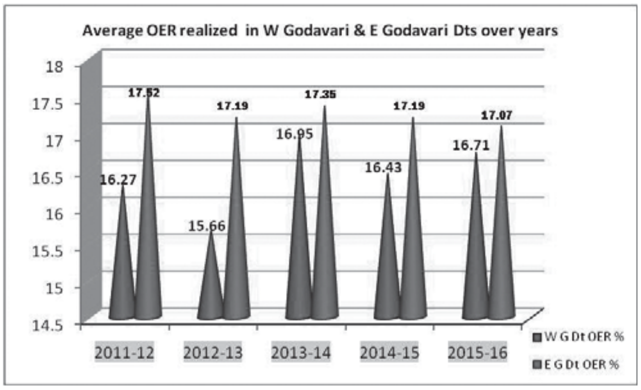


Fig.5: Difference in OER recorded between west and east Godavari plantations.

In the peak season of May to October when 65 to 70 of FFB yield of the plantation is produced, the average value of OER realized is 16.18. During the lean season of yield January to April (18.28%) and August to December (18.58%) the OER obtained is high. Corley and Tinker (2003) concluded that (i) there is seasonal variation in oil percentage and (ii) on the contrary to above findings they stated that fruits in the peak production months there is a tendency to have higher oil content than fruits from other times. In Andhra Pradesh, the peak FFB production periods also coincide with the rainy months during which period the sunshine hours in a day are between 4 and 5 hours in July, August, September compared to 8 hours/day during other months. A high load of fruit on the trees, under limited light conditions, may lead to a low amount of oil produced, which is then distributed among many bunches. Henson (1993) further added that more energy is needed to produce oil than carbohydrates, which imply that a high oil production cannot be compatible with a high bunch load in any particular palm. Nevertheless, the critical observation is that low OER coincides with peak season of FFB production. It is possible that the energy diverted for oil synthesis is diluted due to higher crop load. Probably this is the reason why even if FFB yields are increased, the OER did not show much increase than the regular values obtained in plantations. Hanif and Noor (2002) could not conclude on the reason that poor growth of inner fruits is caused by spatial limitations for development of mesocarp or a lack of assimilates as the reason for low OER.

**Tamil Nadu**: Available data on FFB yield and OER realized for the period 2009-10 to 2011-12 is presented in Table 6. The FFB yield gradually increased over years from 2009-10 to 2011-12 and the average OER realized

**Table 6: FFB received at the mill and the OER obtained during 2009-10 to 2011-'12 in Tamil Nadu.**

| | 2009-2010 | | 2010-2011 | | 2011-2012 | |
|---|---|---|---|---|---|---|
| Month | FFB | OER | FFB | OER | FFB | OER |
| Jan | 39.33 | 16.30 | 151.21 | 17.7 | 11.78 | 15.6 |
| Feb | 46.30 | 17.71 | 65.52 | 15.10 | 110.27 | 14.1 |
| Mar | 72.53 | 17.60 | 130.60 | 14.30 | 394.81 | 15.2 |
| Apr | 69.63 | 17.00 | 83.66 | 17.30 | 279.89 | 15.3 |
| May | 130.70 | 17.50 | 180.20 | 16.10 | 384.71 | 16.1 |
| Jun | 223.25 | 17.70 | 317.96 | 15.40 | 685.37 | 14.8 |
| July | 331.32 | 16.50 | 482.52 | 16.70 | 859.37 | 15.1 |
| Aug | 448.94 | 16.40 | 619.67 | 17.30 | 916.21 | 17.1 |
| Sep | 338.11 | 18.20 | 357.23 | 16.70 | 1141.02 | 17.6 |
| Oct | 222.88 | 20.20 | 218.28 | 17.90 | 859.18 | 17.0 |
| Nov | 124.65 | 18.40 | 113.74 | 16.00 | 415.76 | 15.3 |
| Dec | 31.94 | 17.75 | 191.41 | 16.90 | 385.39 | 18.4 |
| Total/Average* | 2079.57 | 17.61* | 2912.18 | 16.45* | 6443.76 | 15.97* |

varied from 16.30 to 20.20 between months during this period. There is an increase in the yield of FFB and consequently receipt of bunches in the mill, but the OER recorded over the months and years is erratic when compared between years and does not follow any trend (Fig 6, 7) as otherwise normally be expected. Earlier most of the seedlings raised from sprouts imported from ASD Costa de Rica were planted which has reported potential of 25 to 28 % OER. Recent plantings are with more of indigenous and less of exotic sources like Univanich (Thailand). It is to be noted that in all environments whether it is in Andhra Pradesh or Tamil Nadu there is an underlying yield cycle as also quoted by Corley and Tinker (2003) elsewhere.

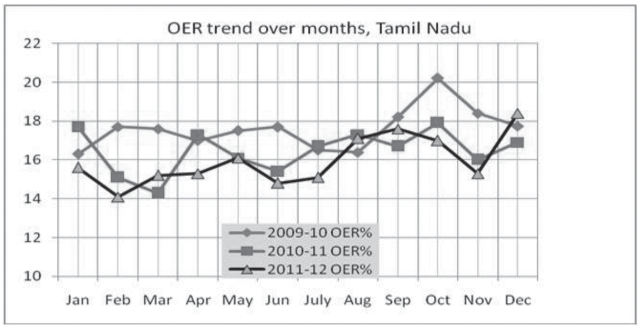


Fig. 6: Trend in OER at different months during 2009-10 to 2011-12in Tamil Nadu (Y axis OER %)

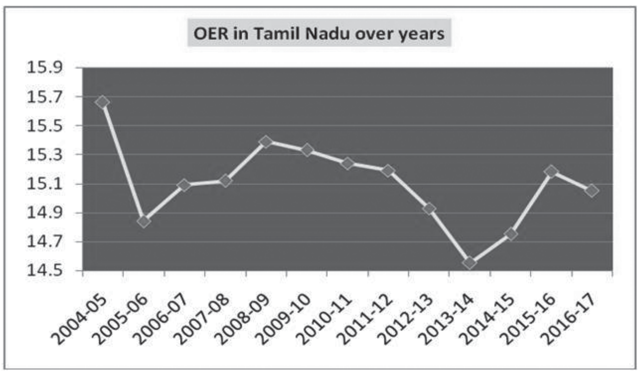


Fig 7: Yearly variation in OER in Tamil Nadu 2004-'05 to 2016-'17

**Karnataka:** The CPO production and OER realized for the years 1993-94 to 2001-02 was reported by Mary Rani and Sharma. Planted during 1990-1991; the OER reported for the year 1995-96 to 2001-'02 indicated that the average OER as 16.18 % (Table 7).

The available data of PAN-INDIA plantation in Karnataka ~~reported~~ for nine years 2009-10 to 2016-17 gives OER ranging from 19.30 to 17.50 with an average value of 18.00. The consistent results give an understanding that if the possible path ways that reduce the losses at plantation level and at the palm oil mill are controlled the OER can be maintained to a level of 20 to 21 per cent (Fig. 8).

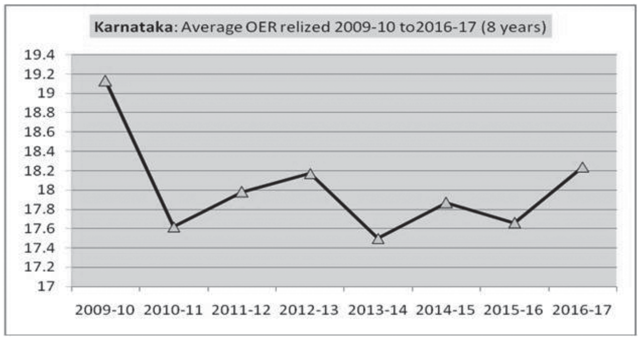


Fig. 8: Yearly variation in OER % in Karnataka 2009-'10 to 2016-'17

**Goa:** The OER recorded over 2003-04 to 2016-17varied from 16.15 to 18.07 with an average value of 16.814. The pattern of OER between years is depicted in (Fig.9). In Goa new oil palm plantations have not come up over the years as expected. The data from existing plantations indicated that as the age of the palms increased, the bunch weight has increased vis-à-vis the OER recovery especially from 2013-2014 onwards.

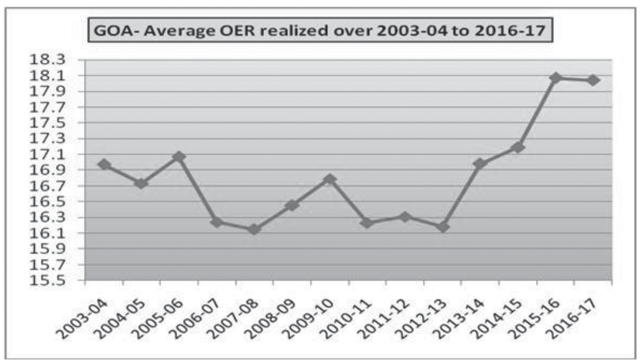


Fig. 9: Yearly variation in OER in Goa 2004-'05 to 2016-'17

**Table 7: CPO and OER realized during 1993-94 to 2001-02 in oil palm plantation in Karnataka**

| Year | CPO (MT) | OER % | Year | CPO (MT) | OER % |
|---|---|---|---|---|---|
| 1993-1994 | 28.92 | 12.18 | 1998-1999 | 535.51 | 16.00 |
| 1994-1995 | 163.85 | 13.68 | 1999-2000 | 738.76 | 16.10 |
| 1995-1996 | 347.91' | 16.23 | 2000-2001 | 643.99 | 16.10 |
| 1996-1997 | 432.35 | 16.22 | 2001-2002 | 573.58 | 16.10 |
| 1997-1998 | 561.25 | 16.49 | Average | 580.90 | 16.18 |

**Mizoram:** Mizoram is mountainous tract where oil palm is a recent introduction. The average OER realized over 2014-15 to 2016-17 is 15.17 (Fig 10).

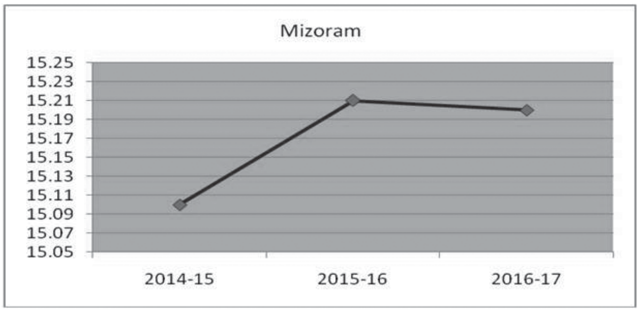


Fig. 10: Yearly variation in OER 2014-15 to 2016-'17.

The OER status for the year 2010-2011 to 2015-2016 was compiled for the state's growing oil palm (Table 8). For Andhra Pradesh, the premier oil palm growing state the OER % varied from 16.51 to 17.09 % for the period 2010-'11 to 2015-'16 with an average value of 16.82 %. For Telengana it was 16.91 % for 2014-15 and 2017-18. For Karnataka the average OER % for 2010-'11 to 2015-'16 barring 2013-'14 was 17.23 %. Tamil Nadu registered a six year average value of 15.68 %; Odisha 16.65 %, Kerala 16.65% and Goa 17.92 % for a five year period. Mizoram oil palm plantations the OER recorded 2014-15 to 2016-17 was 15.17. Considering all the above reporting it is realized that the OER % obtained in the Indian oil palm plantations is low and below expectations, is a matter of concern under given the technical guidance, promised OER at entry level of sprouts of both indigenous and exotic accessions (Table 12), irrigation, manuring and harvesting standards followed for the crop (Table 8).

The information in table 8 on average OER of oil palm plantations from eight states for the years 2010-11 to 2015-16 is discussed along with additional information on OER from oil palm growing states in the country. Earlier Rethinam (2014) compiled the FFB production from different states for the period 1992-93 to 2015-16 and the average OER was computed as 17.35 for the country. Data compiled for eight Oil palm growing states in the country indicate the average OER as 16.79. Taking into cognizance of the above information, the national average OER can be considered as 17.00%. The variation recorded in the data emerged from oil palm growing tracts in Andhra Pradesh, Tamil Nadu and Karnataka, the adopted agronomic interventions, gives an indication that there is ample scope to obtain OER to the extent of 20 to 21%. Considering the climatic setting for oil palm growth especially in Andhra Pradesh, Karnataka, Tamil Nadu, the favorable proven soil conditions and the management there is immense scope to improve the yield of FFB by 25 percent by adopting Better Management Practices (BMP) including the maturity/ harvest standards.

## CONCLUSION

Oil palm cultivation under irrigation promoted during 1986 has really given dividend to farmers by getting FFB yields from 15 to 40 tons / ha /yr depending upon the management adopted by the farmers. Oil Palm development in the country is interlinked that farmers produce raw material and processors extract oil. There is absolute necessity for increasing the OER which will benefit farmers, processors and to the country as a whole by increasing the production of palm oil. Increasing OER % is a complex process which includes the use of DxP seeds having high yield and OER, optimum input management of nutrient, water plant protection, harvest at appropriate maturity, following harvest and post harvest standards; adapting good processing technologies etc. The farmers need to be educated and trained not only in growing oil palm but also in

**Table 8: The OER % from the pooled data available for different oil palm growing states**

| S.No | State | 2010-11 | 2011-12 | 2012-13 | 2013-14 | 2014-15 | 2015-16 | Average OER |
|---|---|---|---|---|---|---|---|---|
| 1 | Andhra Pradesh | 16.51 | 17.09 | 16.87 | 16.77 | 16.85 | 16.84 | 16.82 |
| 2 | Karnataka | 17.5 | 17.50 | 17.5 | 12.51 | 17.21 | 16.43 | 16.44 |
| 3 | Tamil Nadu | 16.64 | 14.47 | 19.73 | 13.22 | 15.04 | 14.98 | 15.68 |
| 4 | Odisha | 16.98 | 16.99 | 16.99 | 16.75 | 15.56 | NA | 16.65 |
| 5 | Kerala | 16.83 | 17.36 | 16.39 | NA | 15.93 | NA | 16.63 |
| 6 | Goa | 17.51 | 17.67 | 18.40 | NA | 17.98 | 18.06 | 17.92 |
| 7 | Telangana | 16.51* | 17.09* | 16.87* | 16.77* | 17.29 | 16.54 | 16.91 |
| 8 | Mizoram | NA | NA | NA | 15.1 | 15.21 | 15.2 | 15.17 |
| | OER % | 16.99 | 16.84 | 17.64 | 14.81 | 16.55 | 16.75 | 16.79 |

maintaining soil productivity, adopting the harvest and maturity standards. India should have a mandate on oil palm cultivation with a target to increase the average FFB yields to 25 tons/ha adopting good agricultural practices (GAP). In general the national target for OER can be 22 % and it is achievable by gearing up government mechanism to implement the programme with effective coordination, guidance, training, demonstrations and above all with a fair price to FFB. The triangle of farmers-processors-government should work together and the goal can be achieved.

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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 + Cocoa** | **Average** | 139 | 378 | 13 6 | 32 | 160237 | 1.56 | 8.0 | |
| | **Range** | 125-150 | 275-563 | 8 to 26 | 5 to 14 | 17 to 51 | 70068 -301306 | 1.21 - 2.08 | 6 to 14 |
| **Coconut + Cocoa** | **Average** | 134 | 445 | 26 | 8 | 26 | 129058 | 1.72 | 10.3 |
| | **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 ($\mu$ 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 Infiltra-tion% | Open Light | Light Infiltra-tion% | Open Light | Light Infiltration (%) | | | Open Light | Light Infiltration (%) | | |
| | ($\mu$ mol m$^{-2}$ s$^{-1}$) | Below Oil Palm | ($\mu$ mol m$^{-2}$ s$^{-1}$) | Below Coconut | ($\mu$ mol m$^{-2}$ s$^{-1}$) | Above Cocoa | Below Cocoa | Below Oil Palm | ($\mu$ 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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RESEARCH ARTICLE

# An Understanding of fertilizer application to oil palm in India and projected yield of fresh fruit bunch (FFB) – A Note

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## ABSTRACT

The oil palm is the most productive crop in terms of oil yield per hectare and resource use efficiency. Oil palm is planted in a triangular system with a population of 143 palms per hectare. The juvenile phase of three years assumes importance as a large proportion of total costs apportioned to that palm-stand, during its life time has already been accrued. The uptake for potassium is high in the initial four years and then stabilizes. Under favorable environment for growth, production of FFB is expected to gradually increase and by the end of 7$^{th}$ year and around 1293 bunches are harvested with a mean bunch weight of 11.6 kg and a FFB yield of 15t/ha.

**Key words:** fertilizer, oil palm, India, FFB

## INTRODUCTION

Oil palm is now recognized as a viable alternative to meet a large extent of the growing edible oil demand in India. The oil palm is the most productive crop in terms of oil yield per hectare and resource use efficiency. Oil palm cultivation was started in 1986-87 as a small farmers' irrigated crop in the West Godavari district of Andhra Pradesh. Simultaneously four All India Coordinated Research Project centers on oil palm under the Indian Council of Agricultural Research (ICAR) were started, one each at Aduthurai (Tamil Nadu), Vijayarai (Andhra Pradesh), Gangavathi (Karnataka) and Mulde (Maharashtra). These centers served as testing grounds for regional adaptability of indigenous and exotic teneras of oil palm and to evaluate their yield potential under Indian agro-climate conditions, to define the nutrient (fertilizer) and irrigation requirement and agro-techniques for optimum yields.

## PLANTING AND FERTILIZERS

Oil palm is planted in a triangular system with a population of 143 palms per hectare. The recommended fertilizer schedule of N, P, K, Mg and B suggested for Indian conditions is given in Table 1.

Potassium, magnesium and boron requirement are commonly observed in view of the high demand and as they manifest in the form of typical symptoms and act as yield limiting nutrients. P deficiency is rare and other micronutrients as well. Mostly basin irrigation is practiced during the first year, at 40 liters/palm and during 2$^{nd}$ year, 80-90 liters / palm and later by micro-sprinklers to wet the nutrient applied circle around the palm. However, irrigation is practiced based on the pan evaporation data as per guidelines suggested. Organic manures are rarely applied. Under Indian conditions oil palm is grown mostly in red sandy loam soils (Alfisols, Inceptisols) besides alluvial soils and paddy growing soils and in black soils with good drainage.

## GROWTH AND NUTRIENT REQUIREMENT

The growth of the palm can be divided into (1) Nursery phase (10-12 months), (2) Immature (juvenile) phase 24-30 months; and (3) Production phase > 30 months. The immature phase lays foundation for a strong root system, leaf development and development of stem (girth) by storing of carbohydrates (assimilates) aided by ablation as a major activity in partitioning nutrients for growth and root development. It is mentioned that the juvenile phase of three years assumes importance as a large proportion of total costs apportioned to that palm-stand, during its life time has already been accrued. Therefore, to reduce or compromise on the maintenance standards especially

**Table 1: Fertilizer recommendation for oil palm**

| **Age of the palm** (years) | **Urea** | **SSP** | **MOP** |
|---|---|---|---|
| | (grams/palm/year) | | |
| 1st year | 870 | 1250 | 667 |
| 2nd year | 1740 | 2500 | 1333 |
| 3rd year onwards | 2100 | 3750 | 2000 |
| **with Di Ammonium Phosphate (DAP)** | | | |
| 1st year | 700 | 435 | 667 |
| 2nd year | 1400 | 870 | 1333 |
| 3rd year onwards | 2100 | 1305 | 2000 |
| **Urea** 46%N; **S.S.P** 16% $P_2O_5$; **DAP** 18 % N & 48 % $P_2O_5$ ; **M.O.P**. 60% $K_2O$ | | | |

Note: SSP: Single Super Phosphate; MOP: Muriate of Potash; DAP: Di Ammonium Phosphate

nutrition at this stage will never be economical at later stages.

Following field planting, under favorable conditions the palm establishes and develops a good root system. The nutrient demand is less in the first year (Table 1). This fertilizer dose is expected to enrich the rhizosphere to meet the growth demand which increases following ablation activities and influences the growth the trunk, besides serves as reserve and paving way for more uniform yield (Corley and Teo, 1976). Doubling the fertilizer dose in the second year of establishment is justified to aid the growth demand of the palms, though it appears to be in excess. The discussion of Ng (2002) on the exponential form of nutrient uptake supports the fertilizer prescription in the production phase of the oil palm starting from 3rd year. An analysis of fertilizer recommendation for oil palm in India is presented in the table 2, which holds good of the expected yield, yield components (bunches and weight of bunch), given by ASD Costa Rica.

At this stage bunch production is estimated to be around 500 gm, most of them are small, devoid of proper fruit set with an average bunch weight of 3 kg and around 1.5 tons of FFB / ha is harvested (Table 2). Many of these bunches may be rejected at the grading yard at the mill. Compared to the fertilizer input in three years *viz.,* 600.6 kg Urea, 373.26 kg DAP, 572.28 kg MOP, 125 .09 kg Mg $SO_4$ applied per hectare, the yield output is low indicating that most of the absorbed nutrients are consumed by growth demand partitioning the assimilates to build up vegetative dry matter related to high yield at later stage of development.

The steep ascent stage sets in the demand and uptake of nutrients is high synchronizing with the development of sufficient leaf area, root and trunk development for resource capture and building sufficient biomass (Ng, 2002). They also clearly indicated the uptake pattern of nutrients matching the demand in producing the yield. The yield plateau is also linked to the nutrient uptake. This is a period in growth where fertilizer prescription can be modified to improve yield of FFB or reduce nutrient application based on soil and leaf analysis.

The uptake for potassium is high in the initial four years and then stabilizes. The nitrogen uptake increases gradually followed by magnesium and phosphorus (Ng, 1977). From the small farmers' point of view under Indian conditions, this stage can be 'plantation care and build up stage' where the genetic potential of the planting material translates into yield of FFB. Some palms exhibit a good sex ratio with good number of FFBs and in some cases the sex ratio is low under the given conditions of agronomic management. No plausible reason has been attributed to this, but if a palm produces around 10 to 12 FFB it is considered as normal. However, Ng (1960) indicated that this may be due to improved mineral absorption without change in CHO status as might be occurring following fertilizer application in light limited situation should result in lower sex ratio.

## YIELD AND YIELD PARAMETERS

Under favorable environment for growth, production of FFB is expected to gradually increase and by the end of 7th year and around 1293 bunches are harvested with a mean bunch weight of 11.6 kg and a FFB yield of 15t/ha. This is firmly aided by the fertilizer the system received *viz.,* 2100 g Urea, 1305 g DAP and 2000 g MOP per palm besides Mg and B (Table 2). It is to mention here that the trunk is the obvious storage organ, because it constitutes about 50% of above ground biomass. Corley and Tinker (2003) reported that after about 10 years of planting the leaf area stops increasing and canopy size stabilizes.

From the 7th or more precisely 8th year onwards the yield is expected to be at steady state and thus entering a 'Care and Maintenance Phase' where the cultivator is expected to get maximum returns for the investment. This is the period of maximum activity of harvesting FFBs, maintaining optimum application of manures and irrigation schedules. Depending upon the season, the harvesting rounds vary between 10 and 15 days. During this period of 8th to 17th year, considering that the average yield is uniformly 18 t/ha, the system produces 9212 bunches with a yield of 18 ton FFB/ ha. Interestingly the average bunch weight increases from 13.8 kg in the 8th year to 23.1 kg in the 17th year. Bunch weight tends to increase with palm age as a result of an increase in bunch size which is influenced by number

**Table 2: Fertilizer input, yield components and yield of oil palm**

| Year | Urea (kg) | DAP (kg) | MOP (kg) | Mg $SO_4$ (kg) | Borax (kg) | Yield FFB tons /ha | No. of Bunches | Average weight (kg) |
|---|---|---|---|---|---|---|---|---|
| 1 | 100.1 | 62.21 | 95.38 | 17.87 | 3.58 | 0 | 0 | 0.0 |
| 2 | 200.2 | 124.42 | 190.76 | 35.74 | 7.16 | 0 | 0 | 0.0 |
| 3 | 300.3 | 186.63 | 286.14 | 71.48 | 10.74 | 1.5 | 500 | 3.0 |
| Total | **600.6** | **373.26** | **572.28** | **129.09** | **21.48** | **1.5** | **500** | **3.0** |
| 4 | 300.3 | 186.1 | 286.14 | 71.48 | 10.74 | 5.0 | 1220 | 4.1 |
| 5 | 300.3 | 186.1 | 286.14 | 71.48 | 10.74 | 8.0 | 1212 | 6.6 |
| 6 | 300.3 | 186.1 | 286.14 | 71.48 | 10.74 | 11.0 | 1209 | 9.1 |
| 7 | 300.3 | 186.1 | 286.14 | 71.48 | 10.74 | 15.0 | 1293 | 11.6 |
| **Total** | **1201.2** | **744.4** | **1144.56** | **125.09** | **42.96** | **39.0** | **4934** | **31.4** |
| Grand Total (7 years) | **1801.8** | **930.5** | **1716.84** | **254.18** | **64.44** | **40.5** | **5434** | **34.4** |
| 8 | 300.3 | 186.1 | 286.14 | 71.48 | 10.74 | 18.0 | 1304 | 13.8 |
| 9 | 300.3 | 186.1 | 286.14 | 71.48 | 10.74 | 18.0 | 1065 | 16.9 |
| 10 | 300.3 | 186.1 | 286.14 | 71.48 | 10.74 | 18.0 | 989 | 18.2 |
| 11 | 300.3 | 186.1 | 286.14 | 71.48 | 10.74 | 18.0 | 933 | 19.3 |
| 12 | 300.3 | 186.1 | 286.14 | 71.48 | 10.74 | 18.0 | 882 | 20.4 |
| 13 | 300.3 | 186.1 | 286.14 | 71.48 | 10.74 | 18.0 | 849 | 21.2 |
| 14 | 300.3 | 186.1 | 286.14 | 71.48 | 10.74 | 18.0 | 818 | 22.0 |
| 15 | 300.3 | 186.1 | 286.14 | 71.48 | 10.74 | 18.0 | 804 | 22.3 |
| 16 | 300.3 | 186.1 | 286.14 | 71.48 | 10.74 | 18.0 | 189 | 22.8 |
| 17 | 300.3 | 186.1 | 286.14 | 71.48 | 10.74 | 18.0 | 119 | 23.1 |
| **Total** | **3003** | **1861.0** | **2861.4** | **714.80** | **107.40** | **180.0** | **9212** | **200.0** |
| Grand Total (17 years) | **4804.8** | **2791.5** | **4578.4** | **998.98** | **171.84** | **220.5** | **14646** | **234.4** |
| 18 | 300.3 | 186.1 | 286.14 | 71.48 | 10.74 | 16.5 | 708 | 23.3 |
| 19 | 300.3 | 186.1 | 286.14 | 71.48 | 10.74 | 18.0 | 638 | 23.5 |
| **Total** | **600.6** | **372.2** | **572.28** | **142.96** | **21.48** | **34.5** | **1346** | **46.8** |
| **Total** | **5405.4** | **3163.7** | **5150.52** | **1268.77** | **193.32** | **255** | **15992** | **281.2** |

(Note: Yield of FFB, No. of bunches Average weight (kg) Source ASD Costa Rica) * Indian recommendation

**Table 3: A summary of fertilizer inputs (kg) and yield (tons) of oil palm.**

| Fertilizer consumption | Urea | DAP | MOP | Mg $SO_4$ | Borax |
|---|---|---|---|---|---|
| One palm (19 yrs) | 37.8 | 30.41 | 36 | 8.8 | 1.35 |
| 143 palms one ha (kg) | 5405.4 | 4350 | 5150 | 1269 | 194 |
| One ha (tons) | 5.4 | 4.4 | 5.2 | 1.3 | 0.0194 |
| One ha yield | 255 t FFB ; 15992 bunches (all size) ; average yield 13.4 t/15.02 t | | | | |

of developing bunches on the palm and the supply of carbon assimilates (Mohammed Hanif Harun, 2000). Mean number of bunches decreased over the same period. The fertilizer applied for the growth, buildup of the plantation and yield from planting to 17 years is 4.804 t urea, 2.997 t DAP, 4.578 t MOP besides 1.126 t Mg $SO_4$ and 172 kg borax. The average yield realized is 1.5 t/ha in the 3rd year, 9.5 tons/ha during 4th to 7th year, 18 tons / ha during 8th to 17th year and 17.25 t/ha during the declining phase of first two years (18 and 19th year). Several reasons are attributed to yield decline like substantial increase in non-photosynthesizing tissues compared to photosynthesizing tissue, limitation in dry matter production of palms due to inter-palm competition for light, height of the palm and difficulty to harvest etc.

Summarizing the data it can be realized that during a field period of 19 years one hectare of the plantation has received 5.4 tons of urea, 4.3 tons of DAP, 5.15 tons of MOP, 1.27 tons of Magnesium sulphate and 194 kg of borax (Table 3), besides an unaccounted amount of usufructs recycled in the system to harvest/produce 255.5 t/ha FFB accounting to 13.44 t FFB / palm in a year. If the active productive 17 years alone is considered, the average yield will be 15.03 t/ha, which is 107 kg/ palm. This indicates the importance of total inorganic nutrition to the system and more so adequate care during the active yielding phase where the yield gradually increases and even stabilizes.

## CONCLUSION

There is scope to reduce the fertilizer input in the system by analyzing nutrient export data in the harvested produce; frequency of fertilizer application to be properly judged considering the irrigation method /season; gaining experience from fertilizer trials in major oil palm growing belt in the country. Use of soil series data to extend yield gap analysis information. It is a monoceous species and irrigation is critical in getting desirable sex ratio/yields and both can be judiciously managed for yield maximization. As area expansion takes place, less productive lands will be brought under oil palm cultivation and integrated nutrient management and irrigation is important.

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RESEARCH ARTICLE

# Oil palm cultivation in waste lands with under-ground water potential –a successful pilot study in Odisha, India

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## ABSTRACT

Indian oil palm as a small holders' crop under irrigation, is grown successfully in varied soil and climatic conditions successfully. Yield levels ranging from 15 to 40 t fresh fruit bunch (FFB)/ ha / year was recorded depending upon the management conditions in the eleven states. About 2.0 m ha have been identified in 18 states for growing oil palm under supplementary irrigation. Besides, about 64 m ha wastelands are also available for identifying certain areas with the possibilities of tapping water sources exploiting underground water source, river through water harvesting . A Pilot study conducted in two districts of Odisha, showed a positive results which will go a long way in increasing the area under oil palm.

**Key words:** Odisha, fresh fruit bunch, oil palm, yield

## INTRODUCTION

Oil Palm, (*Elaeisguineensis* Jacq.), a perennial oil yielding crop, naturally found in Africa was successfully brought under commercial cultivation in Malaysia and Indonesia and later in many Asia –Pacific countries including India. Indian oil palm is unique which grew under supplementary irrigation with soil pH up to 8.5, and maximum temperature of more than $45^0$C during summer. Yield levels ranging from 15 to 40 t / ha/ year was recorded depending upon the management conditions of oil palm growing states in India. Highest FFB yield of 50 t/ ha was also recorded by a small holder in Karnataka. It is being cultivated as small holders' crop under supplementary irrigation in about 0.3 m ha planted in 12 states. India has a potential to grow oil palm almost 2.0 m ha under irrigation in the 18 states identified by expert committee (DOPR 2012; Rethinam 2013, 2016, 2019). Besides these, India is also having large area of waste lands with underground water potential. According to Ministry of Agriculture and JNU Department of Geography 1986 India has 175 m ha of waste lands. Odisha State where the oil palm cultivation is taken up in waste lands gives a new vistas that there is a scope for such area expansion for oil palm. Sometime back oil palm cultivation in waste lands was promoted under Oil Palm Development Project but discontinued since not much head way could be made. So, the Government discontinued oil palm planting in waste land.

## MATERIALS AND METHODS

### Waste lands in India

The Indian Council of Agricultural Research (ICAR) defined Waste lands as lands which due to neglect or due to degradation are not being utilized to their full potential. These can result from inherent or imposed disabilities or both, such as location, environment, chemical and physical properties, and even suffer from management conditions. According to integrated wasteland development programme, wasteland is a degraded land which can be brought under vegetative cover, with reasonable effort, and which is currently under utilized and land which is deteriorating for lack of appropriate water and soil management on account of natural causes. Waste lands are of different types like cultivable wastelands, and uncultivable wastelands**.** Odisha state has got 18,952.74 sq. km of waste lands of various types (Table 1). The waste lands not cultivated for large number of years with shrubs, small trees, rocky patches, heavy clayey soils belongs to private farmers.

**Table 1: Estimated Area under the Wastelands provided by different organization**

| Source | Area (m.ha.) |
|---|---|
| Ministry of Agriculture and the JNU, Deptt. Of Geography (1986) | 175 |
| National Land Use and Wasteland Development Council (First Meeting 1986) | 123 |
| Society for Promotion of Wasteland Development (1982) | 145 |
| Ministry of Rural Development & NRSA (2000) | 64 |

## OIL PALM IN THE WASTE LANDS OF ODISHA

Odisha state has got 18,952.74sq.km of waste lands of various types. The waste lands not cultivated for long number of years with shrubs, small trees, rocky patches, heavy clayey soils belonging to private farmers have been purchased by private companies were utilized for oil palm cultivation after clearing bushes, levelling partially and exploiting the under-ground water, rivers and nalas are given (Fig. 1).

**a) Preparation of land for Planting Oil Palm Seedling**

b) Aview of young plantaion

c) Oil palm with sunhemp in basin

d) Mulching the basin

**e)**

**f)**

**View of oil palm in rocky patch**

**g) Five year old Oil Palm plantation in Badliapara**

**(h&i) Harvesting FFB at Koska**

**j) Palm basin covered with plastic mulch**

**k) Water harvesting sources**

Irrigation sources River Pumping

Water harvesting structures

I **Bore well**

**PREPARATION OF LAND FOR PLANTING OIL PALM-PILOT STUDY**

Land clearing was made by following the norms of forest department leaving the tall trees and clearing the bushes and other small plants. After clearing the land, pits were taken using pot hole digger with 8.26 x 8.26 x 8.26 m spacing to accommodate 180 palms/ ha with oil palm from July 2011 to August, 2014 comprised of Ghana, Deli Dura planting material, imported from ASD Costa Rica. Wherever shallow soils are there, the pit size was increased to 9 $m^3$ and some times more than were also taken using proclainemachine to have wider pits. The pits were filled with top soil and planting was done at a depth of 20 to 30 cm using 35,583 seedlings in 12 plantation sites. The age of seedlings ranging from 13 to more than 24 months (Table2). After planting, basins were formed around the seedlings and sun hemp (*Crotoleriajuncia*), as green manure crop was added. This helped to prevent weed growth, to maintain microclimate in the root zone and also to protect from heavy wind besides adding bio mass to soil. Since the irrigation source was not ready at the time of planting in most of the plantations, pot watering was given for some months and then drip irrigation was installed for giving irrigation. Though the rainfall extends from June to October, the crop suffered during the months of April and May every year. Regular manuring was given in split doses and after two years of planting, fertigation was given with urea, Di ammonium phosphate and Muriate of potash. Manure dose of 2300 to 2600 g Urea, 1500 g DAP, 3000g MOP, 100g Boron, 500g Mg $SO_4$/ palm /year applied in split doses (Table 3).

Recently during the year 2017 polythene sheet mulching at the Palm basins and only one time application of annual dose of fertilizer comprising of 500to 1600of Urea, 100 to 800 of DAP, 1100 to 4500 of SOP, 100 to 200 of Boron, 5kg of vermin-compost and 25kg of FYM was applied before laying out polythene mulch and drip laterals were placed below the polythene sheet.The monsoon rainfall starts from June and extend up to September and in remaining months only scanty rainfall is received. The annual rainfall received in the two districts from 2014 to 2018 are given in table 4.Pollinating weevils were introduced at 2.5 years of planting. The flowering started at 18 to 20 months after planting, ablation was done till the age of 2 years and six months and the first harvest was made within 3 years. Regular harvesting was done at monthly intervals.

**Table 2: Details of oil palm planting in various sites**

| Sl. No. | Site | Company Name | District | No. of Plants | Planted Area | Source of Water | Month of Planting | 1st Harvesting |
|---|---|---|---|---|---|---|---|---|
| 1 | Anlapata | Nayagarh Agriculture Pvt.Ltd. | Nayagarh | 2933 | 40.74 | River | June'11 to August'12 | May'14 |
| | | Angul Oil Palm Ltd | Nayagarh | 1526 | 21.19 | River | June'11 to August'12 | May'14 |
| 2 | Koska | GaniaAgro Pvt. Ltd. | Nayagarh | 2723 | 37.82 | Canal | March'10 to June '13 | Apr'13 |
| | | Daspalla Agro Pvt.Ltd. | Nayagarh | 1440 | 20.00 | Canal | March'10 to June '13 | Apr'13 |
| 3 | Brundabanpur | Daspalla Oil Palm Pvt.Ltd. | Nayagarh | 1545 | 21.46 | WHS & Borewell | July' 2011 | May'14 |
| 4 | Gochhabari | Poibadi Agro Pvt. Ltd. | Nayagarh | 900 | 12.50 | WHS | July'2013 | Apr-17 |
| | | RanpurAgro Pvt. Ltd. | Nayagarh | 480 | 6.67 | WHS & Borewell | July'2014 | 16-Mar |
| 5 | Sankulei | KantamalAgro Pvt. Ltd. | Boudh | 2160 | 30.00 | Nala , Pond, Borewell | August'12 | March'16 |
| 6 | Thakurmunda | BanapurAgro Pvt. Ltd. | Boudh | 1916 | 26.61 | Nala | July'2014 | Aug' 17 |
| 7 | Bhabapur | SonepurAgro Pvt Ltd | Boudh | 2774 | 38.53 | Nala | July'2012 | July'15 |
| | | Madhusudanpur Agro Pvt. Ltd | Boudh | 692 | 9.61 | Nala | July'2012 | July'15 |
| 8 | Birapratapur | SikoAgro Pvt. Ltd. | Boudh | 1441 | 20.01 | Borewell | July' 2011 | May'14 |
| | | CharichakAgro Pvt Ltd | Boudh | 1310 | 18.19 | Borewell | July' 2011 | May'14 |
| 9 | Dihikupa | KuskaAgro Pvt. Ltd. | Boudh | 4298 | 59.69 | River | June'12 to Augst'13 | Aug' 15 |
| 10 | Kelakata | BolagarhAgro Pvt. Ltd. | Boudh | 1607 | 22.32 | Nala | June'13 | Sept'16 |
| 11 | Badaliapada | PadmapurAgro Pvt.Ltd. | Boudh | 1998 | 27.75 | WHS & Borewell | July' 2011 | May'14 |
| | | Madhapur Agro Pvt. Ltd. | Boudh | 1966 | 27.31 | WHS & Borewell | July' 2011 | May'14 |
| | | BhapurAgro Pvt. Ltd. | Boudh | 2594 | 36.03 | WHS & Borewell | July' 2011 to Augst 2014 | May'14 |
| 12 | Dumalapali | BadaliapadaAgroi Pvt. Ltd. | Boudh | 1280 | 17.78 | River | Sept'12 to Aust'14 | April'16 |
| Total | | | | 35583 | 494.21 | | | |

## Table 3: Annual dose of fertilizer application after three years.

| | | | | Dose of fertilizers applied | | | | | Dose of fertilizers appliedin 2016-17 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site | PS | Place | No of plants | Urea | DAP | MOP | Boron | Magnesium Sulphate | Urea | DAP | MOP | Boron | Magnesium Sulphate |
| Anlapata | 1 | | 1311 | 2600 | 1500 | 3000 | 100 | 500 | 2405 | 1391 | 2794 | 100 | 500 |
| | 2 | | 1175 | 3850 | 1500 | 3000 | 100 | 500 | 3760 | 1498 | 3010 | 100 | 500 |
| | 3 | | 1308 | 3220 | 1500 | 3000 | 100 | 500 | 2900 | 1391 | 2795 | 100 | 500 |
| | 4 | | 665 | 2600 | 1500 | 3000 | 100 | 500 | 2405 | 1284 | 2795 | 100 | 500 |
| | | | | 0 | 0 | 0 | | | | | | | |
| Koska | 1 | Second plot low area | 661 | 3850 | 1820 | 3000 | 100 | 500 | 3575 | 1667 | 2850 | 100 | 500 |
| | 1 | 1st plot | 280 | 2600 | 1500 | 3000 | 100 | 500 | 2590 | 1567 | 3010 | 100 | 500 |
| | 1 | Demo | 293 | 3220 | 1500 | 3780 | 100 | 500 | 3265 | 1498 | 3670 | 100 | 500 |
| | 2 | | 1179 | 2600 | 1500 | 3000 | 100 | 500 | 2220 | 1284 | 2580 | 100 | 500 |
| | 3 | | 982 | 2600 | 1500 | 3000 | 100 | 500 | 2590 | 1498 | 3010 | 100 | 500 |
| | 4 | | 768 | 3850 | 1500 | 3780 | 100 | 500 | 2475 | 963 | 2430 | 100 | 500 |
| Brundabanpur | 2 | | 994 | 2600 | 1500 | 3000 | 100 | 500 | 2205 | 1376 | 3075 | 100 | 400 |
| | 1 | Plastic Mulching | 360 | 2600 | 1500 | 3000 | 100 | 500 | 2600 | 1500 | 3000 | 100 | 400 |
| | 1 | | 191 | 2600 | 1820 | 3780 | 100 | 500 | 2030 | 1177 | 2365 | 100 | 400 |
| Gochhabri | 1 | | 900 | 2600 | 1500 | 3000 | 100 | 500 | 1110 | 646 | 1290 | 0 | 0 |
| | 2 | | 480 | 2600 | 1500 | 3000 | 100 | 500 | 1110 | 642 | 1290 | 0 | 0 |
| Poibadi | | | | 2600 | 1500 | 3000 | 100 | 500 | 2405 | 1365 | 2795 | 100 | 500 |
| Kelakata | 1 | | 463 | 2600 | 1500 | 3000 | 100 | 500 | 2405 | 1391 | 2795 | 100 | 500 |
| | 2 | | 557 | 2600 | 1500 | 3000 | 100 | 500 | 2960 | 1712 | 3440 | 100 | 500 |
| | 3 | | 340 | 2600 | 1820 | 3780 | 100 | 500 | 2035 | 1361 | 2970 | 100 | 500 |
| | 4 | | 247 | 2600 | 1500 | 3000 | 100 | 500 | 1295 | 749 | 1280 | 50 | 250 |
| Dumalapali | 1 | | 200 | 2600 | 1500 | 3780 | 100 | 500 | 2590 | 1498 | 3555 | 100 | 500 |
| | 2 | | 810 | 2600 | 1500 | 3780 | 100 | 500 | 2590 | 1498 | 3505 | 100 | 500 |
| | 2 | Entry area ( A & B) | 187 | 2600 | 1500 | 3000 | 100 | 500 | 2590 | 1498 | 3505 | 100 | 500 |
| | 3 | | 83 | 2600 | 1500 | 3000 | 100 | 500 | 2590 | 1498 | 3335 | 100 | 500 |
| Badaliapada | 1 | | 909 | 2600 | 1500 | 3000 | 100 | 500 | 2590 | 1498 | 3010 | 100 | 500 |
| | 2 | | 424 | 2600 | 1820 | 3000 | 100 | 500 | 2590 | 1774 | 3010 | 100 | 500 |
| | 3 | | 665 | 2600 | 1500 | 3000 | 100 | 500 | 2590 | 1498 | 3010 | 100 | 500 |
| | 4 | | 679 | 2600 | 1500 | 3000 | 100 | 500 | 2590 | 1498 | 3010 | 100 | 500 |
| | 5 | | 1104 | 2600 | 1500 | 3000 | 100 | 500 | 2590 | 1498 | 3010 | 100 | 500 |
| | 6 | | 432 | 2600 | 1500 | 3000 | 100 | 500 | 2220 | 1284 | 2580 | 100 | 500 |
| | 7 | | 512 | 2600 | 1500 | 3000 | 100 | 500 | 1233 | 713 | 1433 | 100 | 500 |
| | 8 | | 570 | 2600 | 1500 | 3000 | 100 | 500 | 2590 | 1498 | 3010 | 100 | 500 |
| | 9 | | 809 | 2600 | 1820 | 3000 | 100 | 500 | 2590 | 1567 | 3010 | 100 | 500 |
| | 10 | | 454 | 2600 | 1500 | 3000 | 100 | 500 | 2590 | 1498 | 3010 | 100 | 500 |
| Sankulei | 1 | | 710 | 2600 | 1500 | 3000 | 100 | 500 | 1665 | 963 | 1935 | 100 | 500 |
| | 2 | | 1040 | 3850 | 1500 | 3000 | 100 | 500 | 1850 | 1070 | 2150 | 100 | 500 |
| | 3 | | 410 | 2600 | 1500 | 3000 | 100 | 500 | 1850 | 1070 | 2150 | 100 | 500 |
| Birapratappur | 3 | | 729 | 2600 | 1500 | 3000 | 100 | 500 | 2220 | 1284 | 2580 | 100 | 500 |
| | 4 | | 581 | 2600 | 1500 | 3000 | 100 | 500 | 2220 | 1284 | 2580 | 100 | 500 |
| | 5 | | 310 | 2600 | 1500 | 3780 | 100 | 500 | 2590 | 1498 | 3450 | 100 | 500 |
| | 6 | | 880 | 2600 | 1500 | 3780 | 100 | 500 | 1480 | 856 | 2105 | 100 | 500 |
| | 7 | | 251 | 2600 | 1500 | 3000 | 100 | 500 | 2405 | 1391 | 2795 | 100 | 500 |
| Bhabapur | 1 | | 901 | 2600 | 1820 | 3000 | 100 | 500 | 2220 | 1514 | 2365 | 100 | 500 |
| | 2 | | 808 | 2600 | 1500 | 3000 | 100 | 500 | 2220 | 1605 | 1935 | 100 | 500 |
| | 3 | | 815 | 2600 | 1500 | 3000 | 100 | 500 | 1665 | 963 | 1935 | 100 | 500 |
| | 4 | | 942 | 2600 | 1820 | 3780 | 100 | 500 | 1665 | 1170 | 1620 | 100 | 500 |
| Dihakupa | 1 | | 886 | 2600 | 1500 | 3000 | 100 | 500 | 1480 | 856 | 1720 | 50 | 250 |
| | 2 | | 1194 | 2600 | 1500 | 3000 | 100 | 500 | 1110 | 642 | 1290 | 0 | 0 |
| | 3 | | 801 | 2600 | 1500 | 3000 | 100 | 500 | 1480 | 856 | 1720 | 100 | 500 |
| | 4 | | 600 | 2600 | 1500 | 3000 | 100 | 500 | 1850 | 1070 | 1290 | 100 | 500 |
| | | | 817 | 2600 | 1500 | 3000 | 100 | 500 | 1295 | 749 | 645 | 100 | 500 |
| Thakurmunda | 1 | | 437 | 2600 | 1500 | 3000 | 100 | 500 | 1850 | 1070 | 2290 | 100 | 500 |
| | 2 | | 895 | 2600 | 1500 | 3000 | 100 | 500 | 2220 | 1284 | 2935 | 50 | 250 |
| | 3 | | 684 | 2600 | 1500 | 3000 | 100 | 500 | 1665 | 963 | 1935 | 50 | 250 |
| | | | 35583 | | | | | | | | | | |

**Table 4: Annual Rainfall in the selected Districts**

| Year | Nayagarh | Boudha |
|---|---|---|
| 2014 | 1405.9 | 1706.7 |
| 2015 | 1127.0 | 1072.5 |
| 2016 | 1148.2 | 1133.8 |
| 2017 | 1195.0 | 1154.1 |
| 2018 | 1437.3 | 1627.9 |

## RESULTS AND DISCUSSION

### Initial performance of Oil Palm in Captive plantations in waste lands

Though these plantations were taken with aged seedlings, and some seedling were repeatedly pruned to reduce the seedling growth and planted, pot watering of about 10 liters/plant was given once in 2 or 3 days interval immediately after planting and 100 l/day/palm once in 2 or 3 days to the young planting when the drip was installed, the vegetative growth of the palm was generally good with more number of leaves, flowers and fruit bunches and average bunch weight ranging from 5.0 to 8.0 kg. When water is not adequate more of male flowers were seen.If adequate irrigation water is given to these palms regularly the FFB yield level would easily reach 15 to 18 t/ha/year. The month wise yield pattern of two big plantations is given in Figure 1 and 2. The pattern of yield is very similar in both plantations which is also similar to that of irrigated oil palm in the cultivable land in the state.

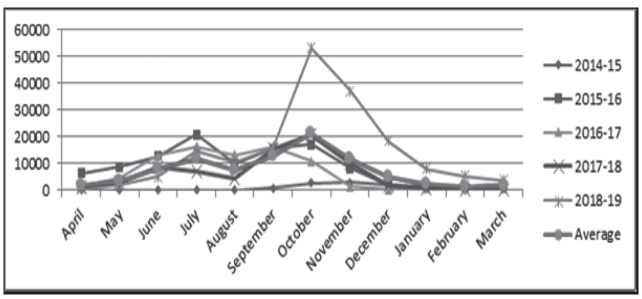


Fig. 1: Month wise yield pattern of Badaliapada plantation (in kg)

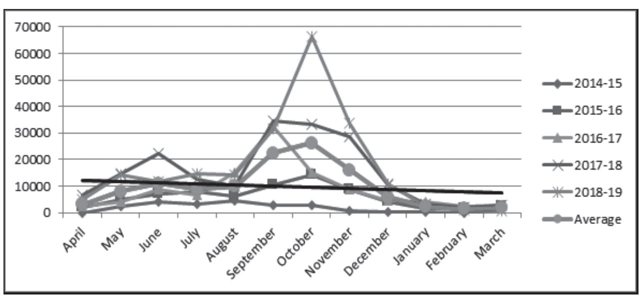


Fig.2: Month wise yield pattern of Anlapata plantation (in kg)

Though 12 plantations were planted in 12 locations, only four major locations *viz* Anlapata, Koska. Badaliapara and Birpratappur were discussed here under representing two soil types The first two were in light textured soils and the other two are black soils. The results obtained on bunch number, bunch weight and yield are presented in table 5, 6, 7 and 8.

In all the locations there is a general increase in bunch numbers, bunch weight and yield over the years. Since the crop had suffereddue to lack of moisture in some years, low FFB yields were recorded. Failure of monsoon and dropping of water table resulted in short supply of water to the palm.

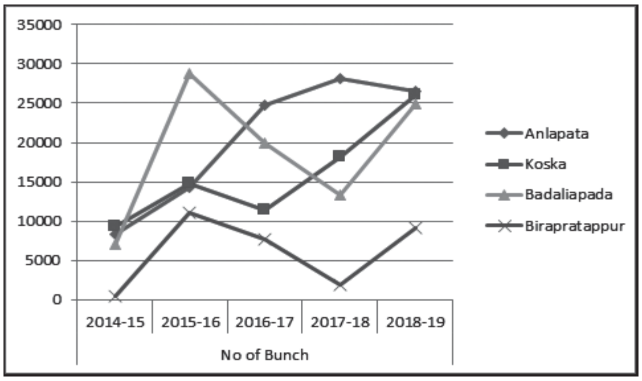


Fig. 3: Number of bunches in four plantations

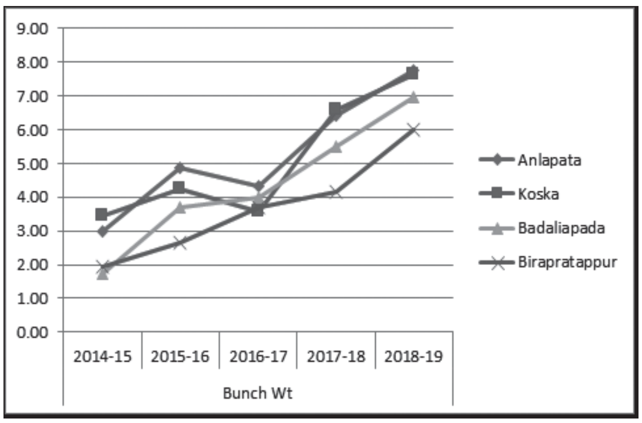


Fig. 4: Bunch Weight in four plantations ( in Kg)

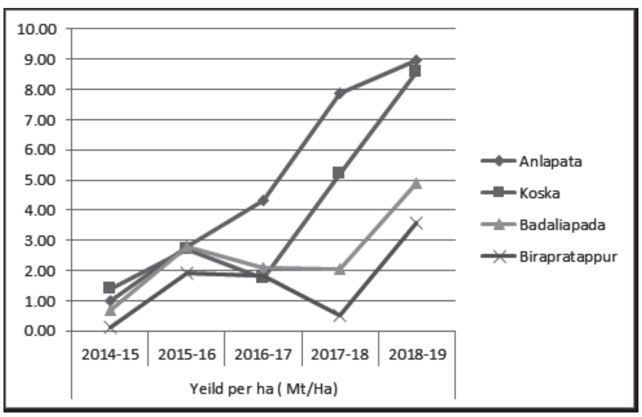


Fig.5: Yield per ha in four Plantations

**Table 5: Number of bunches harvested in four plantations over years**

| Place | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 |
|---|---|---|---|---|---|
| Anlapata | 8365 | 14304 | 24771 | 28093 | 26577 |
| Koska | 9260 | 14707 | 11411 | 18202 | 25990 |
| Badaliapada | 6972 | 28779 | 19892 | 13402 | 24976 |
| Birapratappur | 395 | 11105 | 7670 | 1920 | 9095 |

**Table 6: Bunch Weight (kg) in four plantations over years**

| Place | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 |
|---|---|---|---|---|---|
| Anlapata | 2.97 | 4.86 | 4.31 | 6.44 | 7.75 |
| Koska | 3.45 | 4.23 | 3.57 | 6.60 | 7.62 |
| Badaliapada | 1.72 | 3.70 | 4.01 | 5.50 | 6.98 |
| Birapratappur | 1.95 | 2.65 | 3.69 | 4.14 | 5.98 |

**Table 7: Yield (mt/ ha) in four plantations over years**

| Place | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 |
|---|---|---|---|---|---|
| Anlapata | 1.00 | 2.81 | 4.31 | 7.86 | 8.95 |
| Koska | 1.38 | 2.69 | 1.76 | 5.19 | 8.57 |
| Badaliapada | 0.68 | 2.79 | 2.09 | 2.07 | 4.90 |
| Birapratappur | 0.11 | 1.93 | 1.85 | 0.52 | 3.59 |

**Table 8: FFB harvested in four plantations over year**

| Place | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 |
|---|---|---|---|---|---|
| Anlapata | 24815 | 69548 | 106709 | 180811 | 205879 |
| Koska | 31967 | 62260 | 40751 | 120120 | 198170 |
| Badaliapada | 11971 | 106493 | 79700 | 73676 | 174338 |
| Birapratappur | 770 | 29483 | 28284 | 7946 | 54390 |

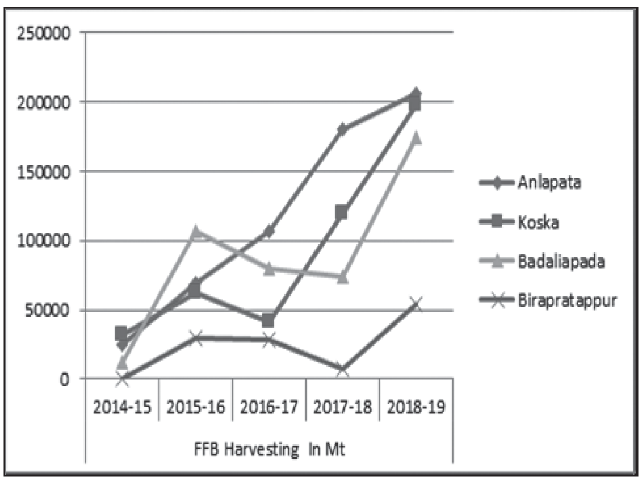


Fig. 6: FFB Harvested in four plantations

## CONCLUSION

The present pilot study has clearly indicates that oil palm in wastelands with supplementary irrigation comes to flowering in 18 months after planting and showed increasing trend terms of bunch number, bunch weight, harvested and FFB yield over years.

Oil Palm in wastelands with irrigation by tapping the ground water sources, through open wells and tube wells; digging water harvesting structures to store the rain water, and pumping water from rivers and nalasis possible to get fairly good yields if adequately irrigated. Wherever thereis water deficit, the bunch number, bunch weight and in turn the FFBharvested and yield reduction were observed . However, the general trend of harvesting from third year recorded increase in number of bunches; bunch weight and FFB yield over the years are quite encouraging.

A systematic pilot study with 1000 to 2000 ha of waste lands with identified assured underground water source in the respective states either allotted to a group of farmers to grow oil palm with the involvement of Processors operating in the respective areas or allotted the land to the processors on long term lease basis to start with and then extend the cultivation to 4.0 to 5.0 m ha of waste lands in the 18 potential states for oil palm, it would be possible to produce 10 to 15 million tons of palm oil and 1.0 to 1.5 m tons of palm kernel oil per year additionally from waste lands and that will go a long way to increase the total palm oil pool which will a long way in increasing the vegetable oil pool in the country.

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RESEARCH ARTICLE

# Methodology for rearing leaf webworm, *Acria meyricki* Shashank and Ramamurthy (Lepidoptera: Depressariidae): A serious defoliator of oil palm

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## ABSTRACT

A simple methodology is described for rearing the successive generations of *Acria meyricki* Shashank and Ramamurthy (Lepidoptera: Depressariidae) in the laboratory. All the components are commercially available and the diet is principally of plant origin. Use of blotting paper smeared with non-absorbent cotton encouraged ovi-position by the adults and allowed easy egg collection. Adults laid eggs with 80.0-95.0 % viability. The ideal conditions for egg laying were 26±0.5°C constant temperature and 55.0-60.0 per cent relative humidity. The survival rate of larvae was ranging from 75.0 to 90.0 per cent and pupa to adult emergence was 100.0 per cent, which resulted in feasible mass rearing process. This is the first report of insect rearing technique for this pest. Suggestions and future applications are indicated.

**Key words**: Leaf webworm, *Acria meyricki*, Insect rearing technique, Oil palm

Oil palm (*Elaeis guineensis* Jacquin: Arecaceae) is an important vegetable oil crop with a capacity of 4-6 tonnes of oil per hectare per year. The introduction of oil palm in different states of India was followed by the attack of native insect species, which became pests on oil palm. Many pests found on oil palms are specific pests of several species of wild palms. Oil palm shared some pests with already established crops like coconut (*Cocos nusifera* L.), areca nut (*Areca catechu*) and palmyrah, *Borassus flabellifer* L. (Kalidas 2004; Kalidas et al. 2006). However, level of damage is varied among them. There are at least 80 species of arthropods are associated with oil palm and many are potential pests and some are serious and inflicting heavy damage on oil palms in India (Dhileepan 1991, 1992; Ponnamma, Biju 1997; Kalidas et al. 2006, 2011; Shashank et al. 2015).

Among the insect pests, defoliators are important pests of oil palm throughout the world causing heavy yield losses (Norman, Basri 2007; Cheong et al. 2010; Martinez et al. 2013). In addition to the known lepidopteran defoliators of oil palm in the World, a new species, *Acria meyricki* Shashank and Ramamurthy (Lepidoptera: Depressariidae) is described from Andhra Pradesh, India on oil palm for the first time (Shashank et al. 2015). The pest is commonly called as oil palm leaf webworm, as the larvae is characterized by constructing white silken web on the leaf and remain inside the web defoliating the leaves.

The pest has become endemic in some of the areas. The infestation is in the range of 80.0-100.0 % in some plantations. In coastal Andhra Pradesh, India, defoliation caused by *Acria meyricki* resulted to the yield losses of 29.0% in the first year, 31.0% in the second year and 21.0% in the consequent year (Kalidas 2004). The occurrence is normally restricted to cooler months of the year (October to March). This pest is occurring regularly, seasonally in the recent years and causing severe damage. Therefore, various research strategies have to be developed in order to develop pest management programme in the field. Hence, it is desirable or necessary to facilitate both basic and applied research. In order to achieve this, practical mass rearing technique is necessary.

*A.meyricki* culture was established in the laboratory, from the larvae and pupae collected in oil palm plantations located in West Godavari District, Andhra Pradesh, India. The larvae were maintained on oil palm leaves. Newly emerged adults were sexed following the guidelines given by Shashank et al. (2015) and were paired. Around 5-10 pairs were confined to transparent plastic jars of 20 x 10 cm (Fig. 1A). A piece of blotting paper was smeared with thin layer of non-absorbent cotton on both sides ( Fig. 1B) and was placed in slanting position without a bent in the plastic mating jar having perforations. Blotting paper with non-absorbent cotton served as substrate for egg laying. The adults were provided with 50 per cent honey fortified with few drops of multivitamin syrup.

The set up were maintained at 26±0.5°C constant temperature and 55.0-60.0 per cent relative humidity in Biological Oxygen Demand incubator. The adults laid eggs after one or two days on and in between cotton fibres. Blotting strips having loaded with eggs were cut into smaller strips (6 x 2 cm). And they were loosely sand witched between fresh nursery oil palm leaf bits in smaller specimen tubes (Fig. 1C and D). Eggs hatched in about six to seven days with 80.0-95.0 % viability. The newly hatched larvae would move from the cotton fibre strips and start feeding on oil palm leaf bits. Fresh leaf bits were provided as and when required for about a week. While providing fresh leaf bits, care was taken, not to disturb the larvae feeding inside the silken web. It is natural for the larvae to leave the leaf bits which lost turgidity and feed on the fresh ones kept along side of the old ones.

Fig. 1. Rearing technique of *A.meyricki* (A) Mating Jar with egg laying substrate; (B) Blotting paper smeared with non-absorbent cotton; (C) Blotting paper strips loaded with eggs along with oil palm leaf bits; (D) Rearing set up for early instar larvae.

When the larvae reach second or third instar stage, they were shifted to transparent perforated plastic jars (15 x 10 cm) having oil palm leaf bits. The bottom and side of the jars were lined with blotting paper, moistened regularly to maintain the turgidity of the leaves. Fresh leaf bits were provided to the larvae regularly until pupation. The caterpillars developed in 20-25 days with 75.0 to 90.0 per cent survival and pupated within the larval webs.

The pupae were collected along with larval webs and maintained, in a small container. This stage lasted for 4-6 days. The survival from pupa to adult was 100.0 per cent. After emergence, the adults were introduced in mating jars to begin a new cycle. This technique was standardized after conducting a series of experiments to know the substrate for egg laying by adults using different substrates.

It was found that the adults preferred to lay eggs on the old larval webs. Hence, this pest is a seasonal pest, and thereby, availability of larval webs is constraint during off season, non-absorbent cotton was smeared on blotting paper to simulate for egg laying. It was found that adults successfully laid eggs on this substrate. This made the rearing process simple and continuous. Still there is scope to rear this insect on artificial diet with some modifications.

This rearing methodology can be used to mass rear *A. meyricki* larvae in the laboratory successfully. Such reared insect colonies can be used for testing efficacy of chemical and botanical pesticides in the laboratory, mass rearing of biological control agents on this host, developing and testing pheromone technology, carrying out plant resistance studies etc.

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