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A Review on Possibilities of Intercropping with Immature Oil Palm

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ABSTRACT

Oil palm (*Elæisguineensis*) is identified as the world's leading edible oil producing plant and well established as a perennial plantation crop in tropical countries. Economic life span of the plant is around 30-35 years and stand per hectare is around 120-135 plants. At the initial stage of the plantations (age up to 3-5 years) there are ample amount of free space available inside young plantations. During this period growers were not getting any income from oil palm and have to spend several other agricultural practices such as weeding. Intercropping with young oil palm is possible and practiced specially by small and medium scale farmers with suitable combinations of crop species. Early identification, proper management of short and medium term intercrops gives better returns for the farmers. Furthermore, in addition to the advantages there were some limitations for intercropping with young oil palm.

Keywords-- Intercropping, Young Oil Palm, Sustainable Resource Utilization

I. INTRODUCTION

The oil palm (*Elæisguineensis*) originates from the tropical rain forest regions of West Africa with the main belts running through the southern latitudes of Sierra Leone, Liberia, Ivory Coast, Ghana, Nigeria, Cameroon, and into the equatorial regions of Angola and Congo (Kwasi 2002). It belongs to the family Palmae, sub-family Cocoideae, having 225 genera with over 2600 species (Opeke 1987). It is a versatile tree crop with almost all parts of the tree being useful and of economic value (Ibitoye et al. 2011).

Oil palm can produce high yields when grown under the right biophysical conditions:

(i.) High temperature all year round, between 25°Cto 28 °C
(ii.) Sufficient sunshine: at least 5 hour of sunshine per day
(iii.) High precipitation: evenly distributed rainfall 1800–2400 mm/year without dry spells for more than 90 days. Higher rainfall can be tolerated as long as soils are well drained
(iv.) Soils: prefers rich, free draining soils, but can also adapt to poor soils with adequate use of fertilizers.
(v.) Low altitude: ideally below 500 m a.s.l. (Better Crops International 1999; Jacquemard 2012).

Following the drop in the early 1990s of the prices of cocoa and coffee which were then the major commercial farming crops in Cameroon, many smallholders turned to plant oil palm (Ngando et al. 2011; Nkongho et al. 2014). This is further illustrated by the amount of germinated oil palm seeds purchased by small and medium size farmers at the IRAD-Specialized Center for oil palm research of La Dibamba (CEREPAH) in Cameroon which rose from 20 % of the total production in 1996 to an average of 60 % in the following years (Ngando et al. 2011). With this data, it is showed that about 5000 ha of oil palm were planted by small and medium size farmers each year during the last decade, making a total of about 90,000 ha for the non-industrial oil palm area in Cameroon (Bakoume and Mahbob2006). In addition to that world–wide oil palm smallholdings boomed since the mid-1990s notably since 1993 with a trebling of planted areas (Rafflegeau and Ndigui 2001).

Despite this increase, the two major factors of production: land and capital still limit the expansion within smallholder farmers 'communities(Nair 1993).The high investment cost to open a new plantation (mainly clearing and seedling cost) and the production cost at the immature stage of oil palm development (Vermeulen and Goad 2006). The length of time (about 3–4 years) needed for the oil palm to start producing is a major problem for the smallholders who have to invest considerable amounts of money and/or labour before deriving income from oil palm plantations. Smallholder farmers are therefore testing different options such as intercropping oil palm with food crops in order to mitigate these costs (Tonye et al. 2004; Zen et al. 2005). Looking at the aspect of weed control, studies have revealed that intercropping often shades weeds to a greater extent, leading to a reduction in weed density and biomass when compared to mono-crops (Liebman and Dyck1993; Tonye et al. 2004).

Ironically, intercropping is not practiced by most if not all famers because the results of intercropping is uncertain and some experiments have shown there is no or inconsistent yield benefits for the farmers. Even with proper management, yields of intercrops can be easily influenced by growing conditions. Although growing conditions affect all agricultural systems, there is evidence to suggest that the complexity of intercropping can make the system more vulnerable to environmental stresses. Combined with the greater degree of management skills required to operate the system, yield

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uncertainty may hamper the adoption of intercropping (Pridham and Entz 2008; Agro brief No4 2011). Furthermore, if crop choices or timing differences in crop life cycles are not managed correctly, the two crops can compete with each other for water, nutrient and other resources with negative yield results (Brainard and Bellinder 2004). In addition to that major problems with farm maintenance operations, which may difficult to mechanize as there is not enough space for the mobile equipment to operate (Amoah et al. 1995). Furthermore, another major problem is the denseness of the crops which can make it physically more difficult to combat diseases, pest attacks and weed problems. Therefore Cost of weeding_best crop combination is implemented and if not well selected, some crops may act as host for transmitting potential pathogens to other crops.

II. SPACE AVAILABILITY FOR INTERCROPPING

Oil Palm is an unbranched monoecious, monocotyledonous tree attains a height of about 20 to 30 meter having economic life of 35 years. It is recognized as the major source of vegetable oil producer with an average oil yield of 4 to 6 tons per hector/ye compared to any other oil yielding crop including coconut and groundnut (Vasanth kumar, 2005). It is planted at a wider space of 9 mx9 m x9 m in a triangular system. It occupies only 5-15 %area during the juvenile phase of the garden (Suresh and Rethinam, 2001). Similarly, 60 to 65 % of the area remains vacant in mature oil palm gardens. Active root system of adult palms under good management is mainly concentrated within a radius of 0.5 to 3m laterally from the bole and 10-40 cm depth vertically (Suresh et al., 2003). This situation offers an ample scope for effective utilization of horizontal and vertical space for growing intercrops, thus providing additional employment opportunities and income for small and marginal farm families during the initial three years of oil palm cultivation (Reddy and Prasad, 2011).

The main objectives of intercropping are effective utilization of space left between two rows of the main crop and out per unit area. Studies conducted by Reddy et al., (2004) on intercropping in oil palm during juvenile phase revealed that there was no adverse effect on growth of oil palm and also intercrops added lot of biomass (varied from 0.5 -17tha^{-1}) which can be utilized by oil palm in future. Under good management oil palm takes three to four years to utilize entire inter space. Intercropping in the interspaced of oil palm is practiced only in India. In other countries where oil palm is grown, intercropping is not practiced because land is not constrained as it is in India. Since it is a perennial crop, there is ample scope for raising intercrops in oil palm plantations during the initial 3-4 years. Farmers have to grow intercrops during the juvenile phase as there will not be income from oil palm crop. Similarly, economic condition and size of land holding of Indian farmer, increased cost of production and FFB price fluctuation are forcing them to go for intercropping in grown up oil palm garden also. Study conducted by Reddiet al., (2015) on intercropping in oil palm proved that growing okra as an intercrop with oil palm generated higher net return compared to other vegetable crops in young oil palm.

III. WEED DISTRIBUTION AND CONTROL

Whether intercropped or not, weed control (manual and / or chemical) in oil palm plantations is unavoidable. Weeds if not attended to, can considerably affect the growth and yield of oil palm. Major weed sob served in young oil palm were Chromolaena odorata (Achakasava), Panicum maximum (Guinea grass), Pueraria phaseoloides (Cover crop), Pennisetum purpureum (Elephant grass), Thaumatococcus daniellii and Bambusa vulgaris (Indian bamboo). These weeds have adverse effects on oil palm and intercrops. Weeds act as a hideout for pests; they are detrimental to oil palm growth, as they compete with the oil palm for nutrients, water and sunlight. They also cause difficulty in movement on the plantation. Among the weeds listed above ‘‘achakasava’’ was the most severe of all weeds present, followed by ‘‘Guinea grass’’ with the least being the ‘‘Indian bamboo’’. (Yvonne K. et al., 2012)

IV. COST OF WEEDING

With the observation of weeding on selected oil palm plantations, 48% practiced only manual weeding while 52% practiced both manual and chemical weeding. Generally, the manual weeding (both slashing and circle weeding) costs on average (€0.27) per palm depending on the severity of the weeds. Spraying off arms was mostly done by respondents themselves with help from their families. For those who paid for labor, it costs on average (€0.08) to spray a palm (Yvonne K. et al., 2012)

V. NUTRIENT STATUS IN THE SOILS

Data regarding nutrient status in the soils at initial stage and after completion of experiment (with and without intercrop plots) are revealed that except nitrogen all components were increased in the soils where intercrops were taken. Nitrogen content in the soils in intercrops was 153.66 kg h^{-1} where as it was 175.61 kg h^{-1}in without intercrops. Decreased in nitrogen content in intercropped soil indicate needs to increase nitrogenous fertilizer while planning intercrops.

VI. FERTILIZER RESPONSE ON IMMATURE OIL PALM

There were significant differences in soil available K content among treatments applied. Higher

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values were observed in K applied pots, compared with, zero level K applied control plots. Highest soil K concentration were observed in 180 K_2O (kg/ha/yr) applied plots.

Significant differences in leaf K concentration were observed among the treatments. Highest leaf K concentration were observed in 180 K_2O (kg/ha/yr) applied plots.

The height and girth of plant and number of fronds did not significantly vary among treatments. The 60 K_2O (kg/ha/yr) applied plots recorded the maximum height while the palms that received 90 K_2O (kg/ha/yr) reported the highest girth and number of fronds.

The number of male flowers, female flowers and bunches did not significantly vary among different treatments. (S. M. Dissanayake., et al 2019)

Nitrogen plays a vital role in oil palm, especially during its immature stage. A field experiment on young immature oil palm was conducted to quantify the uptake of N derived from N_2 fixation by the diazotroph Bacillus sphaericus strain UPMB-10, using the ^{15}N isotope dilution method. Eight months after ^{15}N application, young immature oil palms that received 67% of standard N fertilizer application together with B. sphaericus inoculation had significantly lower ^{15}N enrichment than uninoculated palms that received similar N fertilizers. The dilution of labeled N served as a marker for the occurrence of biological N_2 fixation. The proportion of N uptake that was derived from the atmosphere was estimated as 63% on the whole plant basis. The inoculation process increased the N and dry matter yields of the palm leaflets and rachis significantly. Field planting of young, immature oil palm in soil inoculated with B. sphaericus UPMB-10 might mitigate inorganic fertilizer-N application through supplementation by biological nitrogen fixation. This could be a new and important source of nitrogen biofertilizer in the early phase of oil palm cultivation in the field. (Fitri Abdul Aziz Zakry., et al)

Under stress conditions, changes in plant growth, dry matter allocation, relative water content, leaf relative conductivity, leaf N, P and K concentration are usually observed. These characteristics and related parameters were determined and the experiment results are listed as follows:

(1) Fertilization promoted the growth of oil palm under well-watered conditions, while under water stress conditions its effects on growth was negative. The ratio of root/shoot was increased under water stress condition

(2) Relative water content and chlorophyll a/b content were gradually decreased while leaf relative conductivity was increased quickly under water and nutrient stress conditions during the experiment. It is obvious that water stress had a greater influence than nutrient stress on these parameters

(3) Water and nutrient stress decreased leaf nitrogen and phosphorus concentration but increased potassium concentration

The combination of water and nutrient stress made significant effects on nitrogen and phosphorus concentration, but no significant effects on potassium concentration. Moreover, deficiency of both water and nutrients in combination had the greatest impact on changes in these traits of oil palm.

Water and nutrient deficiency are major factors limiting the productivity and geographical distribution of many species, including important agricultural crops (Conner et al., 1998; Zhang et al., 2007; Tseira and Irit, 2009; Andrews et al., 2010). Fertilization is most effective when trees are not water-stressed, and irrigation is most effecttive when nutrients are not scarce (Sands and Mulligan, 1990). Therefore, understanding the mechanisms of plant tolerance to water and nutrient stress is a crucial environmental research topic (Wang et al., 2009a).

At the end of the experiment, Chlorophyll a/b was significantly influenced by water and nutrient stress. However, Chlorophyll a/b remained stable under control treatment. These results also showed that water stress had a greater influence on these traits than nutrient stress. Nitrogen, phosphorus and potassium concentration As shown in Table 3, at the end of the experiment, the main effects, the interaction between water and nutrient stress, was significant for leaf nitrogen and phosphorus concentration ($P < 0.05$), but had no significant effect on potassium concentration. Nitrogen, and phosphorus concentration was lower in the nutrient and nutrient-water stressed plants compared to the control plant. The highest decrease in nitrogen, phosphorus, potassium concentrations were 11.4 and 27.4%, respectively. But potassium concentration was increased under stress condition.

VII. POTENTIAL CROPS TO INTERCROPPED

Mostly intercropped annual crops are; Plantain (Musa paradisiaca), Banana (Musa acumi-nata), Maize (Zea mays), Groundnut (Arachis hypo-gaea), Cassava (Manihot esculenta), Cocoyam (Colocasia esculenta), Egusi (Citrulluslanatus), Garden huckleberry (Solanum melanocerasum), Amaranthus (Amaranthus hybridus) and Yam (Dioscorea sp.) Bitter leaf Vernonia amygdalina. (Yvonne K. et al., 2012)

VIII. PERFORMANCE OF INTERCROPS IN OIL PALM

Research findings revealed that the yield in intercropping system was significantly increased every year than sole crop. It was 5.00, 12.40 and 14.20 t/ haduring 2016, 2017 and 2018 respectively and yield was 3.74, 9.51 and 9.92 t/ haduring respective years as a sole crop. The pooled mean indicated that yield increment in oil palm (FFB) in mix cropping was 36.40 per cent than

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sole crop. This could be attributed to better growth as indicated by increase in number of leaves and leaf area of the palms under intercropping system. This yield pattern is well supported by Nathet al., (2015) who observed increased in nut yield of coconut in the intercropping situation compared to sole crop.

The yield data of intercrops in mixed cropping system revealed that in first year, banana recorded the highest yield(2.9t/ ha)while elephant foot yam recorded significantly highest yield (2.3 t/ ha) during second year. During third year maximum yield was noticed in pineapple (2.5t/ha). Pooled mean data revealed that the maximum yield (2.28 t/ ha) was recorded in banana followed by elephant foot yam (1.82 t/ ha). Decreased in banana yield in subsequent year may be due to ratoon crops. The year 2015 -16 was the first year and pineapple crop was in establishment phase hence yield of pineapple did not obtain during 2015-16. Data revealed that total yield in intercrop including Oil palm Equivalent Yield (OEY) of intercrop was 13.09t/ hawhile in sole crop it was 7.72 t/ hawhich indicated 69.56 % yield increment due to mix cropping. The cost of production of sole crop for three years was Rs.1, 63,000t/ hawhile it was Rs.3, 33,629t/ ha in inter cropping system. The gross returns per hectare for three years were Rs.5, 91,269/-in intercropping and Rs.1, 32,937t/ hain sole crop. The net returns per year was the highest (Rs.89, 549/-) in intercropping earning Rs.89, 570t /haas an additional returns than sole crop. The highest B: Cratio (1.83) was noted in intercropping system as against 0.82 in sole oil palm crop as it is in immature phase.

Similar finding were observed by Reddietal., (2015) when okra was taken as intercrop in oil palm. Reddy and Suresh (2009) found banana was the most profitable crop when compared with turmeric and spider lily.

Data on effect of intercropping in oil palm on morphological parameters are revealed that average palm height and average numbers of leaves at a time of intercrop were 0.96 m and 22.01 respectively. After three years of intercropping palms height is 2.61 m compare to 2.18 m without intercrop. It is clear that palm height was increased due to intercropping. This could be due to available moisture and shade. Similarly, after three years of intercropping palms in intercrops produced 29.82 leaves while it was 28.42 in without intercrops which were only 22.01 prior to intercropping. Similarly, palms in intercrops recorded increase in leaf length (4.89 cm), number of leaflets (264.8), length of leaflet (79.01 cm), width of leaflet (3.36 cm), maximum width of leaflet (4.47 cm), leaflet area (258.25 cm2) and yield also (10.53 t/ ha) as compared to 4.18 m, 240.9, 74.28 cm, 3.17cm, 4.31cm, 252.80 cm2and 7.72 t/ harespectively in without intercrops. This increased in leaf production and leaf area under intercropping might have resulted in increased in bunch yield of oil palm under intercropping (Nathet al., 2015). Thus study revealed that the yield of oil palm in intercropping system was triggered 36.40 per cent over sole crop along with the additional yield of intercrops (banana, pine apple and elephant foot yam) which provided the additional returns and highest the C:B ratio (1:1.82) suggesting the compatibility of oil palm for intercropping.

Thus it can be concluded that growingbanana, pineapple and elephant foot yam as an intercrop in young oil palm garden up to 4 yearsis the best preposition for earning additional returns from juvenile oil palm orchard under South Konkan region.

IX. REASONS FOR NOT INTERCROPPING

For smallholder farmers as well as for the agro-industry in the study site that did not practice intercropping, the reasons given were as follows: all personnel questioned, said intercropping would result in poor plantation management; in addition to it being detrimental to oil palm yield at production stage. These they emphasized were of utmost importance to them as their primary objective as a company was getting good oil palm yields. SH farmers who did not practice intercropping said intercropping was detrimental at production stage, food crops attract more pests such as rodents and lastly some said that their plantations were further away from the village, an obstacle to regular visits (Yvonne K. et al.,)

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