

Original Research Article

EFFECT OF WATER AVAILABILITY ON THE ESTABLISHMENT, GROWTH, DEVELOPMENT AND YIELD OF OIL PALM IN GHANA

Abstract

*Oil palm (*Elaeis guineensis* Jacq) establishment, growth and yield depend to a large extent on physical and climatic characteristics of the environment in which the palm is established. A field experiment was conducted from 1995 to 2005 to assess the effect of transplanting time and water availability during the time of planting on establishment, growth and yield. Farmers need to know the appropriate time to transplant their seedlings in southern Ghana in order to minimise the seedlings lost at the time of planting. This work seeks to address which month(s) of the year is (are) appropriate to transplant oil palm seedlings in order to achieve high percentage establishment and high yields. In this study, twelve months old DxP (ex OPRI) oil palm seedlings were transplanted onto the field in May, July, September and November signifying different moisture regimes of the year. Treatments were arranged in RCBD with 4 replicates. It was observed that seedlings transplanted in July had better establishment, growth and development than those in May, September and November. The findings of this study have important ramification for oil palm farmers, extension services and future studies in order to maximise the yield of FFB. Recommendation from this trial is that transplanting of oil palm seedlings should be done in July in the semi-deciduous forest zone of Ghana.*

Key words: oil palm, water availability, planting time, establishment, growth and yield.

INTRODUCTION

Water is the most critical factor determining crop establishment in the field. Water interacts greatly with soil nitrogen, affects nutrient uptake and subsequently crop productivity. The

26 effect of water stress on production vary according to the crop, soil characteristics, the root
27 system and severity and **timing of the shortages** during the growth cycle (Ahn, 1993). Oil
28 palm growth and yield is dependent on climate in which the palm is established. Oil palm
29 yield potential is reduced when exposed to **stressful conditions**. In water-limited environment
30 soil water content at sowing is important in determining plant establishment.

31 **The importance of oil palm to Ghana's economy cannot be underestimated in recent times.**
32 Understanding of the growth and development of the crop under field conditions is key to
33 maximise yield. Therefore, monitoring rainfall is useful in predicting oil palm establishment,
34 growth and yield.

35 Studies by Ubi (2004) recommended that in **Nigeria** oil palm seedlings aged between 10 to 12
36 months, should be transplanted into the field in **April and May for good crop performance.**
37 Anonymous, (1980) also indicated that in Ghana, oil palm seedlings should be transplanted to
38 the field in the months of May and June **for the same reason**. However, Rainfall variability and
39 changing weather condition in Ghana has directed attention to the search for appropriate time
40 for transplanting oil palm seedlings to the field so as to increase seedling establishment. The
41 transplanting **time is** also believed to affect the yield cycle of the palm. Therefore
42 manipulating the time of transplanting so as to shift the fruiting period to coincide with
43 period of **FFB** scarcity may have positive **economic implication**. Nouy *et al.*, (1996) indicated
44 that the timing of the peak and lean yield of oil palm may vary with year, location and
45 planting material. Some farmers also perceive that this cycle varies with the time / month that
46 the seedlings are transplanted and that the seedlings transplanted late in the year, September
47 and November produce their peak yield late in the year. This study is thus to establish:

- 48 • The impact of water variability on oil palm establishment, growth and development
- 49 • To define appropriate planting time / **month for** oil palm seedlings establishment and

- Determine when peak yields are obtained in the year at different transplanting times.

MATERIALS AND METHODS

Field experiment was conducted at the Oil Palm Research Institute (OPRI)Kusi in the Kwabibirem district of Ghana from 1995 to 2005. D x P (ex OPRI) oil palm seedlings aged 12 months were transplanted onto the field at a planting distance of 8.8m triangular, equivalent of 148 palms per hectare. The experiment was laid in RCBD with four replications. Each experimental plot was made up of 24 palmseedlings. The months of transplant constituted the treatments.

Treatments details;

May transplant

July transplant

September transplant

November transplant

Cultural practices carried out include growing of a cover crop, *Puerariaphaseoloides* to suppress weeds. Ringweeding was also done around the base of the palms. The inter-rows were slashed every two months to control excessive weeds. One kilogram (1kg) each of muriate of potash, single super phosphate and ammonium sulphate fertilizers were applied per annum to improve the fertility of the soil. Phytosanitary inspection was also carried out periodically to check the onset of pests and diseases.

Rainfall

Rainfall data for the period of the trial were obtained from the meteorological station of OPRI. The monthly rainfall over the experimental period is shown in fig 1a and b. Bimodal

74 rainfall pattern was displayed for all the years. The major rainfall season occurred in April,
 75 May and June with values around 250mm/month in 1995. The minor season started in
 76 September and ended in November. February recorded the lowest rainfall of 10mm but that
 77 did not affect the transplanting periods. The rainfall in December was higher than that of
 78 January but there was a sharp decline in rainfall to below 10mm in the year 1996. In the
 79 following year (1996), the rain started early. Less than 10mm rainfall was recorded in
 80 January, 36mm in February and as high as 360mm was recorded in the month of March.
 81 Unlike the year of transplant, where there was rainfall value of more 130mm from March to
 82 December, there was a sudden drop of rainfall in April to less than 90mm as shown in fig 1a.

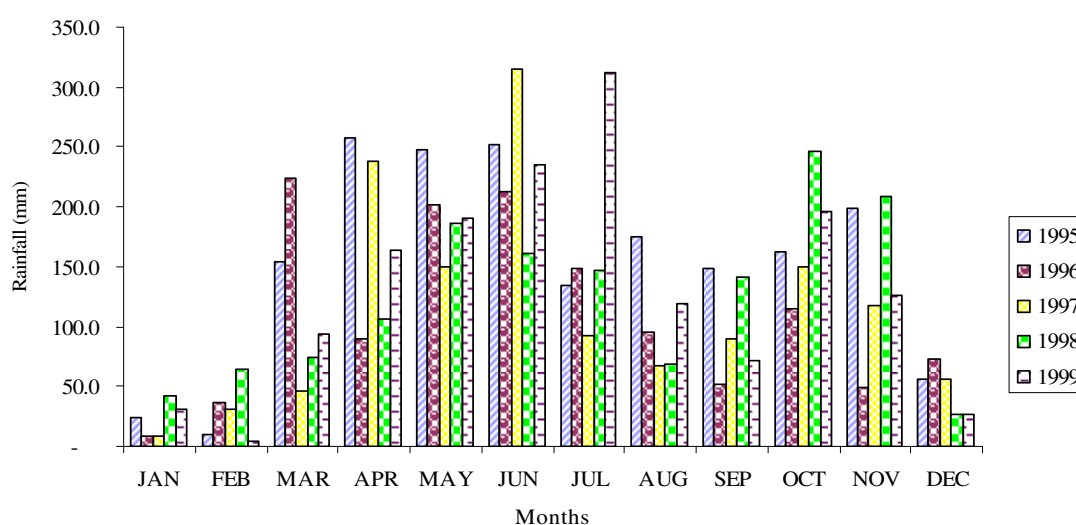


Fig.1a Monthly Rainfall data from 1995-1999

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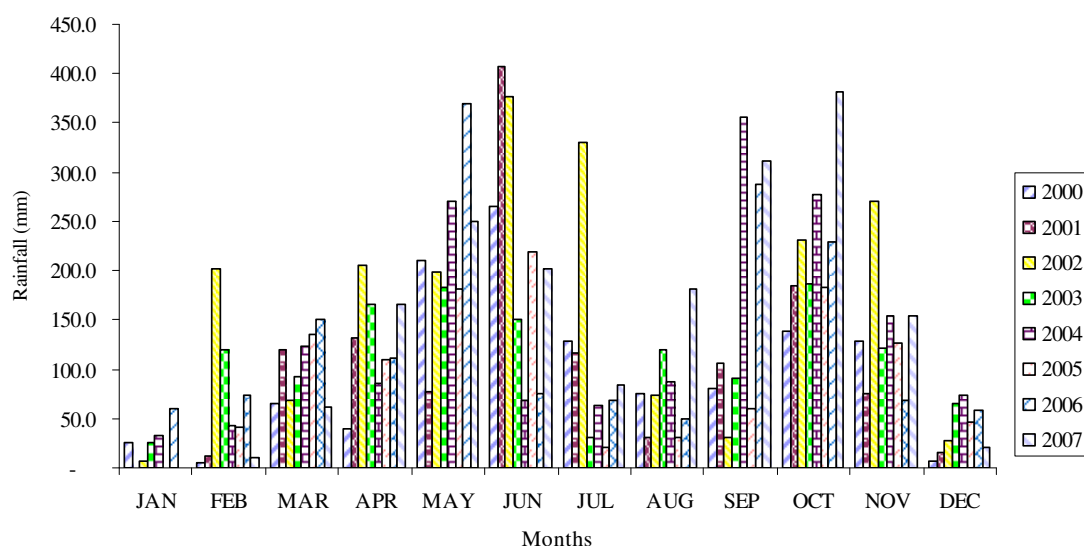


Fig.1b Monthly Rainfall data from 2000-2007

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85 **Vegetative measurement**

86 Seedling establishment on the field was recorded for the first 2 years. The data obtained was
 87 used to calculate the seedling percentage establishment on the field. The plant height was
 88 measured with graduated measuring pole from the base (ground level) of the palm to the
 89 point of insertion of leaf number 33.

90 Leaf area (LA), Leaf area index (LAI) and frond dry weight were taken once a year every
 91 November, anniversary of when the last seedlings were transplanted. These parameters were
 92 determined from the relationship below;

93

94 LA was computed using the equation by Harden *et al.*, (1969).

$$95 \quad LA = b(n \times LW)$$

96 Where:

97 n= number of leaflets, LW=mean of length x mid-width for a sample of the largest

98 leaflets, and b= correction factor=0.55

99

$$LAI = \frac{\text{leaf area}}{\text{ground area}}$$

100

101 **FDW** was obtained using formula developed by Corley 1971. The width and depth of the
102 petiole of the frond number **17** with a callipers and values obtained **were put a formula to**
103 estimate the Frond Dry Weight (FDW).

104

$$FDW = 0.1026 \times W \times D + 0.2362 \text{ (kg)}$$

106 Where: W= width of the petiole of frond 17

107 D= depth of the petiole of frond 17

108

109 Percentage establishment was also **determined** 1st and 2nd year after transplanting.

110

111

112 **Yield measurement**

113 The number of bunches and weight of **FFB** per palm were taken at each harvesting round
114 (weekly) from 2001 to 2005, and these were further compiled to tons/ha/yr.

115 The data collected were analysed with GENSTAT 2007 statistical package and subjected to
116 analysis of variance.

117

118 **RESULTS**

119 **Establishment of the seedlings**

120 Seedlings establishment was determined in terms of percentage **survivabilityof** the total
121 seedlings per month of transplant in the 1st and 2nd year of planting. **High** establishment was

122 recorded in the order July > May > September > November (Table1) which were significant
123 from the other treatments except September and November.

124 **Table 1. Seedlings establishment 2 years after planting**

Treatment	Seedling establishment	
	Mean Establishment	Percentage Establishment
May	19.3	80.2
July	22.8	94.8
Sept	18.8	78.1
Nov.	17.8	74.0
Lsd	3.5	14.53
cv%	16.1	16.1

125

126 **Time / months of transplant of oil palm on LA and LAI**

127 The leaf area and leaf area index showed a linear increase with increase in age (fig. 2 and 3).
128 There were no significant differences ($P < 0.05$) between the treatments. Oil palm transplanted
129 in July had a relatively higher leaf area in all the years under consideration. There was a sharp
130 increase in LA for seedlings transplanted in September in 2003. LA of palms transplanted in
131 May and November were similar for the years 2004 and 2005. The leaf area index (LAI)
132 increased with increasing palm age (fig.3). July transplants recorded the highest LAI in the
133 years under investigation. However it was not significantly different from the other
134 transplants / treatments. This was followed by May transplants for years 2001 and 2002.
135 From 2004 to 2005, September transplant recorded LAI which was higher than that of May
136 but lower than that of July. November transplants recorded the lowest LAI in 2004 and 2005.

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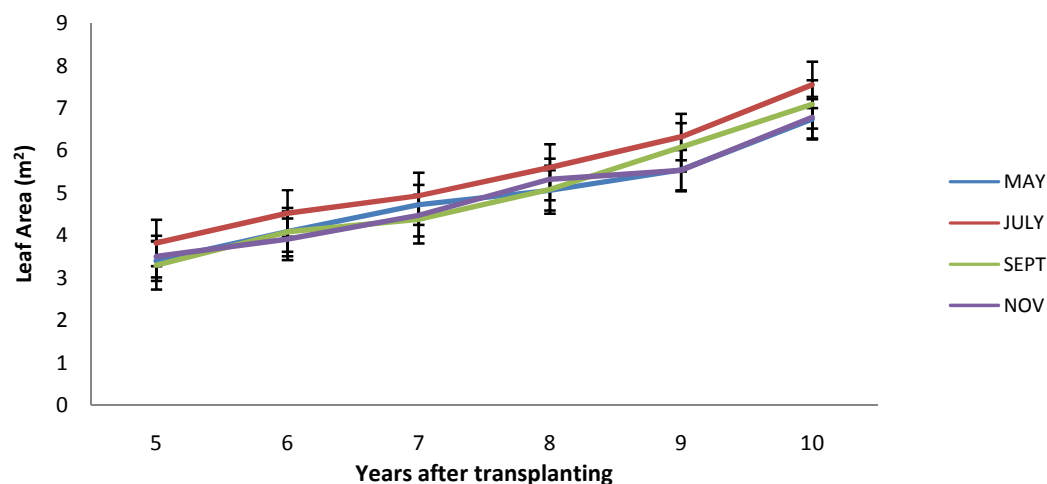


Figure2. Effect of time / month of transplant on LA

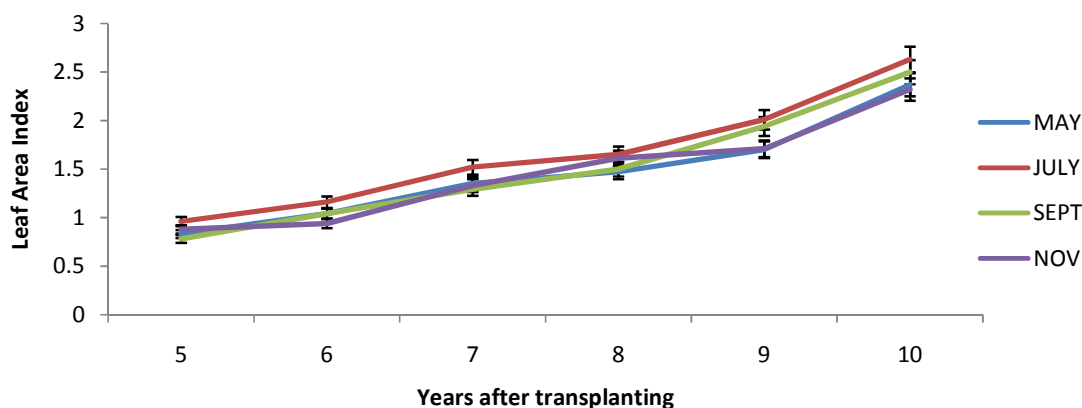
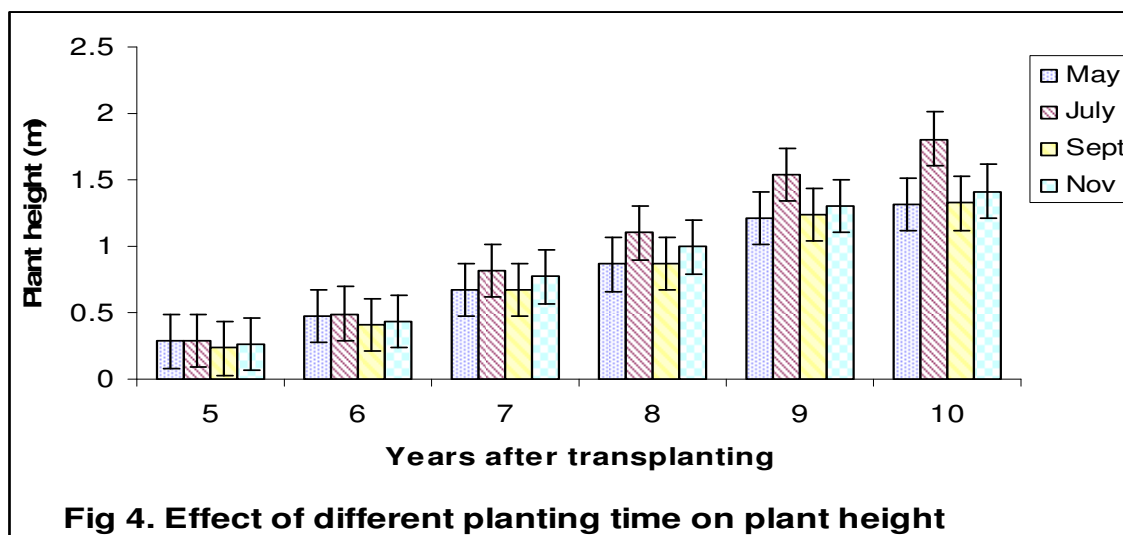


Figure3. Effect of time / month of transplant on LAI

Effect of transplanting time on palm height

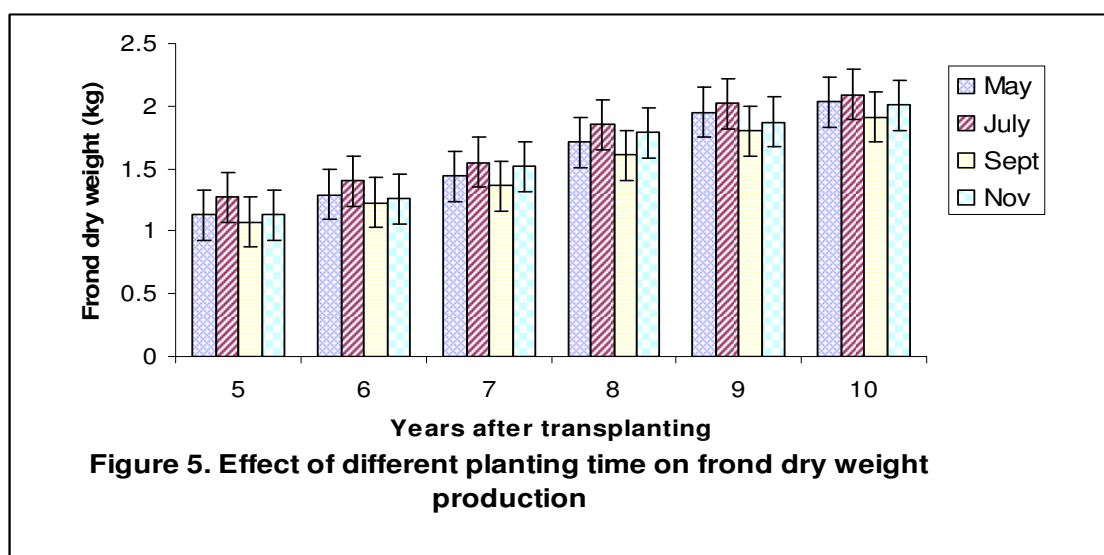
Figure 4 shows the effect of transplanting time / month on plant height. Differences in height were observed among the transplants. The July transplant recorded the highest plant height, followed by those planted in November. Height of September transplant and May transplant did not vary significantly for all the periods of the trial.



148

149 Effect of different planting time on frond dry weight

150 Figure 5 shows the accumulation of frond dry weight from the year 2000 to 2005. The frond
 151 dry weight for the periods 2000-2001 were in the order July transplant > May transplant >
 152 November transplant > September transplant. There was no significant difference ($P \leq 0.05$)
 153 between the treatments. However, July transplant recorded the highest frond dry weight
 154 throughout the experimental period. November transplant on the other hand recorded the least
 155 frond dry weight in all the experimental years. May and September transplants fluctuated in
 156 2002 and 2004.



157

158 Yield and yield components

159 There were no significant differences between the yields of the same year (table 2). There was
 160 an increase in bunch weight with palm age. In the 5th year after transplanting, July
 161 transplant recorded relatively high single bunch weight than the other transplants. In the sixth
 162 year September and November transplants produced heavier single bunches than the
 163 other transplants. This trend for September transplants continued to the 9th year and then
 164 declined during the 10th year. May transplant trailed in all the years except the 5th year and the
 165 10th year. After the sixth year, September and July transplants produced relatively heavier
 166 bunches than that of November and May transplants (fig. 6).

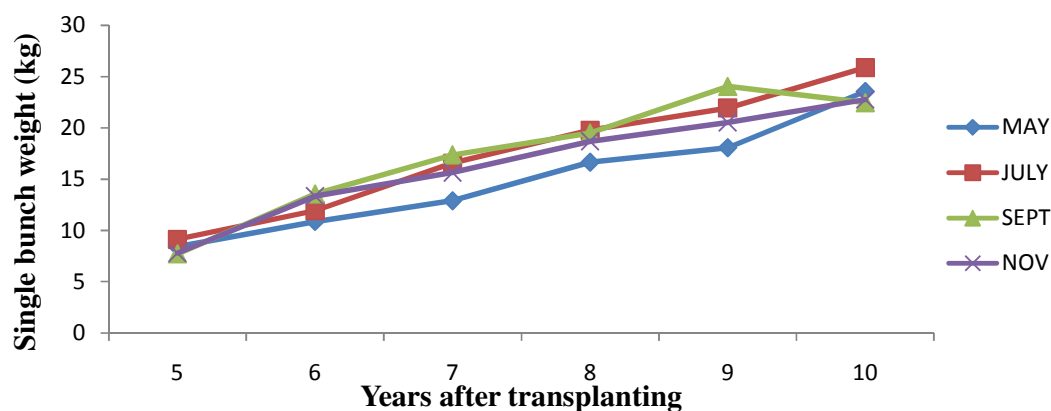


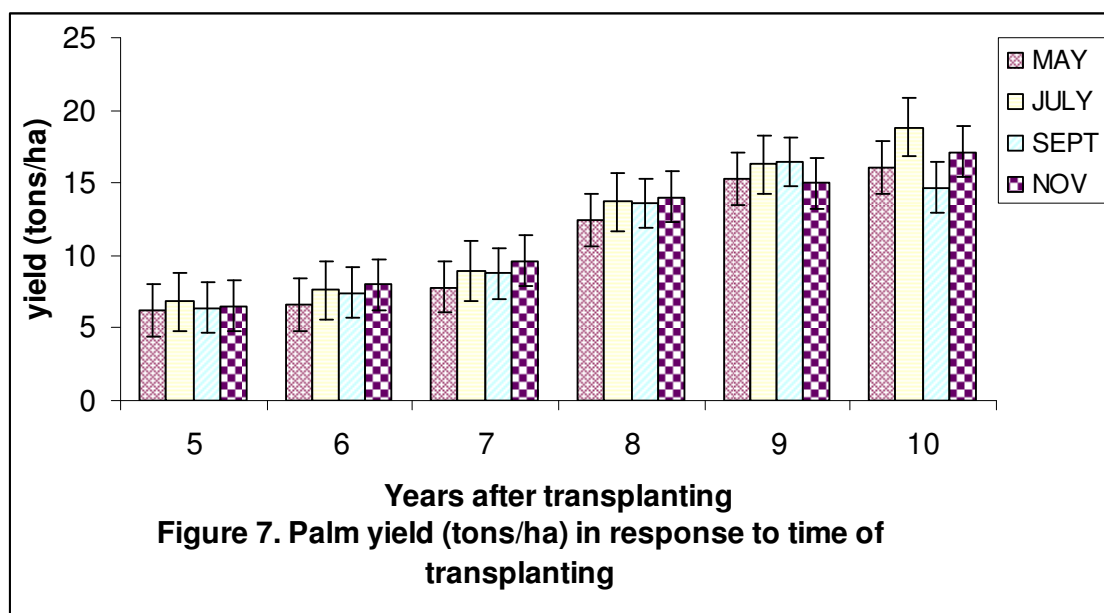
Figure 6. Single bunch weight at different transplanting times

Table 2. Number of bunches per palm per year

TREATMENT	YEARS AFTER PLANTING					
	5	6	7	8	9	10
MAY	8.54	7.59	8.54	11.30	12.45	10.63
JULY	9.61	7.84	8.22	10.77	11.23	11.27
SEPT	9.41	8.08	7.90	10.72	10.84	10.21
NOV	10.4	8.50	9.13	11.33	11.19	11.72
CV%	20.40	23.90	5.20	13.20	7.60	9.50
lsd	2.97	1.26	0.76	1.60	2.10	1.66

The effect of transplanting time on the number of bunches per palm per year is shown in table 2. The number of bunches per palm per year increased withage. The yield became somewhat stable at 8 and 10 years stage with mean values around 10.50–12.50 bunches/palm/year. Even

174 though there were no significant differences between the single bunch weight of palms of the
 175 same age, the November transplants had relatively high number of bunches per plant per year
 176 from the 5th to 7th year after transplanting.



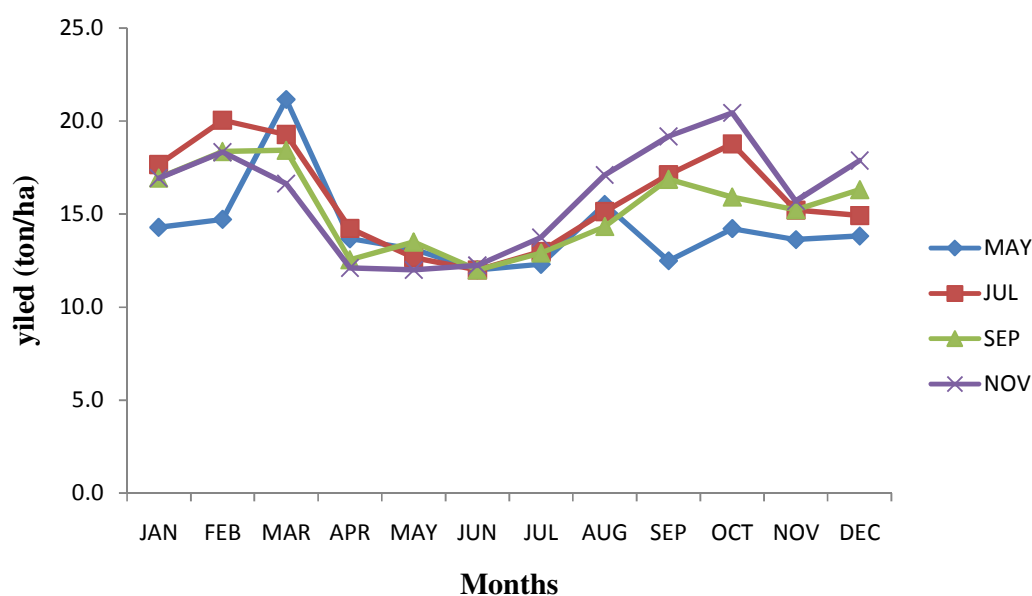
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179 There was linear increase in yield with age of palm, (fig.7). Though there were no significant
 180 differences between the various treatments, at the 5th year, oil palm transplanted in July
 181 produced 6.82 tons per ha. This was higher than the other treatments, November, September
 182 and May which had 6.54, 6.40 and 6.22 ton per ha respectively. From the 6th to 8th year,
 183 November transplants recorded higher yield per ha per year than the other treatments. At the
 184 9th year, the September transplants had the highest yield, followed by July transplants, May
 185 and then November transplants. With the exception of 10th year, yield differences among the
 186 transplant were small. However, July transplants recorded highest yield of 18.82 ton per ha.

187 Results of the trial indicated that, one lean yield period in a year and 2 peak yields in a year
 188 over the experimental period. One of the peaks occurred in March and the other in

189 November. In the first peak season, palms transplanted in May gave the highest
 190 yield followed by July transplant. September and November transplants recorded the least
 191 yields. In the second peak season which occurred around September, October and November,
 192 the yield was in order of November > July > September > May (figure 8.).



193
 194 **Figure 8. Production spread over the experimental period (8 to 10years after planting)**

195 DISCUSSION

196 Effect of transplanting time on oil palm establishment

197 Water availability affected seedling establishment on the field. The number of plants that
 198 were able to establish and grow successfully were in the order of July > September > May >
 199 November (Table 1). Transplants of September were better established than May transplant
 200 probably due to the carry over effects of rains from the previous months. Also there was
 201 enough rainfall throughout the year of transplant (Fig. 1a) this might have also contributed to
 202 relatively good establishment and better performance of the September and November
 203 transplants.

204 **Effect of transplanting time on leaf expansion / leaf area index**

205 Water affects both the activity and size of the leave. For young palms the early expansion of
 206 the canopy facilitates radiation capture is of crucial importance for yield (Henson, 1991a).
 207 The leaf area and leaf area index of the seedlings increased with age. This supports
 208 Corley's (1979) finding that leaf area varies with age. The effect of water availability on the
 209 leaf area was prominent in July transplants (fig 2). High leaf area and leaf area index of
 210 seedlings planted in July maybe attributed to enough moisture availability that aided good
 211 establishment. The availability of water for seedling establishment also affected the
 212 subsequent growth and development of the oil palm. Even though there was not much rainfall
 213 in July, the preceding months had adequate rainfall. Therefore the soil might have had
 214 enough moisture reserve in July when the transplanting was done.

215 **Effect of transplanting time on palm height**

216 Time of transplanting affected the height of the palm. Even though there was no significant
 217 difference among the treatments, the July transplants were ahead of all the treatments (fig.4).
 218 This can be considered as an advantage since its canopy will close faster than the other
 219 treatments. Closed canopy smother weeds, reduce sun impact on the soil and therefore
 220 reduce evaporation from the soil surface and reduce weed control frequency.

221 **Dry matter weight accumulation of oil palm after transplanting**

222 Oil palm productivity is influenced by total dry matter production of each palm. Dry matter
 223 production is highly dependent on the photosynthetic rate of the palm (Mohd Tayeb Dolmat,
 224 1996). Dry matter production is used for both vegetative and reproductive growth. In oil
 225 palm, vegetative growth assumes priority over the reproductive growth (Hartley, 1988). Thus

the requirement of vegetative must necessarily be satisfied before dry matter is diverted into fruit production.

Inadequate rainfall at the time of transplanting affected the rate of growth, development and dry matter production. Seedlings transplanted in May and November where there was inadequate rainfall expressed reduced crop growth and development. Because there had been enough moisture in the previous months before July, the seedlings transplanted had good growth rate. It therefore had slightly high dry matter than the other treatments.

Effect of transplanting time on yield and yield components

The yields were also affected depending on the extent of dry matter produced. The impact of soil water affected the vital phenological and growth processes. This observation was similar to findings by Kassam and Smith (2001). The number of bunches per palm per year was higher in May and November transplants on the 8th and 9th year. July and September transplants recorded smaller number of bunches per palm. Single bunch weight was higher in those transplanted in July and September. This shows that when oil palms are transplanted when rainfall is inadequate, the number of bunches per palm increase at the expense of single bunch weight. Due to adequate rainfall of 270mm, 160mm and 200mm for June, July and August respectively, July transplants received enough moisture which led to good establishment rate and high dry matter accumulation at the vegetative stage and diverted into fruit production at the initial yields. Therefore the initial yields for July transplant were higher as compared to the other treatments. The findings of this work show that transplanting time have effect on the yield of the crop. This finding is in line with findings by Reddy *et al.*, (2003), who stated that the time of sowing affected yield in most crops. This work found out that, seedlings transplanted in minor dry seasons and the end of major rainy season which

occurs in November and July respectively, give high peak yield in the dry season, around November and December when palm fruits are expensive.

The bimodal peaks can also be attributed to the bimodal rainfall season in the area which increases soil moisture that matched or mirrored the yield peaks.

Conclusion

Depending on when regular rain starts, it is suggested that, two to three months rainfall should be allowed before transplanting seedlings. This will increase moisture in the soil, for high percentage seedling establishment and good vegetative growth. From the rainfall values in 1995, it can be deduced that high precipitation in months preceding transplanting time is highly important in plant establishment and subsequent development. The second peak season which occurs in November is very important since palm fruits are very important at that time. It is therefore important to do split planting, i.e. plant some seedlings at July and some at November so that yield could be obtained throughout the year.

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