RESPONSE OF OIL PALM SEEDLINGS TO IRRIGATION AND FERTILIZER LEVELS

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ABSTRACT

The growth and dry matter yield of oil palm seedlings under 2 levels of irrigation and 3 levels of fertilizer treatments were studied in the nursery over a period of 12 months. Seedlings receiving 2 litres of irrigation water each per week (applied in two equal doses of 1 litre each) and those receiving 5 litres each per week (applied in five equal doses of 1 litre each) did not show significant differences ($P>0.05$) in height, number of leaves, leaf area, girth, and fresh and dry weights. The effect of fertilizer on the seedling growth and dry matter yield depended on the level of irrigation. At the 2 litres of water, the optimum rate of NPKMg (12:12:17:2) was 42 g per seedling (applied in 3 equal doses at 3, 5 and 8 months after planting). Whereas optimum rate could not be ascertained at the 5 litres of water irrigation level as leaf number, leaf area, fresh and dry weights of seedling were significantly highest ($P<0.05$) at the highest fertilizer rate of 70 g per seedling than lower rates of 28 and 42 g per seedling. Percent transplantable seedlings and vacancy were not significantly affected ($P>0.05$) by the treatments. The optimum rate of 42 g NPKMg (12:12:17:2) per seedling which is higher than the previously recommended rate of 28 g, under similar watering regime, was attributed to low nutrient status of the nursery soil used.

Keywords: Palm seedlings, irrigation; fertilizer; growth; dry matter yield.

INTRODUCTION

Greenhouse and field studies have shown that oil palm seedlings perform optimally when soil moisture levels do not fall below field capacity throughout the growth period (Ugbah and Babalola, 1990) and when ample nutrients are supplied (Lucas *et al*, 1979) . Experiments on water requirement of oil palm seedlings in field groundbed nursery in Nigeria have shown that an average of 25 mm of water is required by each seedling per week (Sly and Sheldrick, 1961; Rees and Chapas, 1963); although seasonal variations have been reported during the months of February ad March, reaching a peak of about 38 mm per week in early April (Rees ad Chapas, 1963). To satisfy the water requirement of groundbed nursery, 1 gallon (4.5 litres) per seedling per week should be given and in very dry weather this should be increased to 2 gallons (Gunn *et al.*, 1961; Hartley, 1988).

Polybag nursery seedlings, unlike field groundbed nursery seedlings are raised in black polybags where roots are confined in limited volume of soil. These bags may require more frequent watering than groundbeds because of limited soil volume. Preliminary nursery experiments have indicated that 1 - 2 litres of water applied once or twice weekly seemed adequate (Aya, 1972). It is however not known what effect daily watering would have on oil palm seedlings raised in polybags and how this watering regime would affect other cultural practices, such as rate of fertilizer application. In The Far East where irrigation is applied daily to polybag seedlings (Ramli and Duckett, 1987) and in other areas where rainfall is high and evenly distributed, monthly application of 10 g or more of NPKMg (12:12:17:2) per seedling is recommended (Hartley, 1988). This is contrary to the practice in Risonpalm plantations in River States, Nigeria where up to 200 g NPKMg (12:12:17:2) is applied per seedling under heavy irrigation watering (Risonpalm, 1991). Onwubuya (1982) recommends 28 g NPKMg (12:12:17:2) per seedling; and as this appears much lower than the Risonpalm rate, it is necessary to test the effect of different watering regimes on fertilizer requirement.

Fertilizer requirement is also a function of soil nutrient status (Hew *et al*, 1973), and the latter can decline over time due to continuous usage of a piece of nursery site, under very short fallows. This is buttressed

by observations of the growth and paleness of leaves of seedlings receiving the recommended rate of 28 g NPKMg (12;12;17:2); a factor which may have led to arbitrary application of higher rates by the Nursery Officer, NIFOR, 1993. In view of contradictory recommendations and practices, in respect to fertilizer and water requirements, it is pertinent to test the effect of different fertilizer rates and irrigation regimes on the growth and dry matter yield of oil palm seedling in order to ascertain optimum rates.

MATERIALS AND METHODS

The response of oil palm seedlings to dry season irrigation and fertilizer levels were studied for 12 months (July 1993 July1994) at the nursery site of the Nigerian Institute for Oil Research (NIFOR), Benin, Nigeria (6°33'N, 5°37'E). Some climatic data of the NIFOR Main Station covering the period is shown in Table 1. The seedlings were raised by the double-stage nursery method. Unsieved top soil (about 0-15 cm depth) was used to fill both the small pre-nursery) and the large (main nursery) polybags 2 weeks before planting. Analysis of the soil used for the study indicated 4.3% clay, 2.4% silt, 93.3% sand, and a pH of 6.3. Chemical analysis showed 0.08% nitrogen, 0.67% organic carbon, 10.80ppm phosphorus, 0.085, 0.20, 0.40 and 0.175 meq/100g soil potassium, magnesium, calcium and sodium, respectively.

Table 1. Rainfall, sunshine and temperature data for the NIFOR Main Station in 1993 and part of 1994.

Month	Monthly Rain fall (mm)		Sunshine hours per month		Mean daily temperature (°C)	
	1993	1994	1993	1994	1993	1994
January	0.5	46.2	155.0	158.1	26.6	27.1
February	151.5	16.1	204.4	142.8	28.7	28.6
March	91.3	-	195.3	-	27.9	-
April	108.8	214.0	174.0	153.0	28.6	23.5
May	268.8	144.9	182.9	198.4	27.7	27.8
June	227.4	344.4	120.0	135.0	26.6	26.6
July	232.0	404.0	71.3	68.2	23.1	25.3
August	281.2	466.0	55.8	34.1	25.4	25.0
September	270.7	482.0	114.0	55.8	25.5	25.2
October	48.4		179.8		26.5	
November	8.2		186.0		26.8	
December			182.9		26.8	

Sprouted Extension Work Seeds (EWS) were planted in July 1993 into pre-nursery polybags (12.5 x 25 cm lay flat, with a gauge of 250) and at three months after, the seedlings were transplanted into the main nursery polybags (35 x 40 cm lay flat, with a gauge of 500). Both the pre-nursery and main nursery polybags were mulched with bunch refuse (Gunn et al., 1961; Iremiren, 1982). The pre-nursery polybags were clustered together while the main nursery bags were arranged at a spacing of 46 cm between and within rows (Lucas, 1981).

The experiment was laid out as a 3 x 2 factorial in randomized complete block design and replicated four times, with four seedlings per treatment combination. The three levels of fertilizer were applied as NPKMg (12:12:17:2) compound fertilizer at 28 g per seedling (applied in two equal doses of 14 g each at 3 and 5 months after planting), 42 g per seedling (applied in three equal doses of 14 g each at 3, 5 ad 8 months after planting) and 70 g per seedling (applied in five equal doses of 14 g each at 3, 4, 6, 8 and 10 months after planting). The two levels of irrigation water were 2 litres per seedling per week (applied in two equal doses of 1 litre each, Mondays and Thursdays) and 5 litres per seedling per week (applied in five equal doses of 1 litre each, Mondays, Tuesdays, Wednesdays, Thursdays and Fridays).

Plant height, number of leaves and leaf area were measured at 3, 6 and 12 months after planting in the pre-nursery. Leaf area was estimated by methods described by Hardon *et al.* (1969) and Corley (1976). Plants were oven-dried at 65°C to constant weights and the dry weights measured. Girth was taken as circumference of palm base estimated with a thread and measured on metric rule. Transplantable seedlings were vigorous

seedlings that had reached a height of at least 60 cm, had at least 10 leaves and a girth of 13 cm and above, with no growth abnormalities.

RESULTS

Seedling height and number of leaves at 3, 6 and 12 months after planting (MAP) are shown in Table 2. The different levels of irrigation and fertilizer did not have any significant effect (P>0.05) on seedling height up to 12 MAP. There was no significant difference (P>0.05) in the number of leaves at 3 MAP due to the treatments. However, at 6 and 12 MAP seedlings receiving the same level of 2 litres of water per week showed significant differences in number of leaves produced due to fertilizer treatment, with those treated with 42 g of compound fertilizer producing significantly more leaves than those treated with 28 g or 70 g. Whereas seedlings receiving same levels of 5 litres of water per week only showed response to fertilizer at 12 MAP with those treated with 70 g compound fertilizer producing the greatest number of leaves, but these were only significantly higher than those receiving 28 g fertilizer. Number of leaves was not significantly affected by the different irrigation levels at any period.

Table 2: Effect of irrigation and fertilizer levels on height and number of leaves of oil palm seedlings at different ages.

Irrigation (litres/week)	Fertilizer (g/seedling)	Seedling Height (cm/)			Number of leaves/palm		
		3 months	6 months	12 months	3 months	6 months	12 months
2	28	18.4a*	31.5a	59.3a	3.6a	7.9a	12.5a
	42	18.8a	33.0a	73.0a	3.6a	9.0b	14.8b
	70	18.5a	34.2a	65.0a	3.4a	7.0a	10.6a
	Mean	18.6a+	32.9a	65.8a	3.5a	8.0a	12.6a
5	28	19.8a	35.8a	67.0a	3.9a	8.5a	11.4a
	42	19.3a	32.1a	62.0a	3.8a	8.1a	12.3ab
	70	19.5a	34.0a	82.8a	3.9a	8.0a	14.0b
	Mean	19.5a	34.0a	70.6a	3.9a	8.2a	12.6a

*Values under the same irrigation level followed by a similar letter are not significantly different.
+Irrigation means followed by a similar letter are not significantly different.

There was no significant difference (P> 0.05) in leaf area per palm due to irrigation or fertilizer levels at 3 and 6 MAP (Table 3). But the response to fertilizer at 12 MAP depended on the level of irrigation. While at 2 litres of water per week, leaf area significantly increased as fertilizer rate increased from 28 g to 42 g and significantly decreased as rates increased to 70 g, leaf area increased and was significantly highest at 70 g compound fertilizer for palms receiving 5 litres of water per week. Girth was not significantly affected by the treatments, but tended to follow the same trend with leaf area (Table 3).

Table 3. Effect of irrigation and fertilizer levels on leaf area and girth of oil palm seedlings.

Irrigation (litres/wee	Fertilizer (g/seedling)	Leaf area (cm^2Seedling) 3 months	6months	12 months	Girth (cm) 12 months
2	28	68.9a*	410.6a	1883.1a	16.0a
	42	77.4a	503.0a	4189.6b	19.5a
	70	68.5a	366.6a	2041.9a	15.3a
	Mean	71.6a+	426.7a	2704.9a	16.9a
5	28	77.3a	512.5a	1787.7a	15.1a
	42	70.0a	408.8a	2443.2a	16.8a
	70	65.7a	490.5a	4307.4b	19.7a
	Mean	71.0a	470.6a	2846.1a	17.2a

*Values under the same irrigation level for the 3 ages followed by a similar letter are not significantly different.
+Irrigation means followed by a similar letter are not significantly different.

Irrigation levels did not significantly affect fresh weight and dry matter yield (Table 4) but the effect of fertilizer on these parameters also depended on the level of irrigation. For the 2 litres per week irrigation fresh and dry weights were significantly greatest for palms receiving 42 g compound fertilizer compared with lower or higher levels, while fresh and dry weights increased and were significantly greatest at 70 g compound fertilizer compared with lower rates for palms irrigated with 5 litres of water per week. Root dry weight and shoot-root ratio were not significantly affected by fertilizer or irrigation levels (Table 4).

Table 4: Effect of irrigation and fertilizer levels on fresh and dry weights of seedling and shoot-root ratio (dry weight basis) at 12 months after planting.

Irrigation (litres/week)	Fertilizer (g/seedling	Fresh weight/palm (g) Shoot	Root	Dry weight/palm (g) Shoot	Root	Total	Shoot-root ratio
2	28	167.3a*	46.0a	50.6a	15.5a	66.1a	3.3a
	42	321.6b	77.4b	88.3b	23.7a	112.0b	3.8a
	70	194.9a	51.4ab	55.3a	16.4a	71.7a	3.5a
	Mean	227.9a+	58.3a	64.7a	18.5a	83.2a	3.5a
5	28	154.8a	46.3a	44.9a	15.5a	60.4a	3.3a
	42	193.1a	51.0a	54.4a	16.8a	71.2a	3.3a
	70	311.3b	70.9a	89.0b	22.8a	111.8a	3.9a
	Mean	219.7a	56.1a	62.8a	18.4a	81.1a	3.5a

*Values under the same irrigation level followed by a similar letter are not significantly different.
+Irrigation mean followed by a similar letter are not significantly different.

There was no significant difference ($P > 0.05$) in percent transplantable seedlings and vacancy as a result of the treatments (Table 5), although palms treated with 42 g compound fertilizer under irrigation levels of 2 litres and those treated with 70 g compound fertilizer under irrigation leaves of 5 litres tended to have higher values of transplantable seedlings. Percent transplantable seedlings also tended to be higher with higher irrigation frequency (Table 5).

Table 5. Effect of irrigation and fertilizer levels on percent transplantable seedlings, vacancy and leaf colour at 12 months after planting.

Irrigation (litres/week)	Fertilizer (g/seedling)	Transplantable Seedling (%)	Vacancy (%)	Leaf colour
2	28	63.5a[+4]	1.0a[4]	Pale green
	42	76.0a	13.5a	
	70	51.0a	13.5a	Green to dark green
	Mean	63.5a+	9.3a	
5	28	63.5a	1.0a	Green to dark green
	42	88.5a	1.0a	
	70	101.0a	1.0a	-
	Mean	84.3a	1.0a	
				Pale green to green
				Green
				Dark green
				-

[+]Values under the same irrigation level followed by a similar letter are not significantly different.
[*]Irrigation means followed by a similar letter are not significantly different
[4]All values are transformed by x + 1.

DISCUSSION

The non-significant differences due to the two irrigation levels of 2 and 5 litres of water per week were probably due to the non-limiting supply of water to the seedlings at the lower level. At the level of soil at which seeds were planted, the standard nursery polybags (35 x 40 cm) contained about 11 litre soils weighing about 12.5 kg. Available water was estimated at 30 mm (Ugbah and Babalola, 1989). Although water consumption of field nursery increased during February and March to a peak of 38 mm per week in April, the average water consumption per week is put at 25 mm (Sly and Sheldrick, 1961; Rees and Chapas, 1963). Under moderate water consumption therefore the available water in the polybag can serve the seedling for up to one week. The 2 litres of water (40 mm water) is more than adequate for the seedlings. Five litres was therefore excessive, even in areas with slightly higher demand (Corley and Tinker, 2003). This agrees with the suggestion that 1 to 2 litres of water applied once or twice a week seemed adequate for polybag seedlings (Aya, 1972).

Optimum level of fertilizer (42 g/seedling) was achieved with a 2 litre/week irrigation, whereas the highest level of fertilizer (70 g/seedlings) gave the maximum growth under the 5 litres/week irrigation. The difference in response was probably due to the high leaching of nutrients in these sandy soils (Omoti *et al.*, 1983). The 5 litres of water per week (100 mm water) was much in excess of the water capacity of the polybags soil even after considering the consumptive use by the seedlings.

The difference in the optimal rate of 42 g NPKMg (12:12:17:2) per seedling from previously recommended rate of 28 g per seedling under similar watering regime, was probably due to the low nutrient status of the nursery soils used. Whereas the soils used by Onwubuya and Ofoh (1990) were high in exchangeable cations, soils used for this study were low in these elements. Oil palm seedlings demand a lot of potassium in addition to other elements (Lucas et al; 1979; Sidhu *et al*, 2000). Although the nutrient status of soils used in his first study was not reported (Onwubuya, 1982), these soils are expected to be richer than those used in his later study as the experiment was carried out much earlier at the same nursery site that has been in continuous use.

Compound fertilizer, NPKMg (12:12:17:2), increased oil palm growth and dry matter yield up to a certain optimal rate, after which growth was rather depressed. The depression in growth was also reported by

Onwubuya (1982). Optimal rate seemed to depend on soil nutrient status, but watering at these rates should not be greater than 2 litres per seedling per week. Watering seedlings daily could increase fertilizer use, but this is inefficient and uneconomical as lower rates of watering and fertilizer application are not limiting to the palm.

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