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Effect of Salinity on the Performance of Coconut Seedlings in Two Contrasting Soils

S. U. REMISON [1] and G. O. IREMIREN [2]

[1]*Nigerian Institute for Oil Palm Research*
P.M.B. 1030, Benin City, Nigeria

[2]*Dept. of Crop Production, Federal University of Technology,*
P M B 704, Akure, Nigeria

ABSTRACT

Coconut seedlings were raised in poly-bags in two contrasting soils and common salt was applied at the rate of 0, 2, 4, 6, 8, 10 and 12 g per seedling. The study was carried out from June 1982 to July 1983 and December 1982 to November 1983.

The seedlings were quite tolerant of salination. Dry matter accumulated in plant parts were in the order, leaves>roots>stem. Uptake of applied nutrients was very high compared with control treatments in both experiments; it was higher for Na than for Cl. Uptake of nutrients was higher in the maritime than in the forest soil, showing evidence of ecological adaptation of the seedlings to the maritime environment in which they are traditionally grown in Nigeria.

INTRODUCTION

The growth and development of coconut is affected by many management factors. Vigorous growth of trees in the field can only be achieved with selected healthy seedlings. Thus proper nursery management practices are essential.

Coconut is grown extensively along the West African coast and is subjected to a great deal to sea water. The plant was thought to be a halophyte but it is known to grow under a wide range of ecological conditions (Purseglove, 1975). The effects of salinity on plant growth have been extensively studied (see Hira & Sing, 1973; Maas & Nieman, 1978; Manciot *et al.*, 1979). Apart from inducing osmotic adjustment with the attendant effects on water relations and growth, salinity also causes structural changes which vary with plant species and type of salinity.

Sea salt is applied on coconut groves by planters in India, Java and Colombia (Child, 1974; Manciot *et al.*, 1979). Response to sodium chloride has been recorded in coconut well supplied with potassium (Lunt, 1966). Other workers have observed that sodium chloride significantly increased the number of inflorescences and the number of female flowers per tree (Fremond *et al.*, 1966), and the development and fruit yield of coconut (Roperos & Bangoy, 1968).

The response of coconut to other chlorine-containing salts like potassium chloride has also been noted but the importance of chlorine in coconut nutrition in certain countries was reported only in the '70s (Ollagnier & Ochs, 1971; Von Uexkull, 1972; Magat *et al.*, 1975). Chlorine in the form of either KCl or NaCl is easily absorbed by palms (Magat *et al.*, 1975) and the amount of chlorine in the soil depends on rain and sea water (Manciot *et al.*, 1979). However, the physiological role of chlorine in coconut is not yet well understood.

This paper reports the preliminary results of a study on the effect of salinity on growth of coconut seedlings in the nursery.

MATERIALS AND METHODS

The study was conducted at the Nigerian Institute for Oil Palm Research (NIFOR), Benin City, Nigeria from 1982-1983. Two experiments were carried out in polyethylene bags of 40 x 40 cm size and 0.013 cm gauge. The poly-bags were filled with topsoil from two different environments, namely Badagry representing the maritime environment and Benin representing the forest zone. Each poly-bag was filled with an average of 15.0 kg of soil and arranged in the field 45 x 45 cm apart. The chemical composition of soils used is shown in Table 1.

Table 1 - *Chemical Composition of Soils Before Application of Salt*

Soil type	Ph	N (%)	P (ppm)	K	Ca (meq / 100 g)	Mg	Na	Cl (ppm)	C (%)	Exchange acidity meq/100g
Experiment 1										
Benin	5.76	0.26	38.17	0.21	2.35	0.85	0.09	0.007	0.96	0.38
Badagry	6.16	0.19	38.26	0.25	1.70	0.45	0.12	0.009	0.40	0.30
Experiment 2										
Benin	5.19	0.16	37.91	0.60	2.00	1.43	0.37	0.008	1.40	0.55
Badagry	5.25	0.14	37.82	0.38	1.65	0.85	0.35	0.008	0.97	0.45

Seednuts of the tall variety were sown in river sand and seedlings with two leaves were selected after five months. In the first experiment, these seedlings were transplanted into poly-bags on 1 July, 1982. The plants were irrigated adequately. Common salt was applied at the rate of 0, 2, 4, 6, 8, 10 and 12 g per seedling every fortnight. Chemical analysis of salt used is shown in Table 2. Application was done in a ring form about 5 cm from the seedlings and irrigated lightly.

The layout was a 2 x 7 factorial scheme comprising two soils and seven salination treatments. Each treatment had a sample size of ten seedlings and these were replicated three times giving 30 seedlings per treatment. Plant height, leaf number and stem girth were recorded at three-monthly intervals. Plant height was determined by measuring the length from the top of the seednut to the tip of the longest leaf. A non-destructive growth parameter, MHN ('mean-height-number', i.e. plant height in cm multiplied by number of leaves), was determined at three-monthly intervals. In MHN determinations, dead leaves were not counted (Ellern, 1974; Remison, 1982). The rate of change in MHN units was calculated as (a-b)/t, where a is the MHN units during the period under reference, b is the MHN units during the preceding period and t is the time (in days).

Table 2 - *Chemical Composition of Common Salt Used*

pH	7.2
N (%)	0.5
P (ppm)	7.02
K (meq/100 g)	16.0
Ca (meq/100 g)	6.96
Mg (meq/100 g)	1.64
Na (meq/100 g)	1,304.3
Cl (ppm)	570,000
C (%)	1.16
Exchange acidity (meq/100g)	0.35

The plants were grown for 12 months (1 July, 1982 to 30 June, 1983). Salination treatment was stopped four weeks prior to the termination of the experiment. At the end of the experiment, plants were harvested and separated into leaves, stem and roots, washed and oven-dried to constant weight.

The second experiment, carried out from 1 December, 1982 to 30 November, 1983, was similar to the first except that a dwarf coconut variety was used and the trial commenced in the dry season. In both experiments, samples of plant parts were analysed for chlorine and sodium.

RESULTS

The seedlings responded to salt at low rates of about 2 g as evidenced from increased girth, height and leaf number. The plants tolerated higher levels of salt but there was no significant increase in any of the growth parameters (Table 3). Leaf splitting was also not affected.

Table 3 - *Effect of Salt Application on Vegetative Growth of Coconut Seedlings at harvest, Expt. 1*

Rate Applied (g) seedling $^{-1}$	*Girth (cm)*	*Height (cm)*	*Leaf Number*
0	21.3	132.4	7.7
2	25.0	141.2	9.0
4	21.7	123.6	7.3
6	22.7	118.8	8.5
8	21.8	126.4	8.3
10	24.0	133.6	8.2
12	23.5	127.2	7.8
SE	2.34	10.78	0.92

In the first experiment, salt did not influence MHN but it increased with age of the seedlings (Table 4 a). The data on rate of change in MHN showed that there was decrease in MHN during the period May to August (Table 4 b).

Table 4 - *Effect of salt application on (a) Mean Height number (MHN) and (b) rate of change in MHN Units, Expt. I*

(a)

Rate applied (g) seedling $^{-1}$	*Mean height number (MHN)* Nov.	Feb.	May	August
0	315.6	541.5	949.6	1019.5
2	316.8	528.0	1090.1	1270.8
4	230.2	417.5	862.5	902.3
6	266.9	464.4	758.2	1009.8
8	262.7	511.0	877.5	1049.1
10	272.5	517.8	984.8	1095.5
12	314.0	527.4	859.2	992.2

(b)

	Rate of change of MHN Units *Nov. to Feb (F)*	*Feb. to May (M)*	*May to August (A)*
0	2.51	4.53	0.78
2	2.35	6.25	2.01
4	2.08	4.94	0.44
6	2.19	3.26	2.80
8	2.76	4.07	1.91
10	2.72	5.19	1.23
12	2.37	3.69	1.48

Generally, there was an increase in dry matter due to salt application at lower levels of 2-6 g seedling (Table 5). In the first experiment, dry matter of leaves increased by 48% when salt was applied at the rate of 6 g/plant. Corresponding increase in total dry matter (TDM) at the same level of salt was 39%. In the second experiment, the highest increase in TDM of 32% was at 2 g of salt. At the highest concentration of salt, some seedling mortality was recorded.

Dry matter accumulation in plant parts was in the order leaves>roots>stem; the overall mean for both experiments being 283, 54 and 33 g respectively. There was no difference in dry matter between plants in Benin and Badagry soils.

Salt application had effect ($P< 0.05$) on top/root ratio in the first experiment but there was no particular pattern. The uptake of applied nutrients was very high compared with the control in both experiments (Table 6) and it was higher for Na than Cl. Uptake of Na and Cl was much higher ($P< 0.001$) in the maritime (Badagry) soil than in the forest (Benin) soil in the first experiment (Table 7). The differences was less significant ($P< 0.05$) in the second experiment. In experiment 1, there was soil type x salination interaction for Na uptake; when no salt was applied, uptake of Na was higher from the forest soil but with the application of salt at all levels, uptake was higher in the maritime soil.

Table 5 - *Effect of Salt Application on dry weight (g) plant-1 of coconut seedlings.*

Rate applied (g) seedling $^{-1}$	*Leaves*	*Stem*	*Roots*	*Total dry matter (excluding nut)*
Experiment 1				
0	252.3	30.8	65.4	348.5
2	344.8	47.7	76.8	469.3
4	285.5	29.2	67.6	382.3
6	372.7	38.7	74.0	485.4
8	306.6	41.1	73.6	421.3
10	295.4	33.9	60.8	390.1
12	267.2	28.1	40.3	335.6
SE	62.02	9.10	13.13	104.19
Experiment 2				
0	255.5	28.1	36.4	319.9
2	348.0	38.2	36.1	422.3
4	252.2	32.0	44.3	328.5
6	244.5	24.6	57.0	326.1
8	256.5	30.1	45.0	331.5
10	253.9	33.5	44.4	331.8
12	231.8	25.8	32.2	289.8
SE	72.75	7.22	9.81	83.94

Table 6 - *Effect of salt application on top/root ratio and uptake of applied nutrients (Na and Cl) in coconut seedlings.*

Rate applied (g seedling $^{-1}$)	*Top / root ratio*	*Na uptake (g pant $^{-1}$)*	*Cl uptake (g plant $^{-1}$)*
Experiment 1			
0	5.03	23.3	187.5
2	5.21	99.1	368.6
4	4.43	109.4	443.0
6	6.36	146.0	452.1
8	4.97	111.4	397.2
10	5.47	125.4	539.7
12	7.72	202.6	675.5
SE	0.914	28.30	98.80
Experiment 2			
0	8.21	45.1	164.3
2	10.39	160.2	330.3
4	7.29	128.3	343.9
6	5.76	122.8	250.8
8	6.16	122.9	299.8
10	6.66	144.9	281.4
12	8.10	129.5	273.6
SE	1.531	32.71	78.19

Table 7 - *Top / root ratio and uptake of applied nutrients (Na and Cl)in coconut seedlings grown in Benin (forest) and Badagry (Maritime) soils*

Soil Type	*Top/root ratio*	*Na uptake* ($g\ plant^{-1}$)	*Cl uptake* ($g\ plant^{-1}$)
Experiment 1			
Benin (forest)	5.23	88.7	372.9
Badagry (Maritime)	5.86	144.8	502.4
SE	0.488	15.13	52.81
Experiment 2			
Benin (forest)	8.07	106.9	246.48
Badagry (Maritime)	6.95	135.6	309.0
SE	0.665	17.48	41.79

DISCUSSION

The tolerance of coconut to saline conditions has been reported by many workers and the use of NaCl has been a common practice in many coconut groves (Fremond *et al.*, 1966; Roperos & Bangoy, 1968). In fact, the common observation that coconut along coastal areas was more productive than those inland is due to the possibility of abundance of sodium in such areas substituting for potassium (Nartea & Reyes 1973).

The importance of Cl in NaCl and in other Cl sources was not realized until fairly recently. It has now been shown that the response observed from such nutrient applications is due to C1 and not to K or Na since Cl levels in the leaf increased and were correlated with the growth of young palms and the production in adult palms (Ollagnier & Ochs, 1971; Von Uexkull, 1972; Magat *et al.*, 1975). The physiological role of Cl in the nutrition of coconut is not well understood but it is most likely that C1 is associated with the water economy of the plant. It seems that the stomata of coconut leaves deficient in Cl do not function properly (Von Uexkull, 1972). Recent findings indicate that certain families of plants lack chloroplasts and starch in their guard cells. For stomatal movements, such plants require Cl and coconut belongs to this group of plants (Von Uexkull, 1985).

Other workers believe that yield responses with the use of NaC1 cannot be attributed to the effect of Cl (Roperos & Bangoy 1968). In this study, the level of uptake of nutrients relative to the control was greater for Na than for Cl. The higher uptake of Na and Cl in maritime soils in which coconut is traditionally grown in Nigeria is of ecological importance. Though seedlings did not produce more dry matter in the maritime soil, there is clear evidence that the seedlings were physiologically adapted to this environment with regard to uptake of applied nutrients as seednuts for the experiment were collected from the sub-station, Badagry located in the maritime environment. It is possible to establish this unequivocally if experiments are carried on for a longer period; for instance, if materials collected from the two contrasting environments are grown on two such contrasting soils, evidence of ecological adaptation in terms of yield may be firmly established. This aspect will need to be examined in future experiments.

The decrease in MHN units from 9 to 12 months indicates that there was no appreciable increase in growth during this period. Hence it is recommended that seedlings should be transplanted after nine months in the nursery (Remison, 1987).

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