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EFFFCT OF SODIUM CHLORIDE ON GROWTH AND YIELD OF COCONUT PALMS IN A LATERITE SOIL

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Among the fertilizer elements supplied to coconut, potassium is the one which is applied in largest quantity. From time immemorial, farmers of Kerala practised the application of sodium chloride to coconut palms grown in laterite soils. The essentiality of sodium to some halophytes like *Atrip/ex vascicaria* has already been reported, (Brownell, 1965). The beneficial effect of sodium chloride on coconut has been reported by Briones (1931) and Barrant (1975). Ziller and Prevot (1963) reported that the critical level of Na in the 14th leaf was 0.4% which was not desirable to exceed. Smith (1969) reported that Na could replace K in coconut when the foliar concentration of K was less than 0.5% and that of Na was less than 0.4%. Mathew *et al.* (1984) found that substitution of K_2O by Na_2O to the extent of 50% or even *75%* did not reduce the yield of coconut grown in a laterite soil. They made these observations based on the study in which samples were analysed five years after the imposition of NaCl treatments to 24 year old palms which were receiving application of potassium chloride before the commencement of the experiment. The present study was undertaken making use of the same experimental palms studied by Mathew *et al.* (1984), but the samples were drawn when the palms completed 10 years after the imposition of NaCl treatments.

Materials and Methods

The soil and leaf samples were collected from a field experiment which was in progress at the Regional Agricultural Research Station, Pilicode, Kasaragod, Kerala in order to evaluate the effect of sodium chloride on coconut. This experiment was laid out in 1976, in randomised block design with six treatments and four replications maintaining six palms in each plot. The treatments were as follows (T1) Control, (T2) 1000 g K_2O, palm/year, (T3) 750 g K_2O/plam/year + 250g Na_2O/palm/year, (T4) 500 g K_2O/palm/year + 500 g Na_2O/palm/year (T5), 250g K_2O/palm/year + 750 g Na_2O/palm/year and (T7) 1000 g Na_2O/palm/year. The above treatments applied as potassium chloride and sodium chloride were superimposed on 24 year old stock of hybrid palms in 1976 which were receiving N, P and K according to the package of practice recommendation of the Kerala Agricultural University till then (Anon, 1976). In addition to the above treatments, the experimental palms also received N (500 g), P_2O_5 (320 g), CaO (300 g), MgO (170 g) per palm per year as urea, superphosphate, lime and magnesium sulphate respectively, and the cultural practices as recommended by the Kerala Agricultural

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University (Anon. 1976). The soil of the experiment site is laterite and the area receives an average annual rainfall of about 3200 mm. The soil and leaf samples were collected during 1986.

To study the nutrient uptake of palm, the leaf samples (14th leaf) were analysed for the various nutrient contents. Total N, P, K, Na, Ca and Mg were determined following standard analytical procedures (Jackson, 1958; Hesse, 1972). For the determination of chloride in the plant sample, organic matter was destroyed by digestion with HNO_3 and permanganate in the presence of excess $AgNO_3$. Chloride was precipitated as AgCl, the excess Ag being titrated with thiocynate in the presence of acetone, using ferric iron as indicator (Anon, 1972).

The observations on growth and yield of the experimental palms recorded at the Regional Agricultural Research Station were made use for the study. The number of leaves retained at the crown per year, number of female flowers produced per palm per year and annual nut production per palm for the last eight years (1978-85) and during the pre-treatment period were used for the statistical analysis of these data.

The soil samples were subjected to various chemical analyses. Organic carbon, total N, available P (Bray, No. 1), available K (1 *N* neutral NH_4OAc), available Na (1 *N* neutral NH_4OAc), available chloride (water), CEC, exchangeable cations, pH and EC were determined following standard analytical procedures (Jackson, 1958).

The biometric observations were subjected to analysis of covariance taking pre-treatment values as the covariate and the results of chemical analysis of soil and leaf were subjected to analysis of variance (Panse and Sukhatme, 1985).

Results and Discussion

The treatments did not differ in their influence on the number of functioning leaves, number of leaves produced per palm per year, number of female flowers produced per palm per year and the difference in annual yield of nuts per palm between the pre-treatment and post-treatment period (Table 1). Maximum increase in yield was (28.56 nuts/palm/year) in palms receiving T4 (50% substitution of K_2O by Na_2O). Though there was 104.15% increase in yield in T4 as compared to T_1, the difference was not found statistically significant, the significance being lost by marginal difference. When the mean yield of nuts/palm/year was subjected to analysis of covariance technique with post-treatment data for the period 1980-85 and the pre-treatment data for the period 1973-76 (covariate), the treatments showed significant difference in their influences. The maximum value was recorded by T2 (86.84 nuts/palm/year). The treatments T2 was closely followed by T4 and the differences between T2, T4, T5, T6 and T8 were not significant.

The treatments showed no significant difference in their effect on total N, P, Ca, Mg and Cl content of the leaf, whereas K and Na contents of leaf were found significanty influenced by the treatments (Table 2).

Among the soil chemical properties affecting nutrient availability, only available K status of the soil was found to differ significantly by the application of treatments. The organic carbon content of soil, Total N, available P, available Na, available Cl, exchangeable Ca, exchangeable Mg, pH, EC and CEC of the soil did not differ due to the influence of treatments (Table 3).

The yield has been markedly influenced by the application of the treatment, the performance of the palms in treatment receiving full dose of K_2O and 50% K_2O substituted by Na_2O being comparable. The fact that 50% substitution of K_2O by Na_2O did not reduce the yield is of high practical significance since the cost of NaCl is cheaper as compared to KCi. It is believed that Na may partially substitute the role of K in plants and hence maintains the same level of yield at this rate of substitution. It is also possible that requirement of K assessed in terms of KCI may be the combined requirement of K and Cl and the requirement of K would have been over estimated to cover the requirement of Cl also. When KCI is substituted by NaCl, only K is substituted without affecting the supply of Cl to any significant extent, Since in the present experiment, both Na and K are supplied as chlorides it is not possible to partition the effect of Cl from that of K or Na. However, it can be confirmed that the present recommendation of K_2O can be substituted by Na_2O to the extent of 50% without reduction in the amount of Cl supplied. Barrant (1975) concluded that coconut palm should be placed in the category of plants which responded to Na when available K is high.

The uptake of N, P, Ca, Mg and Cl did not vary significantly by the application of treatments. This shows that the proportion of K or Na applied to the soil does not affect the uptake of other nutrients from the soil. The K and Na uptake differed significantly by the treatments. The values of K uptake corresponding to T2, T3. T4, T5 and T6 were 1.116, 0.944, 0.865, 0.843 and 0.604 percent respectively. This gradation in K content clearly reflects the influence of the treatments. The treatments T2 and T3 retained significantly higher amount of K as compared to T1 and T6. However T2, T3, T4 and T5 were statistically on par. While the K content of leaf of palms in T6 was 0.604%, that of T1 was 0.616%. This marginal increase in the content of K in T1 over T6 can be attributed to the antagonism between K and Na. In the presence of high level of Na the absorption of K from soil would have been affected marginally. However, T1 and T6 were statistically on par. Antagonism between K and Na is also evidenced by the negative correlation between K and Na content of leaf (-0.5914*) and Na content of leaf and available K in soil (-0.4230*). Antagonism between Na and K has also been reported by Barrent (1975). However, in the present study, the negative

correlation between K and Na in soil or leaf is partially due to the effect of treatments, because in treatments except T1 (control), the rates of application of K_2O increase while that of Na_2O decrease or vice versa.

The values of Na in leaf ranged from 0.221 to 0.419 per cent. The influence of treatments on the content of Na in leaf was found to be significant- In general, palms receiving higher level of Na retained higher amount of Na in their leaves. However T6, T5, T4 and T3 were statistically on par. The treatment T2 retained significantly less amount as compared to other treatments. T1 contained higher amount of Na as compared to T2. This can be attributed to the antagonism between Na and K. Application of K in the absence of Na would have been adversely affected the uptake of Na from the soil in T2 while such an antagonistic effect of K is not expected in T1 (control).

Yield was found significantly correlated with number of leaves retained by the palm per year ($r = 0.6722^{**}$), total number of leaves produced by the palm per year ($r = 0.5585^{**}$), and number of female flowers produced per palm per year ($r = 0.4964^{*}$). The simple linear regression equation of yield on number of leaves retained by the palm showed that the minimum number of leaves required for the very expression of yield is 13.5 and unit increase in number of leaf will correspond to a yield increase of 5.045 nuts per palm per year. This relationship is quite understandable since palms with higher number of leaves can synthesise more dry matter and give increased yield as compared to a palm with less number of leaves retained. Similar observations have been made by Gopi (1981) and Krishnakumar (1983). The positive correlations between yield and the total number of leaves produced by the palm per year and number of female flowers produced per year are self explanatory. The number of functioning leaves was significantly correlated with the total number of leaves produced per palm per year ($r = 0.7401^{**}$). A palm which produces leaves at a faster rate will normally retain more number of leaves at its crown at any period of time and therefore the relationship between total number of leaves produced and the number of leaves retained by the palm is quite anticipated.

Significant positive correlations between K and P content of leaf ($r = 0.4226^{*}$) and negative correlation between Ca and Mg content of leaf ($r = -0.4809^{*}$) were observed. The increased uptake of K would have favourably affected the uptake of P and the antagonism between the divalent cations Ca and Mg is expressed in the negative correlation between the two.

The application of treatments did not adversely affect the available nutrients status of the soil or the pH, EC or CEC. But there was marked variation in the content of available K in soil between treatments. Treatments receiving higher amount of K retained higher amount of this element in soil. Treatments T2 and T3 differed significantly from all other treatments in this respect. However, T5, T6 and T1 were statistically on par. The amount of Nad applied did not affect the availability of other nutrients.

Table 1

Effect of treatments on growth and yield of palm under sodium chloride trials in laterite soil

Sl. No.	Treatment K_2O g/palm/year	Treatment Na_2O g/palm/year	No. of functioning leaves/palm/year: Pre-treatment 1971-76	No. of functioning leaves/palm/year: Post-treatment 1978-85	No. of functioning leaves/palm/year: Adjusted mean	No. of leaves produced/palm/year: Pre-treatment 1971-76	No. of leaves produced/palm/year: Post-treatment 1978-85	No. of leaves produced/palm/year: Adjusted mean	No. of female flower/plant/year	Yield, nuts palm/year: Pre-treatment 1973-76	Yield, nuts palm/year: Post-treatment 1980-85	Yield, nuts palm/year: Adjusted mean	Difference* in yield, nuts/palm/year
1	0	0	29.65	28.95	28.50	12.25	12.11	11.95	236.75	68.84	75.37	69.72	13.99
2	1000	0	28.93	28.86	28.80	12.11	12.02	11.94	262.15	68.31	92.07	86.84	27.08
3	750	250	28.91	29.35	29.30	11.96	11.99	12.01	219,95	58.67	71.32	73.82	18.38
4	500	500	29.84	30.49	29.94	12.33	12.79	12.59	233.40	59.91	83.30	84.81	28.56
5	250	750	26.50	27.73	29.00	11.26	11.98	12.43	244.37	46.07	70.41	83-02	26.26
6	0	1000	29.18	29.83	29.64	12.06	12.40	12.38	226.95	68.96	81.13	75.38	21.05
CD	(0.05)				NS			NS	NS			15.49	NS

* Between Post-treatment (1978-85) and pre-treatment (1 973-76)

NS = Not Significant

Table 2

Effect of sodium chloride treatments on total nutrient content of leaf

Sl. No.	Treatment K_2O g/palm/year	Treatment Na_2O g/palm/year	Nutrient content of leaf % - N	P	K	Na	Ca	Mg	Cl
1	0	0	1.672	0.108	0.616	0.318	0.777	0.204	0.751
2	1000	0	1.881	0.122	1.116	0.251	0.763	0.166	0.800
3	750	250	1.863	0.118	0.944	0.299	0.740	0.142	0.773
4	500	500	1.689	0.119	0.865	0.342	0.717	0.271	0.817
5	250	750	2.017	0.116	0.843	0.355	0.782	0.138	0.767
6	0	1000	2.111	0.123	0.604	0.350	0.821	0.231	0.787
CD (0.05)			NS	NS	0.068	0.021	NS	NS	NS

Table 3

Influence of sodium chloride applied to coconut palm on soil chemical properties

Sl. No.	Treatment K_2O g/palm/year	Treatment Na_2O g/palm/year	Org. carbon (%)	Total N (%)	Available P (kg/ha)	Available K (kg/ha)	Available Na (kg/ha)	Available Cl (kg/ha)	Exch. Ca (me/100g)	Exch. Mg (me/100g)	pH	EC (mmho/cm)	CEC (me/100g)
1	0	0	1.112	0.135	57.06	168	116.62	94.84	1.63	0 899	5.14	0.115	11.55
2	1000	0	0.984	0.111	60.80	623	108.42	99.83	1.65	0.909	5.29	0.116	12.95
3	750	250	1.079	0.137	53.50	497	106.08	84.85	1.49	0.770	5.25	0.106	12.25
4	500	500	1.020	0.118	58.95	469	118 38	84.85	1.73	0.770	5.39	0.099	12.71
5	250	750	1.076	0.110	53.48	294	120.79	74.86	1.70	0.936	5.39	0.126	10.68
6	0	1000	1.152	0.123	63.86	189	130.70	99.83	1.56	0.856	5.40	0.114	12.83
CD (0,05)			NS	NS	NS	128	NS	NS	NS	NS	NS	NS	NS

Summary

An investigation was carried out drawing soil and leaf samples from coconut palms of a sodium chloride trial conducted at the Regional Agricultural Research Station, Pilicode, Kasaragod, Kerala, in order to evaluate the effect of sodium chloride on growth, yield and uptake of nutrients by coconut palms grown in laterite soil. The treatments were superimposed on 24 year old palms in 1976 and samples for the study were drawn in 1986. The palms were receiving substitution of KCl by NaCl in various proportions for the last 10 years. The study revealed that there was no significant difference in yield of nuts by substitution of KCl by NaCl. However, treatments receiving 100% recommended dose of K_2O and that receiving 50% substitution of K_2O by Na_2O appeared superior to other treatments. There was no significant difference between treatments in the case of other growth characteristics, and the nutrient uptake by the palms except K and Na. Palms receiving higher amount of K or Na retained higher amount of these elements. The available nutrient status of the soil except available K and basic chemical properties of the soil like, pH, EC and CEC remained the same. The available K content in soil increased with increased application of K to the soil.

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