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Effect of Potassium-Sodium Interaction on Foliar Nutrient Concentration and Nut Quality of Coconut (*Cocos nucifera*)

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ABSTRACT

Field experiments were carried out for three consecutive years to evaluate the effect of the interaction of potassium and sodium on foliar nutrient concentration, quality and quantity of coconut, grown in an acidic Ultisols in Kerala, India. The treatments comprised of different levels of potassium (K) as muriate of potash and sodium (Na) (common salt), either alone or in combination. The results showed that interaction between K and Na did not exert a significant effect on the foliar concentrations of nitrogen (N), phosphorous (P) and magnesium (Mg) as against K, Na and calcium (Ca). Full or partial omission of K for >2 years had a negative impact on nut yield, but this could be corrected by application of equal proportions of K and Na, which resulted in an increase in nut yield. The interaction between K and Na did not exert a significant effect on the quality of the kernel as indicated by biochemical characteristics. The treatments receiving K with Na registered a higher content of K and sugar in coconut water, but Na content was highest in full K treatment. Significant differences were not observed between treatments for pH, total mineral, and vitamin C content of the coconut water. The treatments studied could be beneficial to farmers cultivating coconut in acidic soils the world over.

Keywords: Foliar nutrients concentrations, nut quality, potassium-sodium interaction, acidic Ultisol

INTRODUCTION

Coconut (*Cocos nucifera* L.), considered to be the most important and useful of the tropical palms, is grown in more than 80 countries in the tropics. It has been cultivated in India from time immemorial, and India ranks third in the world in coconut cultivation area and first in coconut production (www.bgci.org/education/1685/). Though the palms do not require special care, they respond well to plant protection and nutrient management practices. Tissue nutrient composition has a significant effect on growth, development and yielding ability of plants. The nutrient potassium (K) has a special role in coconut nutrition as it improves the quality of nuts. The yield of the coconut palm is also increased with addition of K, hence a good share (52%) of the cultivation expenses account for the cost of this nutrient alone. India expends INR. 21270 crores (Kinekar, 2011) annually to import K fertilisers, thus efforts are required to increase its efficient

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use. In a study conducted with several tropical crops, Sudharmaidevi *et al*. (2006) found a beneficial interaction between K and sodium (Na) on crop yield in acidic soils. They reported that application of common salt increases yields and reduces the potash requirement of the crops tested. This study aimed to evaluate the effect of the application of Na (in the form of common salt) with K (as a muriate of potash) on foliar nutrients concentrations and quality of the nut in coconut.

MATERIALS AND METHODS

Site Description

The experiment was carried out in a 29-year old coconut plantation of the Instructional Farm of College of Agriculture, Kerala Agricultural University, Trivandrum, India (8°30 'E latitude, 76°54 'E longitude, and 29 m above sea level). The experiments were run for three consecutive years starting from 2004 - 2005. The variety of coconut was West Coast Tall, planted at a spacing of 7 m^2. The mean monthly rainfall of the study location during the cropping season ranged from 0 to 201 mm. The mean maximum and minimum temperature ranges were 29.6°C to 33.3°C, and 21.6°C to 24.9°C, respectively. The soil of the experimental site was loamy skeletal kaolinitic isohyperthermic Rhodic Haplustult with a low cation exchange capacity (CEC) (3.2 cmol (p+) kg^{-1}), acidic (pH <6.0), and with an electrical conductivity of $\leq$ 0.01 dS m^{-1}. The soil had a medium level of available nitrogen (N) (301 kg ha^{-1}) and K (241.1 kg ha^{-1}), and high level of available P (36.2 kg ha^{-1}).

Treatments and Experimental Design

The experiment was laid out in randomised block design with seven treatments and ten replications (*Figure 1*). One tree was taken as one treatment.

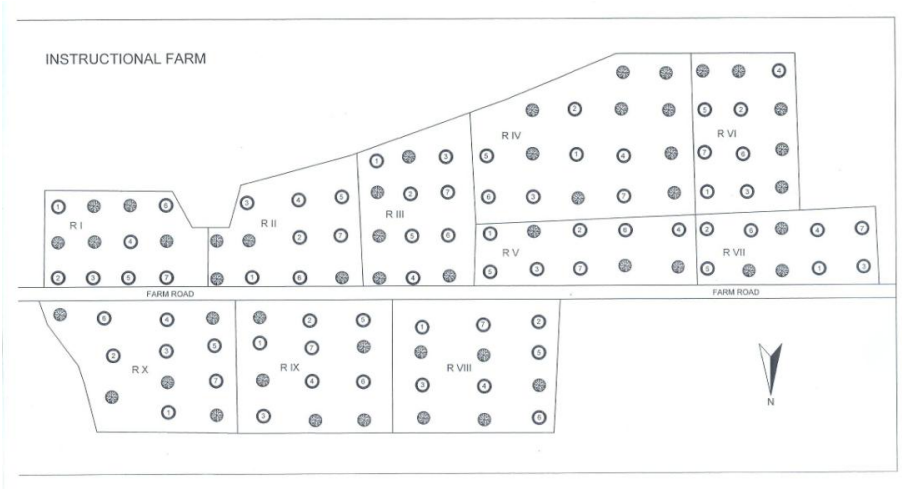

Figure 1: Lay out plan of the experimental field

The treatments comprised different levels of K and Na, either alone or in combination (Table 1). For the combination treatments, a partial dose of K was supplied as muriate of potash with the balance supplied as equivalent Na of common salt. Cattle manure at 25 kg palm^{-1} year^{-1}, N at 0.5 kg palm^{-1} year^{-1} and phosphorus (P) at 0.32 kg palm^{-1} year^{-1} were applied uniformly to all palms. Potassium and Na were applied as per treatment requirements (Table 1). The recommended dose of K for coconut is 1.2 kg K palm^{-1} year^{-1}. Potassium was supplied as muriate of potash (60% K) and Na, as common salt (39.3% Na) (KAU, 2011).

TABLE 1
Treatments and dose of K and Na fertilisers applied

Sl.no	Treat*ments*	Dose of K or/and Na (palm^{-1} year^{-1})
1	100% RD of K as MOP	MOP – 2 kg
2	50% RD of K as MOP	MOP – 1 kg
3	100% RD of K replaced by Na (of CS)	Common salt – 3 kg
4	50% RD of K replaced by Na (of CS)	Common salt – 1.5 kg
5	25% RD of K replaced by Na (of CS) + 75% RD of K as MOP	Common salt – 0.75 kg + MOP -1.5 kg
6	50% RD of K replaced by Na (of CS) + 50% RD of K as MOP	Common salt – 1.5 kg + MOP -1 kg
7	75% RD of K replaced by Na (of CS) + 25% RD of K as MOP	Common salt – 2.25 kg + MOP -0.5 kg

*Cattle manure @ 25 kg palm^{-1} year^{-1}, nitrogen @ 0.5 kg N palm^{-1} year^{-1} and phosphorus @ 0.32 kg P palm^{-1} year^{-1} were applied uniformly to all palms
RD – Recommended dose ; MOP - Muriate of potash; CS – Common salt

Chemical Analyses

Kernel and Coconut Water

Moisture and carbohydrate contents of the kernel were determined by the gravimetric method and titrimetry, respectively. Protein was estimated by the colorimetric method described by Spies (1957) and total minerals content by gravimetry. Coconut water was analysed for pH, total sugars, total minerals (determined by measuring total ash content), and vitamin C content (Thimmaiah, 1999).

Foliar Analysis

For the determination of foliar nutrient concentration, five whole leaflets from the middle portion of the 14th leaf in each palm were collected. The leaflet samples were air dried for two days and then oven dried at 65^{o}C for 48 hours and

powdered. The powdered samples were passed through a 1-mm sieve and mixed thoroughly. Weighed 10 g samples were drawn from this powder and stored in plastic bottles for wet acid digestion. From the stored sample, 0.5 g was digested with 10 ml concentrated H_2SO_4 and 1 g of catalyst mixture for determination of N by the modified Kjeldahl method. For determination of P, K, Na, Ca and Mg, 0.5 g samples were digested with 7 ml of a mixture of nitric and perchloric acid in the ratio of 9:4. Phosphorous was estimated by vanadomolybdate yellow colour method using a spectrophotometer (Systronics Model 169). Sodium and K were estimated using flame photometer (Elico Model CL 22 D). Calcium and Mg were estimated by Versenate titration (Cheng and Bray, 1951).

Nut Yield

The number of nuts per palm was counted in each harvest and recorded.

Statistical Analyses

Statistical analyses of the data were carried out using two-way analysis of variance (ANOVA). The F values for treatments were compared with tabled values. If the values were found to be significant, critical difference values at 5% significance level were calculated to compare means and interpret results.

RESULTS AND DISCUSSION

Effect of the Interaction of K and Na on Foliar Concentration of Plant Nutrients

No significant difference could be observed between treatments in the foliar concentrations of N and P during the final year of the experiment (Table 2). But significant differences were noticed in the foliar concentrations of K and Na. The concentrations of N, P and K were found to decrease in the treatments receiving half the recommended dose of K alone, or half or full Na alone. But in treatments where Na was also applied with K, this reduction was not observed. It was interesting to note that the foliar K concentrations in treatments receiving Na with K were higher than in the treatment of full K. In contrast, foliar content of Na was the highest in plots treated with 100 % K. The results of this study agree with Rubio *et al*., (1995) who found that a high affinity for K uptake was activated by micromolar Na concentrations and vice versa. Evidence for an increase in K uptake in the presence of Na has also been seen in wheat (Box and Schachtman, 2000). Thus, these findings suggest that the efficiency of K use could be increased by adopting combined applications of K and Na.

As far as secondary nutrients were concerned, there was a significant difference in the foliar Ca content of palms. In all the Na treated palms, there was a considerable increase in the Ca content compared to palms given the full K treatment. No significant difference could be observed in the Mg content. The low Ca content in the full K treated palms might be due to the antagonistic effects of K on the absorption of Ca at the absorption sites as reported on a study on onion (Singh and Verma, 2001).

TABLE 2
Effect of interaction between K and Na on foliar nutrient concentration (%) during the final year of the experiment

Treatments	N	P	K	Na	Ca	Mg
100% RD of K as MOP	1.67	0.24	1.41	0.42	1.65	0.55
50% RD of K as MOP	1.62	0.17	1.15	0.29	1.52	0.61
100% RD of K replaced by Na (of CS)	1.51	0.13	1.34	0.31	1.88	0.69
50% RD of K replaced by Na (of CS)	1.53	0.24	1.26	0.26	1.74	0.70
25% RD of K replaced by Na (of CS)+ 75% RD of K as MOP	1.63	0.26	1.44	0.34	1.75	0.77
50% RD of K replaced by Na (of CS) + 50% RD of K as MOP	1.64	0.25	1.48	0.36	2.01	0.74
75% RD of K replaced by Na (of CS)+ 25 % RD of K as MOP	1.65	0.25	1.49	0.37	2.01	0.77
CD (0.05)	NS	NS	0.13	0.01	0.14	NS

MOP – Muriate of potash; CS – common salt; RD- Recommended dose;
CD- Critical difference at 5 % significance level; NS – Not significant

Effect of the Interaction of K and Na on Quality of Nuts

Effect of the Interaction of K and Na on Quality of Coconut Kernel

The interaction of K and Na did not exert significant effect on the quality of kernel as indicated by the biochemical characteristics (Table 3). The conversion percentage of kernel to copra was high in all the treatments which received K and Na together. However, K and Na interaction did not exert significant effect on the quality of the kernel as indicated by the biochemical characteristics. Further, though K is known as the 'quality nutrient', a combined application of K and Na did not enhance the quality of the kernel in this study.

Effect of the Interaction of K and Na on Quality of Coconut Water

The sugar content of coconut water was found to increase with the application of Na alone or in combination with K. The treatments which received Na and K together registered higher values of total sugars in the third year. A significant difference was not observed between the treatments for pH, total ash content (as a measure of total minerals), and vitamin C content (Table 4).

The highest K content was noticed in the treatment where K and Na were applied at 50:50 proportions, and the highest Na content was from the treatment where K alone was applied at the full recommended dose. Coconut water is consumed worldwide for its nutrition and health benefits. The health benefits of drinking coconut water are mainly attributed to its potassium and sugar content. The findings of this study thus indicate that the application of K and Na in equal

TABLE 3
Effect of interaction between K and Na on the biochemical characters of coconut kernel during the final year of the experiment

Treatments	Moisture (%)	CHO (%)	Total minerals estimated from total ash (%)	Protein (%)	Kernel to copra conversion (%)	Yield (nuts palm^{-1} year^{-1})
100 % RD of K as MOP	46.2	7.1	0.79	3.52	57.8	138
50 % RD of K as MOP	42.3	7.3	0.71	3.02	35.0	125
100 % RD of K replaced by Na (of CS)	48.2	7.0	0.78	3.08	50.4	117
50 % RD of K replaced by Na (of CS)	49.1	7.5	0.86	3.18	51.4	126
25 % RD of K replaced by Na (of CS)+ 75 % RD of K as MOP	46.3	7.1	0.83	2.98	61.9	132
50 % RD of K replaced by Na (of CS) + 50 % RD of K as MOP	40.8	7.3	0.80	2.92	62.0	147
75 % RD of K replaced by Na (of CS)+ 25 % RD of K as MOP	44.5	6.9	0.78	2.92	58.2	144
CD (0.05)	NS	NS	NS	NS	3.55	11.04

MOP – Muriate of potash; CS – common salt; RD - Recommended dose;
CD - Critical difference at 5 % significance level; NS – Not significant

proportions enhances the health benefits of coconut water. The effect of Na in increasing the sugar content in crops has been widely reported (Guerrier,1996; Abdulla and Ahmamad,1990; Isroismail, 2007).

Effect of the Interaction of K and Na on Nut Yield

Nut yield varied significantly, with the highest yield being recorded in the treatment that received 50% of the recommended dose of K as a muriate of potash and 50% Na (Table 3). The three treatments where half the dose of K, or the full or half dose of Na alone was applied resulted in decreased nut yield during the third year. No significant difference was observed between treatments receiving the full recommended dose of K and treatments where the balance of the dose was supplied as Na in the form of common salt. Thus, the results indicate that full or partial omission of K for a long period, without replacement by Na, could negatively impact nut yield. The effects of insufficient nutrient application will be reflected in nut yields for a longer period given that the coconut is a tree crop. However, it should be noted that in the treatments where 50% or 75% of the recommended dose of K was replaced with equivalent Na, the yield was found to increase. An increase in crop yield with combined a application of K and Na has been reported by Ivahupa *et al*., (2006).

TABLE 4
Effect of interaction between K and Na on quality of coconut water during the final year of the experiment

Treatments	Total minerals (%)	Total sugars (%)	pH	K (%)	Na (%)	Vit.C mg per 100 ml
100 % RD of K as MOP	0.3	0.70	5.73	0.34	0.08	2.6
50 % RD of K as MOP	0.3	0.67	5.70	0.26	0.01	2.3
100 % RD of K replaced by Na (of CS)	0.3	0.69	5.71	0.29	0.02	2.4
50 % RD of K replaced by Na (of CS)	0.3	0.84	5.90	0.36	0.01	2.6
25 % RD of K replaced by Na (of CS)+ 75 % RD of K as MOP	0.3	0.77	5.82	0.36	0.06	2.8
50 % RD of K replaced by Na (of CS) + 50 % RD of K as MOP	0.3	0.86	5.87	0.41	0.07	2.4
75 % RD of K replaced by Na (of CS)+ 25 % RD of K as MOP	0.3	0.81	5.63	0.38	0.05	2.7
CD (0.05)	NS	0.09	NS	0.03	0.001	NS

MOP – Muriate of potash; CS – common salt; RD – Recommended dose;
CD - Critical difference at 5 % significance level; NS – Not significant

CONCLUSION

The results of this study showed the beneficial interactions between applied K and Na in coconut palms when treated in equal proportions. This interaction resulted in an increase in foliar concentrations of K and Ca, which boosted nut yield without compromising nut quality. The treatments studied could be beneficial to farmers cultivating coconut trees in acidic soils the world over.

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