DOWNWARD MOVEMENT OF EXCHANGEABLE POTASSIUM AND MAGNESIUM AFTER LONG TERM APPLICATION OF FERTILIZER UNDER DIFFERENT PLACEMENT TECHNIQUES: A CASE STUDY AT RANAWANA COCONUT ESTATE, KURUNEGALA

K.D.C. Premarathna[13*], M.K.F. Nadheesha[1], S.S. Udumann[2], C.S. De Silva[3]

[1]Soils and Plant Nutrition Division, Lunuwila
[2]Agronomy Division, Coconut Research Institute of Sri Lanka,
[3]Department of Agriculture and Plantation Engineering, Faculty of Engineering Technology, The Open University of Sri Lanka

INTRODUCTION

Sri Lanka is the fifth largest coconut producer in the world. Coconut industry plays a dominant role in the Sri Lankan economy with a contribution of 0.6 % to the gross domestic production of the country. The coconut cultivation area in Sri Lanka covers 455, 000 ha while the average annual production is targeted to be 2,623 million nuts per year (Anon, 2018b).

To achieve the required yield, fertilizers are incorporated into the soil. Fertilizers are of two main types: inorganic and organic. Major sources of straight fertilizers are as follows: ammonium sulfate and urea for nitrogen (N); Eppawala Rock Phosphate (ERP) and Triple Superphosphate (TSP) for phosphorus (P); Muriate of Potash (MOP) and Sulfate of Potash (SOP) for potassium (K); and ground dolomite for magnesium (Mg). The Coconut Research Institute has introduced fertilizer recommendations for adult palms based on four major nutrients. Accordingly, it is recommended to use 800 g of urea, 900 g of ERP, 1600 g of MOP, and 1 kg of dolomite per palm per year for the adult palms in the Wet and Intermediate zones while changing the P source to 400 g of TSP and ensuring that the other fertilizer sources remain the same. (Mahindapala and Pinto, 1991).

Potassium is important for the yield production (Loganathan and Balakrishnamurthi, 1979). Magnesium, which is a component of chlorophyll taking part in the process of photosynthesis is also important for the yield. Hence, Mg is important factor deciding the number of nuts per bunch, number of bunches, number of fronds and number of female flowers produced by a coconut plant. Both N and P play an important role in the growth of the palm. Many factors of the palm, both internal and external, govern the nutrient uptake. Examples of such factors are the growth of the root zone, active zone for the nutrient absorption, age of the palm, fertilizer types and fertilizer application techniques. Furthermore, the nutrient status of the soil solution, texture of the soil, structure, and slope of the land, type of the soil, water content and pH of the soil affect the nutrient uptake. Proper balance of K and Mg levels of the soil is very important to balance those nutrients as there is an antagonist reaction in the soil related to palm uptake (Jeganathan, 1990). The present research was conducted to investigate the pattern of downward movement of the exchangeable K and Mg ions within the soil profile, after 7 years of fertilizer application under three placement techniques, each with inorganic and organic-inorganic fertilizer practices.

MATERIALS AND METHODS

An experiment was conducted at Ranawana estate in Kurunegala, which belongs to the IL1 agroecological zone to investigate and to compare fertilizer application techniques to increase the efficiency of nutrient uptake. Furthermore, this research was conducted to investigate the pattern of downward movement of two exchangeable cations i.e. K^+ and Mg^{2+} after 7 years of continuous fertilizer application under three different placement techniques, each with inorganic and organic-inorganic fertilizer practices. The experiment was laid in the Randomized Complete Block Design (RCBD) with three replicates. In each plot there were 6 palms and therefore one treatment with three blocks consisted of 18 palms and the space between 2 palms was 26' ×26'. The treatments were applied as shown in Table 1. The treatment application commenced in December 2011 and continued for seven years until 2018. The fertilizer application frequency was once a year. The soil samples for this study were collected from a depth of 0 - 100 cm at 20 cm intervals from the manure circle of each palm after the completion of fertilizer application. Three palms were randomly selected from each plot. Collected soil samples were analyzed for pH, electrical conductivity (EC), and exchangeable K and Mg at selected depths. Data were analyzed using the General Linear Model with Minitab 17 statistical software at 5% significance level and 95% confidence level. Table 1 shows the treatment combinations applicable for the research.

Table 1**: Treatment combinations**

Treatment code	**Fertilizer placement method**	**Fertilizer type**	**Application rates**				
			Goat manure /kg	**Urea /g**	**ERP / g**	**MOP / g**	**Dolomite/g**
T1	Surface application up to 1.75m from the palm	Inorganic only	-	800	900	1600	1000
T2		Inorganic + Organic	15	400	450	1200	500
T3	Fertilizer application in a trench (0.495m wide,10cm deep and 0.5m away from the palm)	Inorganic only	-	800	900	1600	1000
T4		Inorganic + Organic	15	400	450	1200	500
T5	Basin method – 5' 8" radius from the ball outwards	Inorganic only	-	800	900	1600	1000
T6		Inorganic + Organic	15	400	450	1200	500

RESULTS AND DISCUSSUION

There were no significant differences of pH values between the treatments at different depths. The results of the treatment for pH ranged from 5.8 - 6.7. The pH values of the treatment soil ranged as follows: moderately acidic 5.2 - 6.0 < slightly acidic 6.1 - 6.5 < neutral 6.6 - 7.3. Table 2 shows the electrical conductivity values of the treatment applied soils at different depths.

Table 2: Electrical conductivity values at different depths.

Treatment	Fertilizer type	Application method	Electrical conductivity (µs/cm)				
			0-20 cm	**20-40 cm**	**40-60 cm**	**60-80 cm**	**80-100 cm**
T1	Inorganic	Surface	100.79^{bc}	66.72^{a}	33.72^{ab}	30.98^{a}	23.3^{b}
T2	Inorganic + Organic	Surface	185.82^{a}	80.99^{a}	44.25^{a}	43.07^{a}	28.09^{b}
T3	Inorganic	Trench	108.01^{bc}	53.31^{ab}	40.62^{ab}	35.27^{a}	44.41^{a}
T4	Inorganic + Organic	Trench	127.08^{b}	61.33^{ab}	34.41^{ab}	28.55^{a}	22.41^{b}
T5	Inorganic	Basin	82.83^{c}	33.11^{b}	27.86^{b}	27.22^{a}	26.29^{ab}
T6	Inorganic + Organic	Basin	111.47^{bc}	60.24^{ab}	42.64^{a}	32.00^{a}	32.06^{ab}
p Value			0.001	0.009	0.013	0.072	0.001
CV%			**34.35**	**39.41**	**31.32**	**38.49**	**44.46**

At 0-20 cm, EC was significantly higher than those of all the other depths. It reflects the accumulation of nutritional ions on the top and movement of ions from the top to bottom layers indicating the downward movement of ions.

Table 3 shows exchangeable K content of different treatments at different depths. The results show nutrient leaching in every treatment. Exchangeable K levels significantly down from the depth of 0-20 to 80 -100 cm. The treatments have shown a significantly high level of exchangeable K at the depth of 0-20 cm than at the other depths. Each depth of inorganic and organic fertilizer application in trench method (T4) showed a comparatively low K content. This may have been due to the high nutrient uptake by the palm. A slight increase was shown by the inorganic fertilizer application in the trench method (T3) and inorganic fertilizer application in the basin method (T5) at the depth of 80-100cm while the lowest value in inorganic fertilizer application was observed in the surface method (T1). The reason for these results could be the different application methods. In trench and basin applications, the fertilizer incorporation area in the manure circle is lower than in the surface method and it would be the reason for nutrient leaching.

Table 3: Exchangeable K content at different depths.

Treatment code	Fertilizer type	Application method	Exchangeable K^+ (cmol/kg)				
			0-20 cm	**20-40 cm**	**40-60 cm**	**60-80 cm**	**80-100 cm**
T1	Inorganic	Surface	0.60[a]	0.35[ab]	0.22[a]	0.21[ab]	0.087[d]
T2	Inorganic + Organic	Surface	0.78[a]	0.47[ab]	0.27[a]	0.24[ab]	0.16[bc]
T3	Inorganic	Trench	0.55[ab]	0.53[a]	0.31[a]	0.26[ab]	0.46[a]
T4	Inorganic + Organic	Trench	0.30[b]	0.26[b]	0.23[a]	0.18[b]	0.16[cd]
T5	Inorganic	Basin	0.67[a]	0.54[a]	0.39[a]	0.32[a]	0.35[ab]
T6	Inorganic + Organic	Basin	0.56[ab]	0.37[ab]	0.27[a]	0.20[ab]	0.14[cd]
p Value			**0.013**	**0.004**	**0.143**	**0.048**	**0.000**
CV%			**42.25%**	**44.74%**	**48.88%**	**43.65%**	**72.65%**

Table 4 shows the effect of different treatments on the exchangeable Mg at different depths.

Table 4: Exchangeable Mg content at different depths

Treatment code	Fertilizer type	Placement method	Exchangeable Mg^{2+} (cmol/kg)				
			0-20 cm	**20-40 cm**	**40-60 cm**	**60-80 cm**	**80-100 cm**
T1	Inorganic	Surface application	1.31[abc]	0.92[ab]	0.85[abc]	0.89[ab]	0.99[ab]
T2	Inorganic+ Organic	Surface application	1.59[ab]	1.41[a]	1.17[ab]	1.16[a]	1.20[ab]
T3	Inorganic	Trench	1.80[a]	1.34[a]	1.24[a]	1.31[a]	1.63[a]
T4	Inorganic+ Organic	Trench	1.41[abc]	0.99[ab]	0.72[bc]	0.82[ab]	0.81[b]
T5	Inorganic	Basin	0.84[c]	0.56[b]	0.59[c]	0.47[b]	0.72[b]
T6	Inorganic+ Organic	Basin	1.09[bc]	0.99[ab]	0.89[abc]	0.83[ab]	1.12[ab]
p Value			**0.083**	**0.001**	**0.001**	**0.001**	**0.001**
CV%			**43.75%**	**43.21%**	**44.97%**	**47.83%**	**50.16%**

There were significant changes between the five different depths the K content leaching was observed at each depth of every treatment. At the depth of 0-20 cm, the highest exchangeable Mg level was recorded in the inorganic fertilizer application of the trench method (T3) while the lowest was in the inorganic fertilizer application of the trench method (T5). The lowest value of T5 could have been caused by the high Mg uptake by the palm. Similarly, the highest exchangeable Mg was recorded in the T3 at the depths 40-60cm, 60-80 cm and 80-100cm and the lowest Mg concentration was recorded in the T5. The lowest value was recorded at 20-40cm in T3 and the highest Mg content was in the inorganic-organic fertilizer surface application (T2). All the other treatments showed a decreasing pattern up to 80cm and a sudden increase at 80-100 cm except the inorganic-organic fertilizer application in the surface method (T2) and trench method (T4). Table 4 clearly shows that the exchangeable Mg nutrient content of depth 0-20 and 20-40 cm was equal to that of 60-80 and 80-100 cm respectively. Mg, in comparison with K, has a higher tendency for leaching.

CONCLUSION

EC data reflected a significant movement of ions from the top to bottom layers and there were no significant changes of pH at different depths from 0-100 cm. Furthermore, leaching tendency of Mg ion is comparatively higher than that of K in Kurunegala soil series which belongs to red, yellow podzolic great soil group.

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