



Variations in Soil Chemical Parameters of Long Term Sugarcane-Growing Alfisols under Contrasting Cropping Conditions at Sevanagala, Sri Lanka

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ABSTRACT

This study was conducted to determine the variability of soil pH, macronutrients and Na contents in long term sugarcane-growing Alfisols at Sevanagala, South-East of Sri Lanka. The study site included the entire sugarcane-growing area covering its contrasting cropping systems namely, irrigated and rain-fed cultivation on low humic gley (LHG) and reddish brown earth (RBE) soils, and adjacent undisturbed soils. The mean pH of the two soil types was significantly different and ranged from 4.5 to 9.3. Except some soils under rain-fed cultivation with a pH less than 5.5 in RBE soil and a pH greater than 7.5 in LHG soils, pH in all other soils favoured sugarcane growth. Plant available P content of soils were not significantly different among cropping conditions due to its wide variation. In both cropping systems and soil types there were areas with very low to nondetectable P levels. Exchangeable K content was significantly different between LHG and RBE soils with the latter having a mean concentration of 257 mg/ kg that is favourable for sugarcane cultivation. Though, the mean values are higher than the optimum range, there were K deficient patches in the studied area. Soil exchangeable Ca, Mg and Na contents were low in the study area but were significantly higher in LHG soils than in RBE soils contributing to alkalinity in the former soils especially under rain-fed conditions. The sugarcane-growing soils except LHG under rain-fed conditions showed chemical properties similar to undisturbed soils in the area highlighting their buffered nature despite long-term sugarcane cultivation. This study also emphasised the need for site-specific soil fertility management strategies for the Sevanagala sugarcane growing areas.

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INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is a C₄, annually harvested, sucrose-storing perennial true grass, belonging to the genus *Saccharum* (Arceneaux, 1965; Anna et al., 2014). The *Saccharum* hybrid spp. are commercially cultivated in Sri Lanka mainly from south-eastern to north-eastern dry and intermediate regions, primarily on Alfisol soils under contrasting cropping systems namely, irrigated and rain-fed cultivation.

Sevanagala is located on the left bank of the *Walawe* basin in the south-eastern region of the Dry Zone of Sri Lanka in the DL 1b agro-ecological region (Punyawardena et al., 2003). According to Mapa et al. (2010), soils in Sevanagala sugarcane-growing area fall into the Alfisol soil order, and mapped as *Walawe - Mahagal Ara - Ketagal Ara - Sevanagala* association. The *Walawe* series is Typic Haplustalfs (FAO classification: Rhodic Endoentric Luvisols) and *Mahagal Ara* series is Oxyaquic Hapludalfs (FAO classification: Ochric Luvisols). Both of these series belongs to great soil group of Reddish Brown Earth (RBE) soils (Alwis and Panabokke, 1972). The *Ketagal Ara* series is a Low Humic Gley (LHG) soil and according to soil taxonomy it is a Typic Endoaqualfs (FAO classification: Gleyic Cutamic Hyperentric Luvisols). The soil under *Sevanagala* series is Solodized solonetz, taxonomically referred to as Typic Natraqualfs (FAO classification: Gleyic Solanchaks). According to Dharmawardene (2004), 90-95 % of the sugarcane cultivation is dominated on RBE and less than 5 % on LHG soils. Cultivation under Solodized solonetz soil is negligible due to its saline and/or sodic condition and poorly drained nature.

The ideal pH range of soil for the sugarcane crop is around 5.5 and 6.5, where nutrient availability becomes optimal. Even though, the crop tolerates satisfactorily soil pH levels from 5 to 8, pH corrections would be required for optimum performances (Calcino, 2010). A slightly acidic soil pH (5.9 to 6.7) had been observed in RBE soils in other parts of DL 1 agro-ecological zone of Sri Lanka (Mapa and Kumaragama, 1996; Mapa et al., 2010; Sanjeevani et al., 2013). Studies carried out at Sevanagala by the Sugarcane Research Institute (SRI) of Sri Lanka revealed that the

mean soil pH in different sugarcane cropping systems at Sevanagala region could range from 6.3 to 6.9 (Anon., 2000; 2012).

As cited in Singh et al. (2007), sugarcane is an exhaustively nutrient extracting crop that is removing about 205 kg N, 55 kg P₂O₅, 275 kg K₂O, 30 kg S, 3.5 kg Fe, 1.2 kg Mn, 0.6 kg Zn and 0.2 kg Cu from the soil for 100 t ha⁻¹ cane yield harvested every season. Further, this crop has been cultivated as a long-term monoculture crop for over 35 years at Sevanagala, leading to possible soil fertility degradation over the years, although a few lands have been subjected to varying fallow periods and temporary shifting to other cultivations.

At present, there is a paucity in research information on the variability of fertility decisive soil parameters at Sevanagala. Therefore, the objective of this study was to ascertain the variation of soil pH and plant available macro nutrients (P, K, Ca and Mg) under different edaphic conditions (i.e. soil type and cropping system) at Sevanagala sugarcane-growing area. Though not a nutrient, available Na has also been taken into consideration as a decisive element related to alkalinity.

MATERIALS AND METHODS

Study area

Sevanagala sugarcane-growing area is located in the Moneragala district, of Uva province, adjoining the boundaries of Rathnapura and Hambanthota Districts (Figure 1). With the establishment of the Sevanagala sugar factory (6.38 °N, 80.91 °E) in early 1980's, the extent under sugarcane cultivation was expanded in to the central part of the region, which is in close proximity of the Uda Walawe reservoir, the main water source for the area.

Two cropping systems, irrigated and rain-fed cultivation, are being practiced on the lands (Figure 1) that have been provided to the farmers on long-term lease for sugarcane cultivation under the mandatory term of providing the harvest to the Sevanagala sugar factory of the Lanka Sugar Company (Pvt.) Ltd. The company facilitates cultivation by providing fertiliser and agro-chemicals required on loan basis and finally letting to

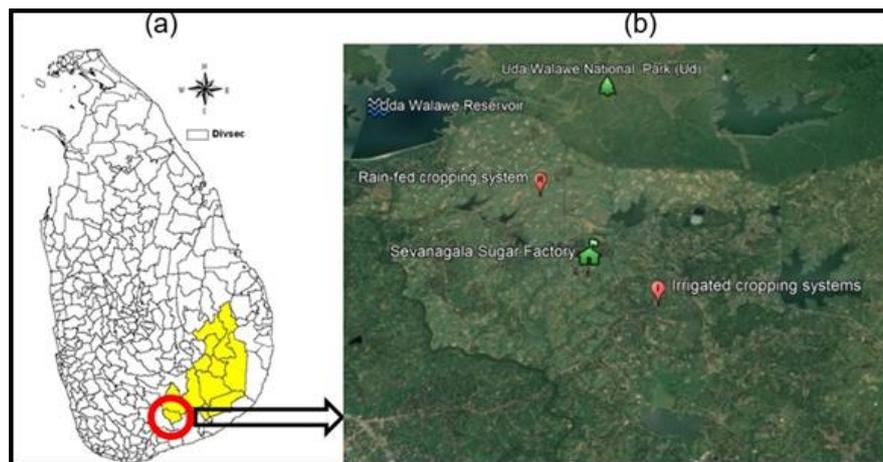


Figure 1: Location of the study: (a) Sevanagala DS division highlighted in a circle within Moneragala District of Sri Lanka and (b) a bird's-eye view of the Sevanagala sugarcane-growing area with its rain-fed and irrigated cropping areas indicated in a satellite image from Google Maps

recover the expenditure through the harvest, thereby ensuring on-time agricultural operations. The total sugarcane-growing land area managed by the company is 4208 ha and divided into sub-sections for its convenience in management.

The landscape is undulating with slopes frequently ranging from 0 – 4 %, where erosional remnants and hillocks are common (Panabokke, 1963). The most recent satellite

image highlights that the elevation of the study area varies from 50 m amsl to 100 m amsl with an average slope of 1.5 %. The recorded maximum slope is 6.1 % (Figure 2). The lands at high elevations are under rain-fed cultivation because they are located higher than that of the outflow of the Uda Walawe reservoir. The lands at lower elevation are cultivated with irrigation water.

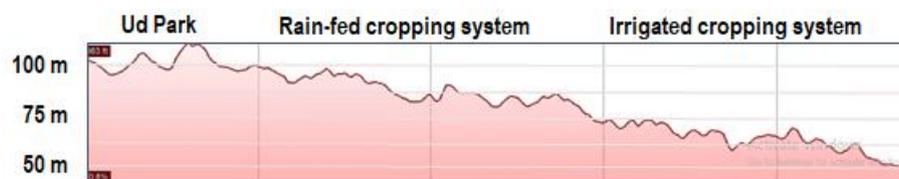


Figure 2: Elevation profile from Uda Walawe National Park (Ud park) to irrigated cropping system of Sevanagala-sugarcane growing area (Created from Google Earth using Image ©2019 CNES/Airbus)

Soil Sampling

The sample size to best represent the Sevanagala sugarcane-growing area was determined using the Slovin formula given below (Adanza, 1995);

$$n = N / (1 + Ne^2)$$

where n is sample size, N is population size, and e is error margin.

The population size of the sugarcane-growing area was considered based on the separate divisions and similar edaphic zones (i.e. based

on soil type and cropping system) of each area. Thereby, the total population size was close to 2500 land units with an error margin at 0.05 giving a total sample size of 340 sampling points. Stratified random sampling technique was used to cover all sugarcane growing divisions considering the cropping system, soil types, landscape position in the catena and growth performance or yield. The average yields of irrigated and rain-fed systems are 100 and 60 t/ha, respectively.

Composite soil samples were collected from each sampling point separately from 0-15 cm and 15-30 cm depths and transported to the Crop Nutrition Laboratory at Sugarcane Research Institute (SRI), Uda Walawe, Sri Lanka. Out of the 340 samples, 54 LHG and 219 RBE soil samples were considered for this study. The balance 67 samples had properties that are not typical for LHG and RBE soils and therefore excluded from this study. Six RBE soil samples each from the two depths were obtained from the Uda Walawe National Park (Ud) to represent the undisturbed soil conditions. Undisturbed LHG soil within the park was not accessible due to the presence of elephants and other wild animals and constant inundation. The soil samples were air-dried at room temperature for a week. Stones were removed, crushed gently with a roller and sieved using a 2-mm sieve.

The pH was determined in a soil and distilled water (1:2.5) suspension by immersing a combination type glass electrode and a pH meter (multi-HACH HQ40d). The electrical conductivity was measured in a 1:5 soil and distilled water suspension (Estefan *et al.*, 2013) using a conductivity meter (TOA CM20S). Plant available P (Olsen-P) content was extracted by 0.5M NaHCO₃ and determined by molybdate blue method (Olsen and Sommers, 1982). The 1M ammonium acetate (pH=7) extractable K, Ca, Mg and Na (Estefan *et al.*, 2013) were measured using an Atomic Absorption Spectrophotometer (Shimadzu, AA 6300).

Statistical analysis

Soil exchangeable K contents exhibited a normal distribution and therefore analysis of variance was carried out using Proc GLM procedure of SAS software (Version 9.1.3) to determine the differences between the two cropping systems and two soil types, separately. The data of all other parameters were not normally distributed and therefore Kruskal-Wallis non-parametric analysis was conducted using Minitab software (Version 17) to determine the significance of cropping systems and soil types on these parameters (McDonald, 2009). All the interpretations were made based on 95 % probability level ($\alpha=0.05$).

RESULTS AND DISCUSSION

Uncultivated soil

The RBE soil at Uda Walawe National Park (Ud) was used to understand the properties of undisturbed soils in the area (Table 1). There was no significant difference in pH, EC, K, Ca and Mg between 0-15 cm and 15-30 cm soil levels except the P content. The significantly lower Olsen-P content in the 15-30 cm layer could be due to the low downward leaching of P and precipitation with excess Ca as calcium phosphate in sub-surface layers. The exchangeable Na content of Ud was not detectable (<1 mg/kg) however it may change over the area and time.

Table 1: Mean \pm standard deviation of the chemical properties measured in RBE soils of the Uda Walawe National Park (n=6)

Depth (cm)	pH	EC (S/m)	P (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)
0-15	6.02 ^a \pm 0.32	0.0052 ^a \pm 0.001	1.7 ^a \pm 0.6	182 ^a \pm 45	47 ^a \pm 19	7.6 ^a \pm 2.7
15-30	5.92 ^a \pm 0.18	0.0034 ^a \pm 0.001	1.1 ^b \pm 0.3	160 ^a \pm 68	59 ^a \pm 12	7.3 ^a \pm 2.1

Note: Means with the same letters are not significantly different at 5 % probability.

Sevanagala sugarcane-growing soils

The values observed for soil pH, EC and other elements (Olsen-P, exchangeable K, Ca, Mg and Na) in long-term sugarcane-growing soils at Sevanagala were analysed separately for different cropping systems and soil types to

understand the present fertility status of the soils under cropping. All parameters except Olsen-P did not exhibit a significant difference between the two depths and therefore data from the 0-15 cm depth only are presented and discussed here.

Soil pH

The pH was significantly different between the two Alfisols at Sevanagala where LHG soils had a higher mean pH than that of RBE soils (Table 2). LHG soils recorded a minimum pH of 5.8 under irrigated conditions and a maximum of 9.3 under rain-fed conditions. The pH of RBE

soils ranged from 4.5 to 7.7 where both were recorded under rain-fed conditions. However, the pH difference from minimum to maximum in above two soils was around 3.4. In contrast the pH among the two cropping systems was not significant and had a smaller difference (2.0) in irrigated soils than in rain-fed soils (3.7).

Table 2: Mean (range) and median soil pH of LHG and RBE soils under irrigated and rain-fed conditions at Sevanagala

	Irrigated (n=141)	Rain-fed (n=122)	Median
LHG (n=55)	6.8 (5.8-7.6)	7.9 (6.6-9.3)	7.15 ^a
RBE (n=208)	6.6 (5.6-7.6)	6.4 (4.5-7.7)	6.52 ^b
Median	6.69 ^a	6.59 ^a	

Note: Medians with the same letters are not significantly different at 5 % probability.

The mean pH observed in this study for each cropping system and each soil type was similar to previous studies conducted by SRI (Anon, 2000; 2012). According to Calcino (2010) pH in RBE soils falls within the favourable nutrient availability range (5.5-6.5) for sugarcane cultivation. The results in this study closely relates with the pH in RBE soils of other regions of Sri Lanka (Mapa and Kumaragamage, 1996; Mapa *et al.*, 2003, and Sanjeevani *et al.*, 2013)

The significantly higher pH of soils occupying the lower parts of a catena has also been observed by others as well (Brubaker *et al.*, 1993; Rosemary *et al.*, 2017). The highest pH of 9.3 was recorded in LHG soils under rain-fed conditions and indicates medium to strong basic conditions (above pH 8), thus, affecting nutrient availability to the crop. It may have been due to the accumulation of basic cations brought down naturally through run-off and leaching (Brubaker *et al.*, 1993), as LHGs are found in lower lying areas. The Figure 2 proves that there are lower elevation areas in the rain-fed cropping system which are not connected to the lower irrigated cropping system directly. This highlights the need of reducing alkalinity of LHG soils under rain-fed conditions. However, LHG soils under irrigated conditions had pH between 6.7-6.9 in the top 0 – 15 cm soil which have become comparatively more favourable for sugarcane

with continuous irrigation that could have enhanced leaching of basic cations.

The undisturbed Ud soil had a mean pH of 6.02 which was lower than that of irrigated and rain-fed soil under sugarcane cultivation (Table 1 and 2). The pH range of the Ud soil was between 5.4 and 6.5, denoting a well buffered nature with a narrow minimum to maximum range around 1. The comparatively acidic condition of Ud soil could be related to the highest elevation in the area where higher run-off and leaching of basic cations may have been taken place in comparison to lower lying areas.

Soil electrical conductivity

Soil EC was significantly different between the two cropping systems and two Alfisols in the study area at Sevanagala (Table 3). The highest mean EC (0.029 S/m) was recorded in LHG soils under rain-fed conditions with a minimum of 0.003 S/m and a maximum of 0.06 S/m. Locations even with the highest soil EC values fall under the 'non-saline' (< 0.2 S/m) soil salinity level (Shahid *et al.*, 2018) but it is important to monitor the salinity in the long run particularly in the lower parts of the catena under rainfed conditions preventing crop damages in the future. Under rain-fed and irrigated cropping conditions the RBE soils exhibit a lower EC level than that of LHG soils.

Table 3: Mean (range) and median soil EC (S/m) of LHG and RBE soils under irrigated and rain-fed conditions at Sevanagala

	Irrigated (n=141)	Rain-fed (n=122)	Median
LHG (n=55)	0.019 (0.005-0.04)	0.029 (0.003-0.06)	0.02 ^a
RBE (n=208)	0.012 (0.005-0.03)	0.009 (0.003-0.02)	0.01 ^b
Median	0.012 ^a	0.009 ^b	

Note: Medians with the same letters are not significantly different at 5 % probability

The soil EC under the irrigated conditions ranged from a minimum of 0.005 S/m to a maximum of 0.04 S/m. The upper limit of the EC under irrigated conditions fall under the 'non-saline' soil salinity level category (< 0.2 S/m) highlighting comparatively more favourable conditions for sugarcane cultivation than under rain-fed cultivation. The EC observed by Anon, (2000) were comparatively lower than the mean EC values given in Table 4. However, the lowest EC values measured in this study were comparable between the two studies.

The continuous cultivation of sugarcane has already increased the soil EC levels (Table 3) in comparison to the undisturbed Ud soil (Table 1). Results of both pH and EC given above for rain-fed conditions suggest that there could be LHG soil patches at lower lying areas in isolation or with very little connections downward along the catena that could become less suitable for sugarcane cultivation in the future.

Table 4: Mean (range) and median soil Olsen P (mg/kg) of LHG and RBE under irrigated and rain-fed conditions at Sevanagala

	Irrigated (n=141)	Rain-fed (n=122)	Median
LHG (n=55)	12.1 (1.1-46)	6.8 (0.4-20)	6.1 ^a
RBE (n=208)	12.8 (0.1-76)	10.1 (<0.05-63)	8.1 ^a
Median	8.3 ^a	6.7 ^b	

Note: Medians with the same letters are not significantly different at 5 % probability.

In contrast to the soil types there was a significant difference between irrigated and rain-fed cropping systems. In both cropping systems and soil types there are areas with very low to not detectable Olsen P levels resulting micro-environments deficient in available P for the sugarcane crop. Very low available soil P levels could retard root growth thus affecting the long term ratoons (Sundara et al., 2002; Shukla et al., 2008).

Soil macronutrients

The Lanka Sugar Company (Pvt.) Ltd. provides fertilisers required for the crop to its out-growing farmers in order to obtain higher yields. Therefore, the macro nutrient contents of the sugarcane-growing soils could have been different from that of undisturbed Ud soil. The variation of plant available P, K, Ca, Mg as well as non-nutrient Na contents in the studied edaphic conditions are analysed and interpreted in the subsequent sub-sections.

Plant available soil phosphorous (Olsen-P)

The Olsen-P content exhibited a wide variation within the Sevanagala sugarcane-growing areas. In irrigated soils it varied from very high levels of 76 mg/kg for RBE soils and up to 46 mg/kg for LHG soils to very low levels such as 0.1 (RBE) and 1.1 (LHG). Similar trends could be observed in the two soils under rain-fed conditions. The median values were 8.1 and 6.1 mg/kg for LHG and RBE soils, respectively and were not significantly different (Table 4).

Soil exchangeable potassium

The soil exchangeable K exhibited a significant difference between the two Alfisols at Sevanagala where K in RBE soils was significantly higher than that of LHG soils (Table 5). Under RBE soils the minimum level was 15 mg/kg compared with <1 mg/kg in LHG soil. In both cropping systems there are patches with very low exchangeable K levels.

However, mean value for RBE and LHG soils are 257 and 168 K mg/kg, respectively while mean values for irrigated and rain-fed conditions are 213 and 212 K mg/kg, respectively.

Although the mean values are high, there are patches deficient in exchangeable K contents in the Sevanagala sugarcane-growing area which require site-specific attention. Potassium is an important macronutrient for sugarcane growth and maturity, and about 120-150 mg of exchangeable K/kg is considered favourable for optimum growth under local conditions (Weerasinghe *et al.*, 2017). Further, continuous fertilisation has led to widening of the upper limit.

Both plant available P and exchangeable K contents are similar to that observed by Anon. (2000) and Anon. (2012), but comparatively higher than that of undisturbed soil (Table 1) confirming that the continuous cultivation of sugarcane and supply of P and K fertilisers have increased mean soil test levels but adoption levels of fertiliser practices by farmers have also created a spatial heterogeneity in these two properties.

Exchangeable calcium

The soil exchangeable Ca content was not significantly different between the two cropping systems (Table 6), but exhibited a significant difference between the two Alfisols.

The variation of LHG soils was from 20 to 126 mg/kg under rain-fed conditions with a mean of 74 mg/kg while RBE soil had a variation from 8 to 32 mg/kg with a mean of 19 mg/kg. Under irrigated conditions the exchangeable Ca contents varies from 19 to 48 mg/kg with a mean of 32 mg/kg in RBE soils and from 23 to 66 mg/kg (mean 37 mg/kg) in LHG soils (Table 7). The rain-fed cropping system depicted a wide variation from 8 to 126 mg/kg when compared to the narrow variation under irrigated conditions from 9 to 66 mg/kg. The result indicated that salt cations accumulated at the surface of LHG under rain-fed conditions could affect plant growth especially during the dry season. Similar patterns were not observed under irrigated conditions. The observed mean Ca levels were comparatively lower than that recorded by Anon. (2000).

Exchangeable magnesium

Similar to exchangeable Ca content, the exchangeable Mg content showed a significant difference between LHG and RBE soil types where both soil types had a range from very low levels to about 30 mg/kg (Table 7). There was no significant difference between the two cropping systems and the maximum in both was around 30 mg/kg. Even though the Mg contents were comparatively low, the Ca/Mg ratios were optimum for growth of sugarcane (Elwali *et al.*, 1984).

Table 5: Mean (range) Exchangeable K (mg/kg) of LHG and RBE under irrigated and rain-fed conditions at Sevanagala

	Irrigated (n=141)	Rain-fed (n=122)	Mean
LHG (n=55)	195 (<1-396)	142 (<1-326)	168 ^b
RBE (n=208)	232 (56-506)	283 (15-435)	257 ^a
Mean	213 ^a	212 ^a	241

Note: Means with the same letters are not significantly different at 5 % probability.

Table 6: Mean (range) and median exchangeable Ca (mg/kg) of LHG and RBE under irrigated and rain-fed conditions at Sevanagala

	Irrigated (n=30)	Rain-fed (n=30)	Median
LHG (n=30)	37 (23-66)	74 (20-126)	47 ^a
RBE (n=30)	32 (19-48)	19 (8-32)	25 ^b
Median	31 ^a	28 ^a	

Note: Medians with the same letters are not significantly different at 5 % probability.

Table 7: Mean (range) and median exchangeable Mg (mg/kg) of LHG and RBE under irrigated and rain-fed conditions at Sevanagala

	Irrigated (n=30)	Rain-fed (n=30)	Median
LHG (n=30)	8.6 (<0.1-14)	11.7 (<0.1-30)	8.4 ^a
RBE (n=30)	7.3 (<0.1-26)	3.8 (<0.1-8)	5.3 ^b
Median	7.3 ^a	6.2 ^a	

Note: Medians with the same letters are not significantly different at 5 % probability.

Exchangeable sodium

Both soil type and cropping system significantly affected the exchangeable Na contents in the soil. The exchangeable Na content in LHG soils had a maximum of 162 mg/kg exchangeable Na content (Table 8). In contrast, the RBE soils had only a maximum of around 18 mg/kg. The exchangeable Na contents in the two cropping systems were significantly different where the median was <0.1 mg/kg in irrigated cropping system while it was 1.3 mg/kg in rain-fed cropping system. The rain-fed condition recorded the highest Na content of 162 mg/kg and it was under LHG soils. However, the exchangeable Na percentages in all soils were less than 15 % suggesting that there are no sodic conditions in Sevanagala sugarcane-growing soils.

According to the results in Tables 6, 7, and 8, soil exchangeable Ca, Mg and Na was significantly higher in LHG soils than in RBE soils under rain-fed conditions. The result suggests that salt cations accumulated at the surface of LHG soil could affect plant growth

during extended dry periods. Similar conditions were not observed in soils under irrigated cropping system.

The sugarcane-growing soils have variable levels of Na salts which could have accumulated over the years in lower parts of the catena especially in LHG soils under rain-fed conditions. This could be justified with Figure 2, where the lower catena in the rain-fed conditions have minimum connections to the lower elevation irrigated area. Therefore, most of the Na salts have been accumulated in the rain-fed areas and during dry periods Na salts accumulate on surface soils. The Mg salts in sugarcane-growing soils are almost comparable to that of undisturbed soils, however Ca contents in cultivated soils were higher than that of and uncultivated soils. The values observed for Ca, Mg and Na in this study are comparatively lower than that observed by Anon. (2000), and this could be due to location and sampling time differences between the two studies.

Table 8: Mean (range) and median exchangeable Na (mg/kg) of LHG and RBE under irrigated and rain-fed conditions at Sevanagala

	Irrigated (n=30)	Rain-fed (n=30)	Median
LHG (n=30)	5.2 (<0.1-20)	67 (<0.1-162)	1.36 ^a
RBE (n=30)	3.6 (<0.1-16)	3.5 (<0.1-18)	<0.1 ^b
Median	<0.1 ^b	1.3 ^a	

Note: Medians with the same letters are not significantly different at 5 % probability.

CONCLUSIONS

The RBE soils under both cropping systems and LHG soils under irrigated conditions have a pH around 6.5 which is favourable for sugarcane cultivation. In-contrast, the LHG soils under rain-fed conditions exhibit a trend towards alkalinity with an upper pH limit

around 9. At present both RBE and LHG soils in the study area are categorised as 'non saline' however there are patches of the latter that are prone to be saline soils in the future. Further, due to high pH, EC and Na conditions the LHG soils under rain-fed conditions are unfavourable for sugarcane cultivation at Sevanagala. Necessary measures are required

for lands becoming unfavourable for sugarcane cultivation in the future. The sugarcane-growing soils except LHG soils under rain-fed conditions showed properties comparable to undisturbed soil in the area with minor deviations highlighting its buffered nature despite long-term cultivation of sugarcane.

In contrast to the soil types, there was a significant difference in soil available P between irrigated and rain-fed cropping systems even though with variation. In both cropping systems and soil types there are areas with very low to not detectable Olsen P levels. Though the mean values are high compared with the optimum range, there are patches deficient in K in the Sevanagala sugarcane-growing area which require site-specific attention. The exchangeable Ca, Mg and Na contents were comparatively low in this area. This study created an avenue for a detail spatial analysis through variogram modelling and mapping of key soil properties across the sugarcane-growing soils at Sevanagala.

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