Spatial distribution of organic carbon in selected arecanut gardens of Karnataka

M DINESH KUMAR and MY ULLASA

Department of Agronomy, College of Agriculture, Shivamogga 577204 Karnataka, India
Email for correspondence: ullas.653@gmail.com

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ABSTRACT

Spatial distribution of organic carbon was studied in different ecosystems such as traditional, tank-fed, bore well-fed and canal irrigation in Shivamoga, Chickamagaluru and Davanagere districts of Karnataka. The chosen gardens were 15-18 years old with medium management. The standard grid technique with a spacing of 50 x 50 m was employed to draw soil samples from the selected study areas at 0-30 cm depth with global positioning system (GPS) identity. The data were analysed for pH, salts and organic carbon. Among the areas studied Humcha and Konandur soils were acidic and Agaradhalli soils were neutral to slightly acidic while others were tending towards basisity in soil reaction. Kabbala (mean value of 0.81 dS/m) and Kerehosahalli (mean value of 0.59 dS/m) soils showed little higher salt accumulation than rest of the soils. Status of organic carbon remained high to medium for Chikkingala, Agaradahalli, Kabbala and Kerehosahalli whereas Humcha, Konandur and Banoor soils remained of medium to low status. Utilizing variable value of this data the study areas were mapped in geographic information system (GIS) environment. For each location depending on its site specific variations nutrient application approaches for future are advised to the farmers.

Keywords: GIS; organic carbon; recommendation; site specific management

INTRODUCTION

Soil organic carbon is very important as it determines ecosystem and agro-ecosystem function and influences soil fertility, water holding capacity and many other functions. It is also of global importance because of its role in the global carbon cycle as it plays an importnat role in the mitigation or worsening of atmospheric levels of greenhouse gases. Soil is the largest reservoir of terrestrial carbon storing approximately 53 per cent of it. Carbon is the key ingredient in soil organic matter (57%) by weight (Thenneragh et al 2014). Soil organic matter is created by cycling of organic compounds in plants, animals and microorganisms in the soil. A soil with high organic matter is more productive than the same soil where much of the organic matter is deplored by means of tillage, erosion of soil, water, air, temperature, poor management practices etc. Minimizing these aspects is an important step to reverse and building soil quality which usually requires leaving residues on the surface or ground cover crops. One of the agriculturists' major opportunities to help mitigate the effect of climate warming gases lies in the management of soil to increase organic matter content thereby removing C from the atmosphere. Soil OC is highly sensitive to changes in land use with changes from native ecosystems such as forest or grassland to agricultural systems. Perennial crops such as arecanut almost always result in greater variations in soil OC. In agricultural systems cultural practices such as soil and crop management have been known to affect crop yield and soil C sequestration.

India is the largest producer of arecanut in the world (7.29 lakh tonnes). Within India Karnataka stands first in areca production by contributing nearly 62 per cent (4.6 lakh tonnes) to country's total (Anon 2016). The crop is traditionally well acclimatized in coastal and hilly zone situations of laterite soils of undulating topography with moderate to heavy rainfall. Being a top plantation commercial crop its cultivation is ever extending in all situations including clay soil belts of non-traditional areas. The influence of soil parameter is one of the main factors governing the phyto-availability of an element. The serious concerns in arecanut cultivation are huge yield gap from location to location, sustained nutrient requirement and low nutrient use efficiency (Bhat and Sujatha 2009). Hartemink (2005) stated that large quantities of nutrients are immobilized in the above and below ground of perennial crops paving way for lesser efficiency. Thus maintaining appropriate levels of soil OC is of paramount importance not only for sustained growth and yield but also for its better use efficiency. Location-wise application of fertilizers and other management aspects differ. Coastal and hilly tract farmers rely more on the available sources of bio-wastes while the farmers of transitional and dry tracts do apply tank silt, red earth etc to get higher yields from plants. A need therefore exists for a generically applicable system for estimating current soil organic carbon status that is likely to occur in tropical areas. Considering these points a study was undertaken to assess the soil OC in the farmers' areca gardens of both traditional and non-traditional tracts.

MATERIAL and METHODS

Arecanut is grown in different eco-systems. Depending on variability in topography, soils and water supply four different situations of arecanut growing area viz traditional belt, canal area belt, tank-fed belt and bore well-belt were chosen for the study in 2013-14 (Fig 1). In all these study areas the crop was aged 15-18 years with medium management. The study area comprised 232 acres of areca garden belonging 65 farmers from Shivamogga, Chickamagaluru and Davanagere districts of Karnataka (Table 1).

The standard grid technique of 50 x 50 m was employed to draw soil samples from the selected study area at 0-30 cm depth. Further using global partitioning system (GPS) coordinates the base maps of the study area were developed in geographic information system (GIS) environment. Soil samples collected from each grid were dried, powdered, sieved with 2 mm mesh and analyzed by following the standard methods of analysis. The pH and electric conductivity (EC) were measured with glass electrode in a 1:2.5 soil/water suspension (Jackson 1973) and organic carbon (OC) by rapid titration method (Walkley 1935). For each location depending on sufficiency (>0.6) and deficiency (<0.6) classification criteria, OC status maps were prepared on base map of each study area separately with the help of GIS. Similarly pH (<6.5 as acidic, 6.5 to 7.5 as neutral and >7.5 as saline or sodic) and EC (<1 dS/m as low, 1-2 dS/m as medium and >2 dS/m as high) were also drawn using GIS tool. The points having the same category were grouped into class as a polygon by using inverse distant weighed method interpolation technique and maps for the individual were generated using GIS environment.

RESULTS and DISCUSSION

The location-wise compiled soil analytical results for major nutrients are accomplished in Table 2. Soil variability maps for major soil parameters in the study area are provided in Figs 1 and 2.

Traditional area: This area is represented by Humcha and Konandur locations of Shivamogga district. This is a typical hilly zone cool area receiving 2800 mm rainfall spread over from June to November. The soils were typically lateritic and acidic in reaction (mean value of 5.69) having very low salt accumulation (0.03-0.1 dS/m). Leaching of cations with fixation of phosphorus and zinc was a common feature. OC showed high (around 45%) to medium (around 33%) status. Similar results were also obtained by Shetty et al (2008) in areca gardens.

Tank-fed area: Tank-fed area was represented by Banoor and Chikkingala locations of Chickamagaluru district. The tanks nearby were filled due to rains in hilly zone and the collected water sustained the perennial crops during off rainy seasons. These areas received around 550 mm rainfall and majority of soils were basic in nature with very low salt accumulation. The virginity of soil was lost due to continuous growing situations and more of abiotic stress situations like variation in temperature, relative humidity, sunshine hours etc. Majorly management and supply pattern from different sources were the probable reasons for these variations. The OC status remained medium (with 57%) to low (with 34%) indicating more requirement of organic sources as a remedy. Amount of variation largely depended on management factors which is supported by the studies of Yadava (2010) in Tarai region of Himalayas.

Bore well-fed area: Bore well-supported areca garden was represented by Kerehosahalli location of

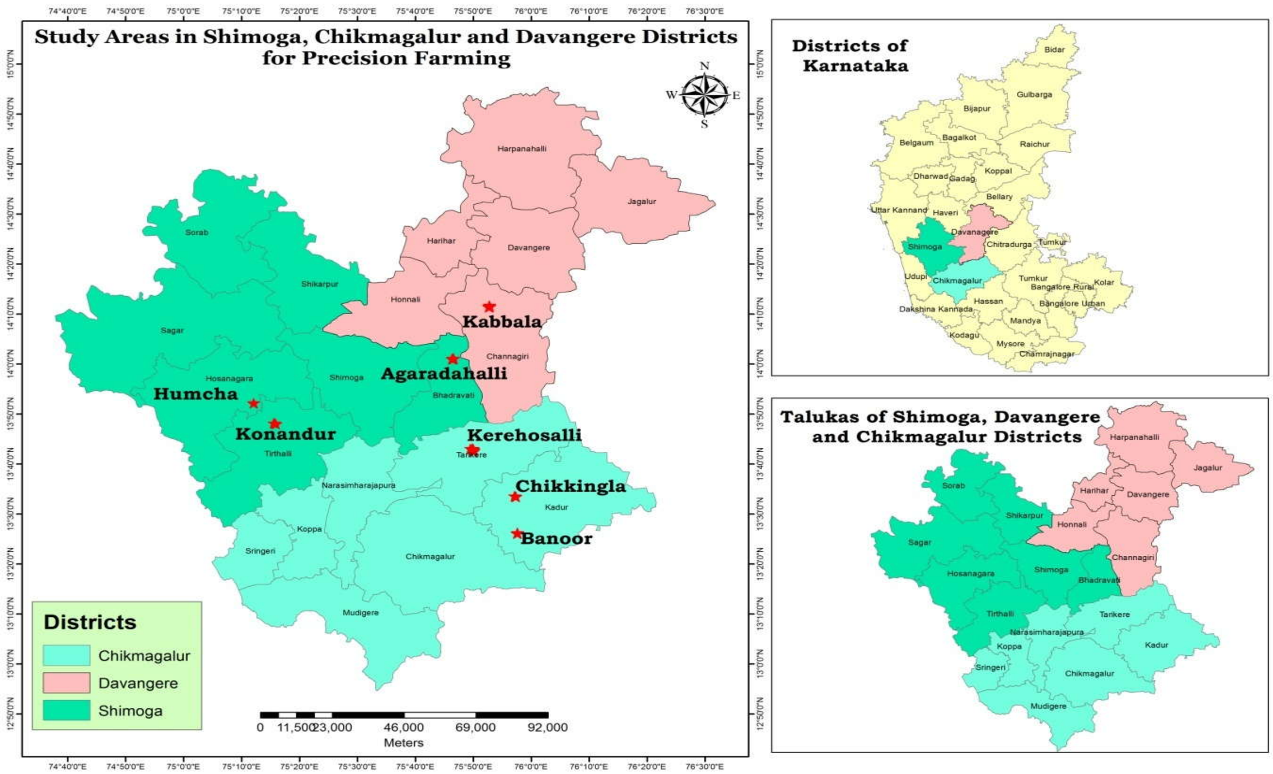

Fig 1. Different study areas of arecanut

Table 1. Details of the study area

Item	Traditional area Humcha and Konandur	Tank-fed area		Borewell-fed area Kerehosalli	Canal-fed area	
		Banoor	Chikkingala		Agarada-halli	Kabbala
Number of farmers	14	6	8	11	19	7
Area (acres)	42	23	25	38	54	50
Number of samples	66	47	50	61	86	80
pH range	5.24-6.61	7.29-8.64	7.91-8.66	7.06-8.27	6.10-8.06	6.82-8.62
Soil reaction	Acidic	Basic	Basic	Basic	Basic	Basic

Tarikere Taluk, Chickamagaluru district as almost a continued stretch of piece of land to that of tank-fed area. With almost same amount of rainfall (510 mm) and absence of any irrigation sources farmers opted for bore wells extensively for irrigation and hence grew perennial crops. These bore well-fed soils were basic in nature with varying salt accumulation from 0.24 to 0.83 dS/m indicating need for maintaining good quality water for crop irrigation. The OC ranged from 0.23 to 1.18 g/kg indicating that 60 and 36 per cent of the samples analysed belonged to high and medium status. These variations can be attributed to management aspect as could be evidenced from the studies of Barman et al (2013) and Kumar et al (2015).

Canal-fed area: Canal-fed area was represented by Agradahalli location of Bhadravathi Taluk in Shivamogga district and Kabbala location of Channagiri Taluk in Davangere district. Agaradahalli is blessed with Bhadra river canal while Kabbala with both

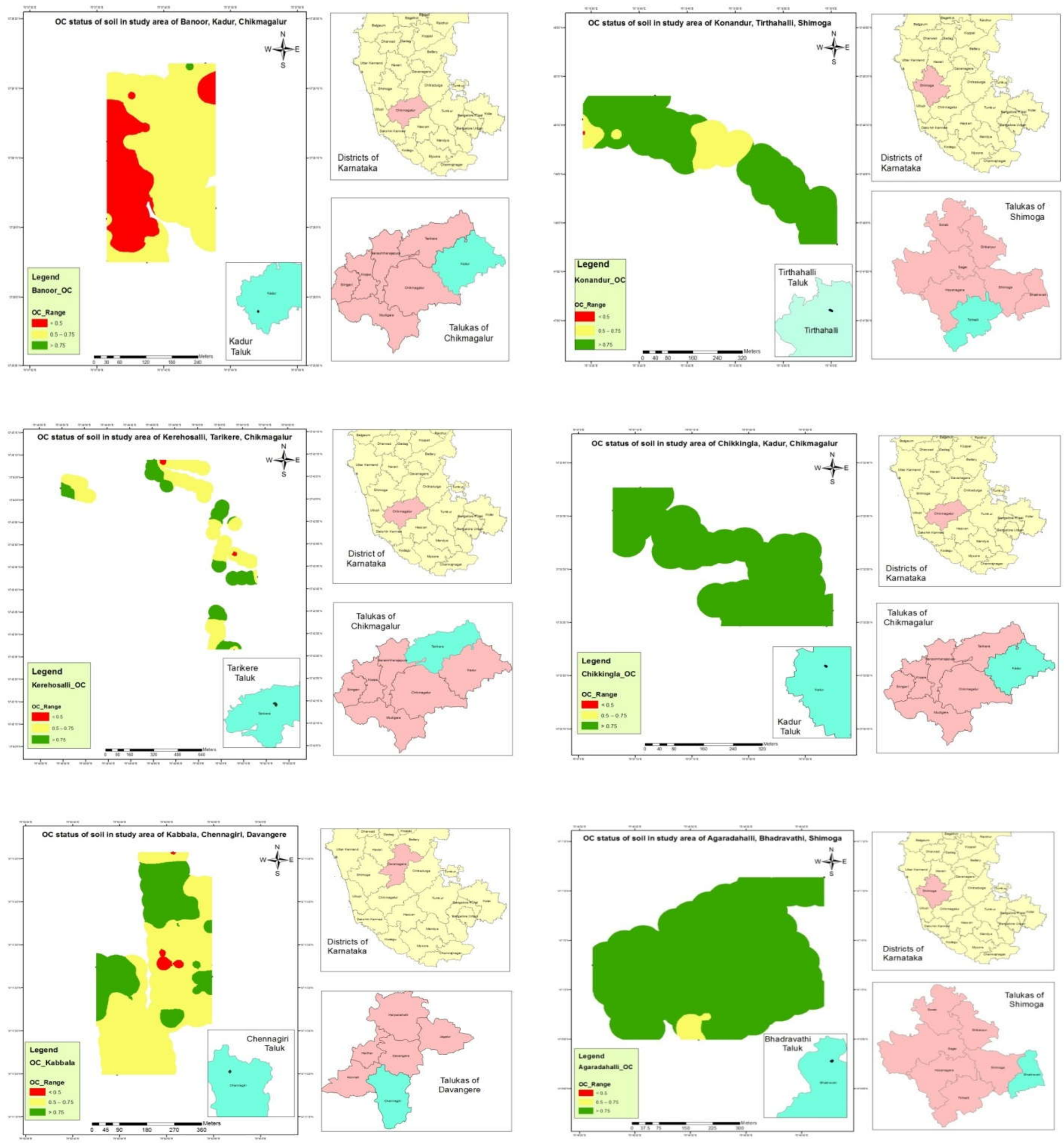

Fig 2. Organic carbon content of soil in different study areas of arecanut

Bhadra canal as well as Shantisagara tank feeder canal and hence had proved assured source of irrigation. Agaradahalli soils were neutral (around 70%) to slightly acidic (around 28%) in reaction. The salt load remained lower with a mean value of 0.28 dS/m. The organic carbon status remained higher to that of other locations indicating probably the better management aspect. Kabbala soils were tending towards basicity with a higher salt accumulation among the locations having a mean value of 0.58 dS/m. It warranted keeping low with better organic practices or such others. However the status of organic carbon clearly indicated the same trend wherein around 80 per cent of samples remained medium to high sharing almost equal proportion. Such variations are also indicated in the studies conducted by Dhanasekara and Mohamed (2014).

Table 2. Location-wise status of soil parameters

	pH	EC (dS/m)	OC (g/kg)		pH	EC (dS/m)	OC (g/kg)
Humcha and Konandur				**Agaradahalli**			
Average	5.91	0.06	0.82	Average	6.77	0.29	1.03
Maximum	6.61	0.10	2.63	Maximum	8.06	0.82	1.40
Minimum	5.24	0.03	0.33	Minimum	6.10	0.15	0.54
Rating out of	Acidic-65		Low-14	Rating out of	Acidic-24		Low-00
66 samples	Neutral-01		Medium-22	86 samples	Neutral-60		Medium-04
	Basic-00		High-30		Basic-02		High-82
Banoor				**Kabbala**			
Average	8.00	0.08	0.57	Average	8.02	0.81	0.69
Maximum	8.64	0.16	0.78	Maximum	8.62	2.78	0.99
Minimum	7.29	0.03	0.41	Minimum	6.82	0.20	0.43
Rating out of	Acidic-00		Low-16	Rating out of	Acidic-00		Low-13
47 samples	Neutral-3		Medium-26	80 samples	Neutral-06		Medium-36
	Basic-44		High-05		Basic-74		High-31
Chikkingala				**Kerehosahalli**			
Average	8.4	0.20	1.06	Average	7.92	0.59	0.75
Maximum	8.66	0.30	1.37	Maximum	8.27	0.83	1.18
Minimum	7.91	0.15	0.80	Minimum	7.06	0.24	0.23
Rating out of	Acidic-00		Low-00	Rating out of	Acidic-00		Low-02
50 samples	Neutral-00		Medium-00	61 samples	Neutral-05		Medium-37
	Basic-50		High-50		Basic-56		High-22

Among the areas studied Humcha and Konandur soils were acidic, Agaradhalli soils were neutral to slightly acidic while others were tending towards basisity. The variation in pH across the study area may be due to the inherent heterogeneity of soil occurrence of various soil types like red and mixed red within the region and to some extent due to influence of parent material and resource region specific differences in the cultural and the fertilizer management practices of the growers (Borzecka-Walker et al 2008).

Humcha and Konandur belonged to high rainfall areas and hence soils were basically acidic due to leaching of bases etc. The pH values of Banoor, Chikkingala, Kerehosahalli and Kabbala were generally tending towards higher status due to the fineness of texture and aridity. Occurrence of poor quality ground water was perhaps responsible for making surface soil slightly saline as it was marked by proportion of medium soil EC values due to its capillary rise during drought conditions. It can also be noted here that Kabbala (mean value of 0.81 dS/m) and Kerehosahalli (mean value of 0.59 dS/m) soils showed little higher salt accumulation than rest of the soils clearly indicating the alarming situation in future years if enough care was not exercised. It is supported by the reports of Vijaya Kumar et al (2015).

Status of OC in arecanut gardens showed a relative tendency across the study area. The surface layers had the status of high to medium for Chikkingala, Agaradahalli, Kabbala and Kerehosahalli. Other areas such as Humcha and Konandur and Banoor soils remained of medium to low status.

It is evident that management of the crop with organic residues vary from farm to farm which is chiefly determined by irrigation and other resource availability. In arecanut gardens usually turnover of residual biomass (spathe, leaf and husk) from trees is quite enough to maintain OC status of soil. The judicious management is essential for striking balance between yield sustainability and soil quality. It reflects on sustained carbon status round the year apart from other essentialities like favourable nutrient uptake from plants and losses due to practices followed in the garden as well as season and water.

The soil type, bulk density, temperature and soil micro-climate of the individual gardens, rate of decomposition as influenced by temperature and micro-climate and other such factors influence the retention of organic carbon below the top layers as evidenced in the studies conducted by Sharma and Singh (2001) and Binita et al (2009).

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