Catena 111 (2013) 1–8

Contents lists available at ScienceDirect

Catena

journal homepage: www.elsevier.com/locate/catena

Influence of hill slope on biological pools of carbon, nitrogen, and phosphorus in acidic alfisols of citrus orchard

Rangeh K. Wanshnong, Dwipendra Thakuria *, Christy B. Sangma, Vishram Ram, Pradip K. Bora

School of Natural Resource Management College of Post Graduate Studies, Central Agricultural University, Umiam 793103, Meghalaya, India

ARTICLE INFO

Article history:
Received 12 June 2013
Received in revised form 2 July 2013
Accepted 23 July 2013

Keywords:
Dissolved organic carbon
Khasi mandarin
Microbial biomass
Nutrient cycling
Potentially mineralizable nitrogen
Soil enzymes

ABSTRACT

This study assessed how different hill slope positions under uniform management practice within a *Khasi* mandarin orchard (*Citrus reticulata* Blanco) influence biological pools of carbon (C), nitrogen (N), and phosphorus (P), and soil quality. The orchard soils (0 to 15 and 15 to 30 cm depths) of summit, shoulder and backslope hill slopes were analysed during post-monsoon (October–November) and post-winter (March–April). Higher soil moisture content, organic carbon (SOC), pH, size of biological pools {microbial biomass-C, -N and -P; dissolved-OC (DOC), MBC:SOC, potentially mineralizable-N (pMN)}, and soil dehydrogenase and acid-phosphomonoesterase activities were in order of summit > shoulder > backslope. Principal component analysis revealed that hill slope position and soil moisture had significant influence on variability of soil biological pools. Sizes of biological pools were significantly higher in post-monsoon than post-winter. Higher MBC and DOC in summit supported significant higher pMN compared to that in shoulder and backslope. The soil quality index within the orchard differed significantly between hill slope positions and higher soil quality was in order of summit > shoulder > backslope. In conclusion, hill slope position and soil moisture had coupled control on spatio-temporal variability in soil biochemical attributes within an orchard in spite of uniform orchard management practice. We believe these findings will ignite new thoughts that the current approach of uniform orchard management within a horticultural orchard especially on hill topography may not be appropriate.

1. Introduction

Understanding how nutrient resources vary at landscape levels has become the focal point of much ecological research in recent years. Characterization of spatial and temporal variability of nutrients in relation to site characteristics is critical for accurate prediction of rates of ecosystem processes (Schimel, 2007). Most studies on the impacts of land use conversion and changes in agricultural management practices indicated that these factors are the major drivers of spatial variability in soil physico-chemical properties, as well as soil biota communities (Tilman et al., 2002; Wallenius et al., 2011). Orchards associated with hill slope topographies are particularly subject to spatial variability in soil fertility resulting from differences in the angles of slopes, yielding varying runoff potentials. In India, orchard planters mostly ignore such anticipated spatial variability in soil fertility while formulating nutrient management practices. For example, the variability in soil fertility within drip circle and inter-row spaces due to long term soil management practices in guava and sapota orchards was recently reported (Hazarika et al., 2011). In addition to spatial variability, the temporal variability in soil moisture within a horticultural orchard may influence plant productivity. Soil moisture is known to influence both net primary productivity (NPP) and soil microbial community composition, and thereby influence microbial processing of large pools of C, N, and P in soil organic matter (Brockett et al., 2012; Harper et al., 2005). Thus, it was hypothesised that biological fractions of soil C, N, and P are likely to be influenced by temporal variability in soil moisture along slope on hill topography within an orchard.

In India, citrus plantation covers over 0.923 million hectares, with a production of 8.60 million tonnes per annum. Among citrus cultivars, *Khasi* mandarin (*Citrus reticulata* Blanco) is a premier horticultural crop, particularly in the North Eastern Hill States (Srivastava and Singh, 2009). *Khasi* mandarin orchards are typically located on hill slopes, extending up to 1000 m above mean sea level. In general, *Khasi* mandarin orchards cover the summit, shoulder and backslope of hills. Health and yield of *Khasi* mandarin trees are generally poor on the backslopes compared with those on the summit and shoulder, regardless of tree age and genotype, assuming uniform recommended orchard management practices (Suresh-Kumar et al., 2008). It is likely that the spatial variability in soil fertility at different slope positions will result in variable growth and yield within citrus orchards. In addition, the long dry spell during winter months (December to February) may negatively impact soil biological activities in orchard soils along the hill slope. Feeder roots of citrus plant mostly proliferate in the surface soil layer (0 to 15 cm depth). As a result, feeder roots may be stressed for water and plant-available forms of nutrients during winter

* Corresponding author. Tel.: +91 9436767009.
E-mail address: thakuria.dwipendra@yahoo.co.in (D. Thakuria).

0341-8162/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.catena.2013.07.009

months. Adverse soil conditions such as these may damage feeder roots, thereby disrupting flower initiation in February.

This study investigated how soil biological pools of C, N, and P (as indicators of nutrient cycling potential) vary along hill slope positions at flower initiation (March to April) and fruit ripening (October to November) in *Khasi* mandarin. In addition, the impacts of uniform orchard management practice over a long-term period (10 years) on soil quality were compared between hill slopes within the orchard. The indicator parameters of soil biological pools of C, N, and P analysed were: soil organic carbon (SOC), moisture content (MC), pH, microbial biomass-C, -N and -P (MBC, MBN and MBP), MBC:SOC, dissolved organic carbon (DOC), soil available- N and -P (Avl.N and Avl.P), potentially mineralizable-N (pMN), dehydrogenase activity (DHA) and phosphomonoesterases activity (PHA).

2. Materials and methods

2.1. Orchard location, soil characteristics and yield trend

A model citrus orchard {cultivar — *Khasi* mandarin (*C. reticulata* Blanco), orchard area 2.5 ha and age 10 years} (geographic position 25°41′21″ N, 91°55′25″ E and 753 m amsl) was selected for this study. Before establishment of the orchard, the area was under *Khasi* pine forest (*Pinus kesiya* Royle ex Gordon) and the adjacent areas to the orchard are still under intact forest. The hill topography was categorised into four distinct slope positions, viz. summit, shoulder, backslope and toeslope (Fig. 1). The orchard area was extended along the summit, shoulder and backslope. Soil of the orchard was acidic red soil (Alfisols, USDA Taxonomy) and texture was sandy clay (% sand, 45.16 to 49.54; % silt, 13.40 to 14.07; and % clay, 38.13 to 41.62). The maximum water holding capacities of soils at summit, shoulder and backslope were 38.31%, 34.12% and 31.67%, respectively at 0.33 bar and 22.68%, 20.93% and 18.47%, respectively at 15 bar (Momin, 2011). The orchard was maintained as per the standard package and practices of *Khasi* mandarin recommended for the North Eastern Hill States of India (Suresh-Kumar et al., 2008). *Khasi* mandarin plants were 10 years old and generated from rough lemon root stock. The external application of nutrients, viz. N, P, and K, per plant over 10 years was approximately 4.0, 3.2, and 4.7 kg as urea, single super phosphate and muriate of potash, respectively (year-wise details in Table S1). Total quantity of organic manure received in 10 years by each plant was approximately 225 kg (Table S1). The slope positions within the orchard differed significantly from each other in terms of the annual average fruit yield since 2002 (Fig. 1). The yield trend in the orchard was in the order of summit (15.2 t ha^{-1} yr^{-1}) > shoulder (11.1 t ha^{-1} yr^{-1}) > backslope (6.2 t ha^{-1} yr^{-1}). Citrus decline-like syndrome was more prominent at backslope, whereas healthier plants were on the shoulder and summit (Fig. S1).

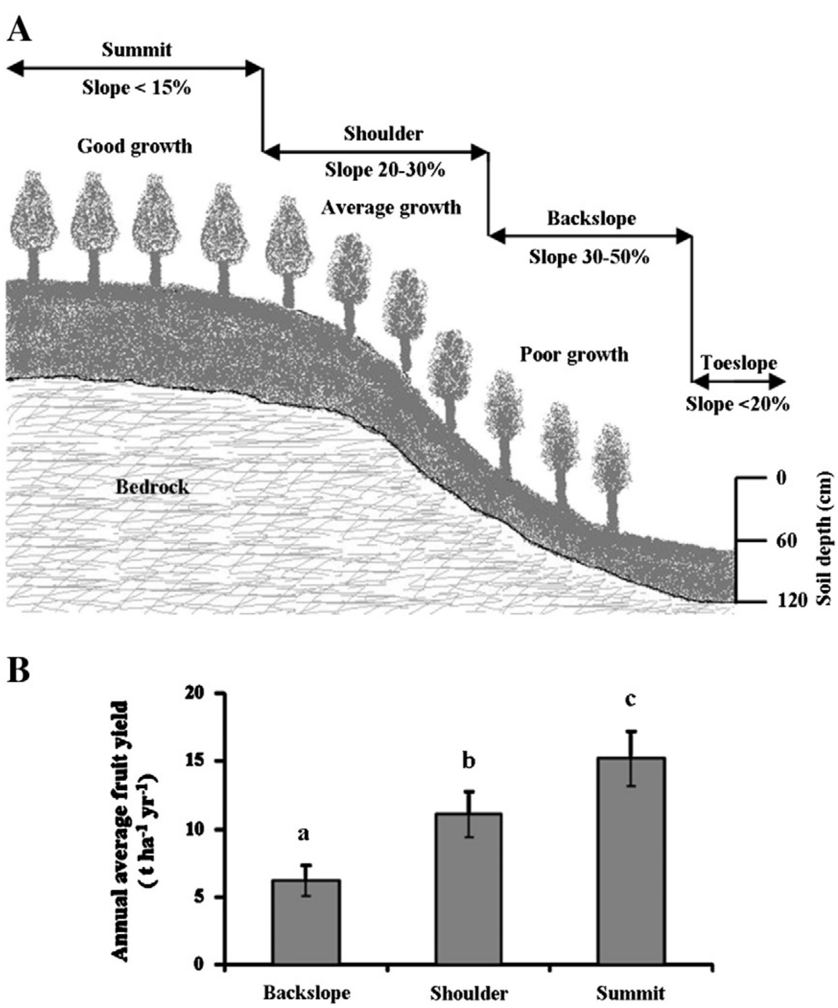

Fig. 1. The *Khasi* mandarin (*Citrus reticulata* Blanco) orchard on the hill slope: (A) schematic of hill topography including slope position and soil depth; and (B) annual average fruit yield of *Khasi* mandarin since 2002. Soil cores were collected from the summit, shoulder and backslope.