MANAGEMENT IMPACTS ON ALLOPHONIC SOIL CARBON SEQUESTRATION

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Background

- Background Soil organic carbon (SOC) is a composite indicator of soil quality.
- Management practices affect SOC concentration and stocks.
- There is limited information available on SOC distribution in Allophonic soils used for different crop production systems.
- We hypothesized that kiwifruit orchards may have higher soil organic carbon stocks at depth, as it has a deeper rooting system, than shallow rooted pastoral and arable production systems.

Objectives

To test the hypothesis, the aims of this study were (i) to quantify vertical variation of SOC carbon stock and (ii) to evaluate the organic carbon accumulation rates in Allophanic soil used for kiwifruit production systems as compared to grasses (pastoral) and annual crops (arable) for the last 30 years.

Materials and Methods

Study Sites and management

The experiment was conducted near Tauranga (37˚43S 176˚06E) located in the Bay of Plenty region. The experimental sites are approximately 50 m above sea level, free draining, and have little or no compaction. The average lowest and highest monthly maximum temperature of the study site is in July (9.8˚C) and February (19.3˚C), respectively. The average lowest and highest precipitation of the study area is January (74 mm) and March (128 mm), respectively. Soils of all experimental sites are classified as Allophanic Orthic Pumice soils (Vitrads/Vitricryands Andisol, USDA; Mollic Andosol, FAO) formed predominantly from ryolitic tephra between ~ 4000 and 40,000 years ago during the region's geographic history of periodic volcanic eruptions. Three sites were chosen: kiwifruit orchard, pasture (perennial ryegrass and clover); and arable (annual vegetable crops) land located geographically in the same area, with the present crop grown under integrated management for more than 30 years. Disturbed and undisturbed soil sample were collected at 0-10 cm, 10-30 cm, 30-50 cm and 50-100 cm depths. In the kiwifruit orchard, a 500 gram composite sample was obtained by mixing soil samples collected from between the plants along the row (vine row); in the middle of the sward between the rows (grass alleyway) and from the area that machinery travels along between the rows (wheel tracks). Soil samples were processed and analyzed for several basic soil properties. Soil organic carbon was estimated by using the regression equation developed for Allophanic soil by the 'Carbon in Orchard Soils Team' (Rahman et al., 2010) as extensive measurements of SOM by comparing loss-on-ignition, wet chemistry (Walkley and Black, 1934) and dry chemistry (TruSpec® CHN Determinators, LECO Corp., St Joseph, MI, USA). All results were calculated based on oven-dried soil at 105˚C, 24h).

Fig. 1. Soil Sample Collection from Pastoral Site

Summary of Results

Background information of experimental site and results are summarised in Tables 1-2 and Figures 2-3.

- Averaged across soil depth, C concentration was significantly highest in kiwifruit orchard, intermediate in pasture, and lowest in arable soils.
- Irrespective of management practices, C concentration decreased significantly with increasing soil depth. The C concentration shown a similar or slightly different pattern when expressed on a stock basis, calculated by taking the differences in antecedent bulk density.
- When combined with soil depth (0-100 cm), the profile-wise C stock (257.5 Mg ha-1) in kiwifruit orchard was 2.2 and 1.9 times higher than the arable and pasture lands, respectively.
- The proportion of C in the soil profile was more uniform in kiwifruit orchards than pastoral and arable soils.
- Kiwifruit orchards exhibited a significantly higher capacity for C storage at 50-100 cm deep than both pastoral and arable soils is most probably associated with greater root distribution of kiwifruit at deeper soil depths.
- Allophanic soils planted with kiwifruit showed more carbon sequestration potential than soils planted with both pastoral and arable crops.

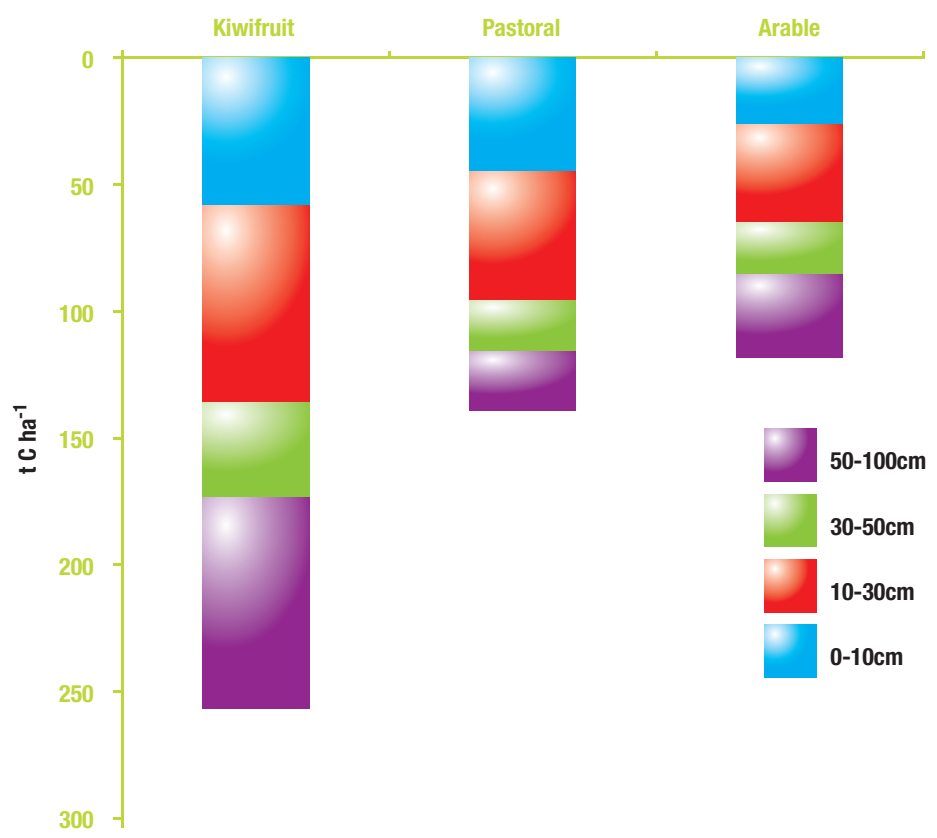
Table 1. Annual nutrient inputs of experimental sites

	Kiwifruit	Pastoral	Arable
Average nutrient inputs (kg ha^{-1} yr^{-1})			
Nitrogen	67	106	158
Phosphorus	28	60	32
Potassium	161	62	23
Sulphur	98	73	50
Magnesium	17	13	13
Calcium	38	25	150
Boron	4	-	-

Table 2. Soil organic carbon of different cropping practices

	Depth (cm)	Kiwifruit	Pastoral	Arable
Concentration (%)				
	0-10	7.84	6.05	3.03
	10-30	4.97	3.00	2.17
	30-50	2.41	1.23	1.28
	50-100	2.27	0.67	0.91
Relative proportion				
	0-10	3.46	9.01	3.35
	10-30	2.19	4.46	2.40
	30-50	1.06	1.84	1.42
	50-100	1.00	1.00	1.00
Storage capacity (%)				
	0-10	22.42	32.32	21.87
	10-30	30.46	36.50	32.59
	30-50	14.52	14.22	17.55
	50-100	32.61	16.96	27.99

Fig. 2. Soil organic carbon in Bay of Plenty allophanic soils under different crops



Conclusions

Compared with arable and pastoral production, kiwifruit orchards are more likely to enhance soil organic carbon sequestration at deeper soil depths. Some management practices such as establishing higher C:N ratio (more lignin and less carbohydrate and protein); and/or lower N:C ratio plants as a cover crops or introducing plant material and compost will help to maintain potentially high SOC stock in Allophanic soils.