Soil phosphorus status in organic and conventional vegetable farms in Southeast Queensland, Australia

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Abstract

The soil phosphorus (P) status (0-10 cm) of two farming systems (organic (OF) and conventional (CF) vegetable farms) at two locations (Gatton and Stanthorpe) was examined amongst a suite of soil fertility indicators. The P status was similar between farming systems, in contrast to some broad-acre organic systems. Examination of farm management records revealed substantial overlap between P inputs at both localities with CF systems also receiving organic inputs, e.g. green manure and composts. A statistical analysis of the effects of different inputs also indicated that P fertility did not vary significantly between farms. Soil P levels were medium to high across farm types indicating a potential environmental risk for vegetable producers particularly in sandy well drained soils. The three methods of extraction Colwell, Olsen and Resin were well correlated with each other and produced similar results indicating the similar nutrient pools exist between farming system.

Introduction

Organic farming is considered an alternative to conventional farming, providing sustainable crops with high export demand and less environmental effect (Wood et al., 2006). In Australia, growth in organic production is estimated at 15-25% annually. Growth is expected to continue because of strong domestic demand and expanding markets overseas, especially in Asia (Alexandra and May, 2004). However, Australian organic growers face particular challenges due to infertile soils, high climatic variability and large distances between farms and input sources (Malcolm et al., 1996).

Soil health is a central tenet of organic agriculture and is critical to sustainable agriculture (Widmer et al., 2006). However, fertility management in Australia may not respond well to European organic methods. Of specific concern are the findings of Penfold (2000) and Ryan et al. (2004), who indicated that plant available P is a limiting factor in organic farming due to the low natural abundance of P and slow rate of release from organic-certified fertilisers. Organic farming may deplete soil P built up during conventional management (Gosling and Shepherd, 2005). But recent research in Australia has indicated a positive balance of P in organic vegetable production (Wells et al., 2000), suggesting that the problem of P limitations in organic production in Australia are restricted to specific farming systems (e.g. broad-acre enterprises) and specific bio-physical conditions (e.g. high pH soils).

A soil survey was conducted to determine whether the P limitations faced by broad-acre grain growers in southern and western Australia are also a problem for typical vegetable growers in the east of the continent. The survey also sought to identify the different management strategies adopted by vegetable farmers to manage soil fertility.

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Materials and methods

Soil samples (0-10 cm) were collected from two different localities in south east Queensland, Gatton (Vertosols-medium clay) (27.5° S, 152° E, 94 m elevation) and Stanthorpe (Tenosols-sandy loam) (28.6° S, 152° E, 872 m elevation) from organic vegetable farms (OF) and neighbouring conventional farms (CF) on similar soils (Isbell, 1996). In February 2005, five OF and three CF were sampled at Gatton and four OF and four CF at Stanthorpe. Selected properties were resampled in 2006.

Soil samples were air-dried, and sieved (<2 mm) prior to analysis. Labile P was estimated using three common methods: Olsen (Olsen et al., 1954), Colwell (Colwell, 1963) and Resin (Guppy et al., 2000) in 2005. Correlations between the three methods were calculated.

All farmers completed a questionnaire about their farm practices in the last five years regarding the amount and type of green manure or cover crops (GM), bulky manure application (BM), compost application (CT) and synthetic fertiliser application (SF). Since the number of farms sampled was low and the quality of questionnaire responses was variable, the data were classified as “Yes” or “No” indicating if the management practice was used or not. Percentage of farms within each farming system receiving each input were calculated (Table 1).

The data were subjected to a two factor ANOVA using R programming (R Development Core Team, 2003) for each management variable with location as the other factor. Sampling date was not significant for all variables ($P > 0.05$), as was the interaction term ($P > 0.05$), hence the data was pooled across years.

Results

Soils from Gatton were alkaline (pH from 7.7 to 8.6) and Stanthorpe soils were acidic to neutral (pH from 5.5 to 7.6). No difference in P status was observed between the farming systems ($P > 0.05$) and locations ($P > 0.05$). Sixty and forty percent of CF in Gatton received compost and green manure respectively. Twenty nine, fifty seven and seventy one percent of CF in Stanthorpe received CT, GM and BM respectively (Table 1). Further analysis based on different types of fertilisers revealed no difference in soil P status ($P > 0.05$) irrespective of extraction method. The three methods of available P analysis were well correlated among each other with R^2 value of 0.72, 0.84 and 0.85 for Colwell:Resin, Colwell:Olsen and Olsen:Resin respectively. The P levels were generally medium to high for vegetable production (Peverill et al., 1999) both in OF and CF.

Discussion

The similar soil P status between organic and conventional vegetable farms in two locations with contrasting soil types and climatic conditions indicates that organic vegetable farmers are not at a nutritional disadvantage compared to their conventional counterparts, as has been reported for some organic broad-acre cropping systems (Penfold, 2000; Ryan et al., 2004). A survey conducted by van Dienpeningen (2006) also reported no difference in P levels between organic and conventional farms in Netherlands. Also there are reports of positive P balance in different organic farming system such as vegetables in (New South Wales) Australia (yellow earth - *Luvic Ferrasol*) (Wells et al., 2000) and cereal legume crop rotations (*sandy clay loam soil*) in Italy (Marinari et al., 2006). Our survey confirms that many conventional growers include substantial inputs of organic fertilisers, so that the distinction between organic and conventional systems is less well defined than might be expected, a result reported earlier by van Diepeningen et al. (2006)

The medium to high P levels for both CF and OF (Peverill et al., 1999) suggests that all are high input production systems with potential for adverse environmental effects, such as nutrient leaching, especially in sandy soil (e.g. Stanthorpe) (Zhang and MacKenzie, 1997).

Table 1: Percentage of farms using particular fertilisation practices and soil phosphorus levels of organic and conventional vegetable farms in Queensland (means and standard errors are given with the range in brackets)

Farm	GM (%)	BM (%)	CT (%)	SF (%)	Colwell P (µg g^{-1})	Olsen P (µg g^{-1})	Resin P (µg g^{-1})
Gatton organic	100	100	100	0	104±14.3 (62-146)	48±5.7 (37-66)	107±10.8 (64-163)
Gatton conventional	40	0	60	100	151±18.9 (126-188)	66±6.3 (55-77)	134±11.6 (110-173)
Stanthorpe organic	67	67	50	0	137±71.4 (24-341)	51±24.3 (12-122)	99±32.5 (13-236)
Stanthorpe conventional	57	71	29	100	163±79.0 (40-395)	51±14.9 (20-92)	95±25.5 (20-183)

GM-green manure, BM-bulky manure, CT-compost, SF- synthetic fertiliser

The good correlation between the three extraction methods and the similar P levels between OF and CF measured by the three methods indicate that soil P pools in organically farmed soils were equivalent to those in conventionally managed soils (Watson et al., 2002).

Conclusions

Results of the soil survey of organic and conventional vegetables farms in two contrasting locations revealed that soil P was similar between farming systems, partly due to the high use of organic inputs in CF. This finding contrasts with reports of P deficiencies in other Australian organic farming systems. The medium to high P levels in CF and OF confirm that these are high input systems with the potential for adverse environmental effects. The three extraction methods were well correlated and demonstrated that different pools of soil P were similar across farming systems.

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