Renewable Agriculture and Food Systems

cambridge.org/raf

Research Paper

Cite this article: Robusti EA, Mazeto VA, Ventura MU, Soares Júnior D, Menezes Jr AO (2020). Soybean crop profitability: biodynamic *vs* conventional farming in a 7-yr case study in Brazil. *Renewable Agriculture and Food Systems* **35**, 336–341. https://doi.org/10.1017/S1742170518000613

Received: 9 May 2018
Revised: 26 October 2018
Accepted: 18 December 2018
First published online: 12 February 2019

Key words:
Agroecology; conservation systems; costs; financial indicators; organic agriculture; price

Author for correspondence:
Maurício Ursi Ventura, E-mail: mauriciourisventura@gmail.com or mventura@uel.br

Soybean crop profitability: biodynamic *vs* conventional farming in a 7-yr case study in Brazil

Eliane Araujo Robusti[1], Vagner Antonio Mazeto[2], Maurício Ursi Ventura[3], Dimas Soares Júnior[4] and Ayres de Oliveira Menezes Jr[5]

[1]Depto. Agronomia, Universidade Estadual de Londrina, CCA, Rodovia Celso Garcia Cid, Pr 445 Km 380, Campus Universitário Cx. Postal 10.011, CEP 86.057-970, Londrina, PR, Brazil; [2]Depto. Agronomia, Universidade Estadual de Londrina, CCA, INSTITUTO EMATER––PR, extension service, Rodovia Celso Garcia Cid, Pr 445 Km 380, Campus Universitário Cx. Postal 10.011, CEP 86.057-970, Londrina, PR, Brazil; [3]Depto. Agronomia, Universidade Estadual de Londrina, CCA, Rodovia Celso Garcia CiD, Pr 445 Km 380, Campus Universitário Cx. Postal 10.011, CEP 86.057-970, Londrina, PR, Brazil; [4]Instituto Agronômico do Paraná, IAPAR, Rod. Celso Garcia Cid, 375––Conj. Ernani Moura Lima II, Londrina, PR, 86047-902, Brazil and [5]Depto. Agronomia, Universidade Estadual de Londrina, CCA, Rodovia Celso Garcia CiD, Pr 445 Km 380, Campus Universitário Cx. Postal 10.011, CEP 86.057-970, Londrina, PR, Brazil

Abstract

Organic/biodynamic agriculture has been reported worldwide as a suitable system to conserve or even regenerate natural resources. Due to the lack of long-term studies regarding the profitability of tropical organic *vs* conventional farming, the economic performance of biodynamic *vs* conventional soybean was studied using data from a consecutive 7-yr case study in a farm with 48.4 ha of biodynamic soybeans in Paraná State, Brazil. Analyses of production costs and financial indicators were adjusted at updated values according to inflation in the period. Effective operational costs were 4.4% higher in biodynamic than in conventional farming. The biodynamic yields were lower (3.6%) than those of conventional. Prices were 57% higher in biodynamic than in conventional, making biodynamic farming more profitable than conventional farming, as shown by financial indicators (gross revenue, gross margin, net margin, net income and capital income were 50.7, 99.9, 122.9, 150.4 and 166.9%, respectively, higher in biodynamic than in conventional). The price equilibrium point (PEP) was 3.4% higher for biodynamic farming; the leveling point was 36.9% higher for conventional farming. Manual weeding and plowing increased organic costs. Higher biodynamic trading prices than those of conventional triggered a PEP suitable for covering higher costs and thus boosting profitability. Further investigations and policies are suggested to further improve biodynamic farming efficiency and sustainability.

Introduction

Agriculture provides food, fibers and energy for a growing population worldwide. Due to an increasing search for agricultural supplies, civilization faces pressures on forest depredation, greenhouse gases, biodiversity loss, agrochemical pollution and soil degradation (Reganold and Wachter, 2016). To conciliate these two demands, the development and practice of sustainable agriculture principles are important.

Organic agriculture comprises some farming practices that discard synthetic pesticides, fertilizers and genetically modified organisms (GMOs). As a consequence of practicing organic agriculture in the long term, maintenance and regeneration of soil may be necessary (Mäder *et al.*, 2002; Seidel *et al.*, 2017). Organic farming—as a collective—comprises some lines or schools with some specific traits; among them, biodynamic farming proposes to create a balanced farm whose activities are strongly integrated and that uses some specific preparations made from fermented manure, minerals and herbs. In general, practicing biodynamic or traditional organic management provides similar beneficial effects on soil fertility and biology, yields and economic performance (Mäder *et al.*, 2002; Birkhofer *et al.*, 2008; Forster *et al.*, 2013). Biodynamic farming preparations are not used to add nutrients, but to stimulate and regulate processes of nutrient and energy cycling, and to improve soil and crop quality. Recent studies have showed that preparations from biodynamic farming may even enhance yields, chemical composition and phytosanitary status (Jariene *et al.*, 2015; Picone *et al.*, 2016; Maneva *et al.*, 2017; Nabi *et al.*, 2017; Jariene *et al.*, 2018).

The input costs of conventional farmers are generally higher than those of alternative low-input systems, such as organic/biodynamic farming. In recent growing seasons, technological rates or royalties have been included in GMO seed costs by biotechnology companies to price herbicide or insect resistance (Bt-engineered plants), which raises costs even more. Due to these costs and the development of resistance of weeds to herbicides and insects to

Bt-proteins (failures in control), farmers' interest in non-GMO seeds is growing. Synthetic fertilizers and pesticides also overtax conventional management costs, which increases variable or effective operational costs (EOCs). However, conventional agriculture is referred to as able to produce more with less labor.

In general, organic foods, such as tomatoes, have higher prices but lower variations. Production costs are also lower (17.2%), which affords higher profitability (59.9% in the summer and 113.6% in the winter growing seasons) (Luz *et al.*, 2007).

Almost 34 million ha of soybean are presently cultivated in Brazil. In addition, 22.5 million more ha are cultivated in the countries bordering southern Brazil (Argentina, Paraguay and Uruguay). These agriculturally extensive areas represent great environmental hazards that may be minimized by replacing chemical-based agriculture—in general, designated conventional—by more sustainable systems such as organic/biodynamic farming. However, in general, there is a lack of studies dealing with long-term comparisons between organic and conventional farming systems in Latin America. Long-term studies are more trustworthy due to the diminishing effects of climatic and economic short-term variations (Nemes, 2009).

Profitability is a guiding factor when farmers make their decisions, including choosing crop systems. A series of interviews conducted in Australia showed broad consensus on the risks facing organic farming (McCarthy and Schurmann, 2018). Since soybean production occupies the largest cultivated land in Brazil, one first step to guide toward changing to more sustainable farming is to obtain a favorable scenario in organic/biodynamic farming related to crop operation accounting. Here, we present results from a 7-yr case study comparison between biodynamic and conventional farming profitability by using analysis of production costs and financial indicators.

Material and methods

This study was performed using data provided from a Farm in São Pedro do Ivaí County, Parana State, Brazil (Latitude 23°49′33.90″S and Longitude 51°52′43,33″W). The farm is a family operation containing 217.8 ha, of which 188.54 is used to produce grains, including soybean [biodynamic (48.4 ha) and conventional (96.8 ha)]. The same conventional management was used previously the onset of the comparisons.

Farm system profitability was compared during seven crop growing seasons (from 2004/5 to 2010/11). The conventional system, in which ordinary regional practices oriented by official extension service were used, was compared to biodynamic certified [Instituto Biodinâmico de Desenvolvimento (IBD)] operation. A no-till approach using herbicides was used in the conventional system, while in the biodynamic system, soil was plowed before sowing and manual weeding during soybean development. Soil fertilization was performed using soluble fertilizers for conventional and organic compost plus specific preparations [compost preparation; BD 500 (cow manure placed in a horn maintained buried in the soil during autumn and winter) sprayed on the soils and BD 501 (powered quartz placed in a horn maintained buried in the soil during spring and summer)] sprayed on the plants.

The fields were settled side by side and were similar in relation to soil type (red eutrophic nitosol), fertility and relief and both were previously managed conventionally, which may be considered representative of the standard management of soybean crops in Brazil. In conventional system, disease and weed were controlled using synthetic chemical pesticides. In biodynamic system, nuclear polyhedrosis virus; home-made traps (2L PET bottles) using cow urine as attractive; and Bordeaux mixture were used to control *Anticarsia gemmatalis* (Lepidoptera: Noctuidae); brown stink bug *Euschistus heros* (Hemiptera: Pentatomidae); and soybean rust, *Phakopsora pachyrhizi*, respectively. In general, same equipments were used in both fields except plow and hoes which were used just for biodynamic. Sprayers and seeders were carefully washed before moving between fields.

Data were recorded weekly by the farmer and agronomist consultant and included machinery and equipment operations, occasional labor, seeds, pesticides or biodynamic inputs and transport, which made up the EOC. Permanent labor, depreciation, opportunity and insurance costs were added to EOC to generate total cost (TC).

For depreciation, insurance and opportunity costs, the percent participation in TCs from the Department of Rural Economy of the Secretary of Agriculture and Supply of Paraná (SEAB/DERAL, February, 2017) was adopted using the same values independent of management because the costs of organic and conventional management were quite similar to those previously sown (Di Domenico *et al.*, 2015).

Financial indicators were calculated in dollars/ha and according to Matsunaga *et al.* (1976), Ronque *et al.* (2013) and Martins *et al.* (2016) (Table 1). Data were stored in electronic spreadsheets in which calculations were performed. The values were adjusted for the base date of August 2017, in accordance with the general price index—domestic availability stipulated by Fundação Getúlio Vargas (IGP-DI/FGV), for the purpose of converting nominal values into real values to compare exempt from effects related to inflation during the study period.

Results and discussion

The EOC, which refers to machinery and implements, eventual labor, seeds and other inputs to biodynamic or conventional farming systems, is presented in Tables 2 and 3, respectively.

Temporary labor and external transportation were higher in biodynamic than conventional farming in all growing seasons. Temporary labor was used for manual weeding during cropping. Labor costs in organic crops are currently 7–13% higher than conventional costs (Crowder and Reganold, 2015). As there is no receiving structure or organic product in the vicinity of the property, grains were transported to Ponta Grossa or Campo Largo Counties, where the biodynamic soybean was received for trading.

In general, biodynamic farming inputs, including fertilizers, were lower than those of conventional farming systems mostly due to the inclusion of synthetic herbicides, insecticides and fungicides to conventional farming (Tables 4 and 5). Variations in the costs of the production factors resulted in higher EOC in the biodynamic farming in the growing seasons from 2005/6 to 2008/9. In contrast, lower EOCs were obtained for biodynamic than for conventional farming in the 2004/5, 2009/10 and 2010/11 seasons. The EOC was 4.4% higher in biodynamic than conventional farming considering the means of the seven growing seasons.

Fixed expenses, including depreciation, direct charges, insurance, financial charges and other expenses, were considered similar in the two farming systems as previously established in the methodology. The relative similarity of the costs between biodynamic and conventional farming agrees with the general pattern in which fixed, variable and TCs have been seen as not

Table 1. Financial indicators, formulae and description

Financial indicators	Formulae	Description
Effective operational cost (EOC)	EOC = ∑ (Ph.Qh) + ∑ (Pj.Qj)	Sum of expenditures on inputs and temporary labor—disbursable costs
Total operational cost (TOC)	TOC = EOC + D + Pl	Sum of EOC and other non-disbursable operating costs, for example: Depreciation (D), Permanent labor (PL), direct charges, insurance, financial charges and other expenses
Total cost (TC)	TC = TOC + CR + LR	Sum of TOC plus Interest (I) or Capital remuneration (CR) and Land remuneration (LR), composing the Opportunity cost (OC)
Gross returns (GR)	GR = ∑ (Pi.Qi)	Price multiplied by the quantity produced
Gross margin (GM)	GM = GR–EOC	Indicates the amount to remunerate fixed costs
Net margin (NM) or Operating net income (ONI)	NM = GR–TOC	Profitability of the activity in the short term, showing the financial and operating conditions
Net income (NI)	NI = GR–TC	Farmer compensation
Price equilibrium point (PEP) or Average cost (AC)	PEP = (TC/Q)	Minimum price to pay production costs
Leveling point (LP)	LP = (TC/P)	Minimum price, given the selling price of the product, to cover the costs of

Source: authors.

Table 2. Effective operational cost (EOC) for soybean biodynamic farming systems (growing seasons from 2004/5 to 2010/11)

Specification[a]	2004/5	2005/6	2006/7	2007/8	2008/9	2009/10	2010/11	Means
Machinery and implements operation	130.82	194.88	176.95	174.67	144.10	206.20	178.49	172.30
Eventual labor	109.89	26.75	15.86	63.84	98.68	29.40	25.50	52.84
Seeds	67.50	93.75	58.49	45.94	46.99	43.47	44.13	57.18
Inputs	228.15	178.83	159.04	180.74	247.79	42.21	64.53	157.32
External transportation	70.64	58.84	96.66	79.16	54.30	98.27	107.10	80.71
Total EOC	607.00	553.05	507.00	544.37	591.84	419.53	419.75	520.36

Source: authors.
Values corrected to August/2017 (IGP-DI/FGV).
(US$ ha^{-1}).
[a](US$ ha^{-1}).

significantly different between organic and conventional farming (Crowder and Reganold, 2015). However, our results disagree with previous revisions, which attributed a reduction in variable costs (50–60%) for grain production compared between organic and conventional farming (Nemes, 2009).

Financial indicators for biodynamic and conventional farming are presented in Tables 4 and 5, respectively. The TCs are presented in Table 6. When lower values for EOC, TOC and TC in biodynamic agriculture were found, better results in the period were obtained. The TC (EOC+TOC+OC) obtained in biodynamic farming was lower in the 2004/5, 2006/7, 2009/10 and 2010/11 growing seasons and higher in the 2005/6, 2007/8 and 2008/9 growing seasons than in conventional farming (Tables 4 and 5).

The biodynamic farming system net income (NI) was 150.4% higher than that in the conventional farming system, despite the oscillations of productivity. Similar yields were obtained in the 2004/5, 2005/6, 2008/9 and 2010/11 growing seasons. A higher yield was obtained in biodynamic than conventional farming in the 2006/2007 growing season.

In general, global yield averages are 8–25% lower in organic than conventional farming, but under certain conditions (crops, growing conditions and management practices), organic systems come closer to matching conventional systems in terms of yield (Reganold and Wachter, 2016), and this was the case in the present study, in which productivity was just 3.4% lower in organic farming. Soybean is one of the crops in which higher values of relative yield between organic and conventional farming have been reported (de Ponti *et al.*, 2012). In general, organic production of leguminous crops tends to be closer to conventional production than other types of plants (Crowder and Reganold, 2015).

Yields from biodynamic farming being higher than those from conventional farming probably reflects previously reported higher resilience in organic systems during drought years due to higher soil moisture availability (Nemes, 2009; Seidel *et al.*, 2017). The results reported here contradict previous studies in Brazil, in which a reduction of 35% yields in organic soybean compared with conventional farming systems was found—this comparison was achieved using data from just one season (Di Domenico *et al.*, 2015).

The productivity of the biodynamic fields in the three first growing seasons was not lower than that of conventional fields (Tables 2 and 3). These data reinforce previous findings in which leguminous plants were suggested to be included in the conversion to organic growing seasons (McBride and Greene, 2009; Forster *et al.*, 2013; Crowder and Reganold, 2015; Seidel *et al.*, 2017).

Biodynamic soybean prices were higher than under conventional farming in all growing seasons [means premium US

https://doi.org/10.1017/S1742170518000613 Published online by Cambridge University Press

Table 3. Effective operational cost (EOC) for soybean conventional farming systems (growing seasons from 2004/5 to 2010/11)

Specification[a]	2004/5	2005/6	2006/7	2007/8	2008/9	2009/10	2010/11	Means
Machinery and implements operation	136.05	132.47	133.58	239.37	162.89	214.60	147.11	166.58
Eventual labor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Seeds	67.50	93.75	44.61	38.87	34.46	50.39	47.07	53.81
Inputs	383.56	303.15	235.99	206.05	239.95	203.68	212.23	254.94
External transportation	21.98	21.40	32.22	23.18	27.15	11.76	25.50	23.31
Total EOC	609.09	550.76	446.40	507.48	464.46	480.43	431.91	498.64

Source: authors.
Values corrected to August/2017 (IGP-DI/FGV).
(US$ ha^{-1}).
[a](US$.ha^{-1}).

Table 4. Indicators for biodynamic soybean farming system in the growing seasons from 2004/5 to 2010/11

Specification[a]	2004/5	2005/6	2006/7	2007/8	2008/9	2009/10	2010/11	Means
Effective operational cost (EOC)[a]	607.00	553.05	507.00	544.37	591.84	419.53	419.75	520.36
Total operational cost (TOC)[a]	649.28	594.74	549.86	586.17	631.69	466.49	464.63	563.27
Opportunity cost (OC)[a]	78.37	73.99	73.19	69.57	65.93	79.27	73.41	73.39
Total cost (TC)[a]	727.66	668.74	623.05	655.74	697.62	545.76	538.03	636.66
Productivity[b]	49.59	49.59	55.37	46.28	37.19	48.35	53.72	48.58
Sale price—bags[b]	24.62	27.16	26.86	38.53	39.57	28.43	28.44	30.52
Gross returns (GR) (GR)[a]	1221.09	1347.00	1487.41	1783.17	1471.58	1374.89	1527.64	1458.97
Gross margin (GM)[a]	614.09	793.95	980.41	1238.81	879.73	955.36	1107.90	938.61
Net margin (NM) or Operating net income (ONI)[a]	571.80	752.25	937.55	1197.00	839.88	908.40	1063.02	895.70
Net income (NI)[a]	493.43	678.26	864.35	1127.43	773.96	829.14	989.61	822.31
Capital income(CI)[a]	465.65	630.46	827.63	1119.35	725.09	786.64	972.22	789.58

Source: authors.
Values corrected to August/2017 (IGP-DI/FGV).
[a](US$ ha^{-1}).
[b](Bags—60 kg ha^{-1}).

$11.09 per bag (57.08%)]. Worldwide premium prices of organic products [in general, 29–32% (Crowder and Reganold, 2015)] are influenced by costs, quality, selection, amount of sales, placement and consumer market, which affect supply and demand (Nemes, 2009; Post and Schahczenski, 2012). Productivity and price are directly related to values of gross return and, as consequence, net margin and NI. Gross margin (GM) in biodynamic farming (medium of the seven growing seasons) was double (99.9%) than in convention farming. GM has been reported to be 21% higher on average in organic farming than in conventional farming (Crowder and Reganold, 2015).

The price equilibrium point (PEP) is the minimum price at which farmers should sell the production to cover the TCs of the operation. PEP was US$0.44 higher in biodynamic than in conventional systems (Table 7), which indicates the need for premium prices in biodynamic systems to make the operation profitable, as has been frequently reported (Crowder and Reganold, 2015).

The leveling point (LP) from soybean produced in conventional farming was higher than that found for biodynamic farming (an average of 12.5\more bags per season) (Table 7), which indicates that minimum yields for coverage of the costs, considering the received prices, were lower in biodynamic farming than in conventional farming.

Previously, organic production has been referred to as generally more economically profitable than conventional farming due to the reduction of costs and premium prices despite frequent yield decreases (Nemes, 2009). However, a nationwide survey administered in the USA demonstrated that soybean produced from organic farming had higher production costs but was more profitable with premium prices (McBride and Greene, 2009). Our case study showed a similar pattern. Profitability was previously reported to be higher in organic than conventional farming in southern Brazil (just one growing season comparison), and better financial performance of organic farming was due to premium prices and higher input expenditures in conventional farming (Ortega, 2006).

Manual weeding and plowing were the agronomic factors responsible for increasing costs in biodynamic compared with conventional farming. Weeds are the principal limitation for the expansion of annual organic crops because they are the most serious threat to production. In addition, temporary labor for manual weeding is scarce due to low remuneration and is a painful activity. The results presented here reinforce the importance of concentrating efforts in developing alternative management of weeds to be used in annual crops such as soybean.

In addition to yields and profitability, other factors must be considered when comparing farming systems. These include

https://doi.org/10.1017/S1742170518000613 Published online by Cambridge University Press

Table 5. Indicators for conventional soybean farming system in the growing seasons from 2004/5 to 2010/11

Specification[a]	2004/5	2005/6	2006/7	2007/8	2008/9	2009/10	2010/11	Means
Effective operational cost (EOC)[a]	609.09	550.76	446.40	507.48	464.46	480.43	431.91	498.64
Total operational cost (TOC)[a]	651.38	592.45	577.82	568.93	570.23	527.39	476.79	566.43
Opportunity cost (OC)[a]	78.37	73.99	73.19	69.57	65.93	79.27	73.41	73.39
Total cost (TC)[a]	729.75	666.44	651.01	638.50	636.16	606.65	550.20	639.82
Productivity [b]	49.59	49.59	53.72	50.83	37.19	58.26	53.72	50.41
Sale price—bags[b]	17.94	15.24	17.21	24.63	23.98	16.98	19.99	19.43
Gross returns (GR) (GR)[a]	889.43	755.89	924.65	1252.24	891.81	989.42	1074.12	968.22
Gross margin (GM)[a]	280.34	205.13	478.25	744.76	427.35	508.99	642.22	469.58
Net margin (NM) or Operating net income (ONI)[a]	238.05	163.43	346.83	683.31	321.57	462.03	597.34	401.80
Net income (NI)[a]	159.68	89.44	273.64	613.74	255.65	382.77	523.93	328.41
Capital income(CI)[a]	131.98	41.62	237.67	604.57	206.72	342.00	507.32	295.98

Source: authors.
Values corrected to August/2017 (IGP-DI/FGV).
[a](US\$ ha^{-1}).
[b](Bags—60 kg ha^{-1}).

Table 6. Total production cost (TC) (ha) for soybean biodynamic and conventional farming systems, growing seasons from 2004/5 to 2010/11, Paraná (US\$ ha^{-1})

Specification[a]	2004/5	2005/6	2006/7	2007/8	2008/9	2009/10	2010/11	Means
TC biodynamic farming	727.66	668.74	623.05	655.74	697.62	545.76	538.03	636.66
TC conventional farming	729.75	666.44	651.01	638.50	636.16	606.65	550.20	639.82

Values corrected to August/2017 (IGP-DI/FGV).
[a](US\$ ha^{-1}).

Table 7. Price equilibrium point (PEP) and leveling point (LP) for soybean production in biodynamic and conventional farming. São Pedro do Ivai/PR, growing seasons from 2004/5 to 2010/11 (US\$ ha^{-1} for 60 kg ha^{-1} bags)

Specification	2004/5	2005/6	2006/7	2007/8	2008/9	2009/10	2010/11	Means
Price equilibrium point (PEP) soybean biodynamic (US\$)	14.67	13.49	11.25	14.17	18.76	11.29	10.02	13.38
Price equilibrium point (PEP) conventional (US\$)	14.72	13.44	12.12	12.56	17.11	10.41	10.24	12.94
Difference PEP	−0.04	0.05	−0.87	1.61	1.65	0.87	−0.23	0.44
Leveling point (LP) soybean biodynamic (bags)	29.55	24.62	23.19	17.02	17.63	19.19	18.92	21.45
Leveling point (LP) soybean conventional (bags)	40.69	43.73	37.82	25.92	26.53	35.72	27.52	33.99
Difference LP	−11.13	−19.11	−14.63	−8.90	−8.90	−16.53	−8.60	−12.54

Source: authors.

externalities such as ecosystem services, biodiversity conservation, water pollution, soil quality, food pesticide contamination and pesticide worker exposure, and when these factors are also considered, differences in favor of organic farming systems become more perceptible (Reganold and Wachter, 2016). The total economic value of environmental services was previously seen as higher in organic than conventional farming (differences ranged from US\$340.00 to 4.850,00 ha^{-1} yr^{-1}) (Sandhu *et al.*, 2008). Future investigations may confirm this trend under tropical/subtropical environments.

The small difference in favor of conventional soybean yields *vs* those in biodynamic farming that was observed in this long-term case study is a surprising finding because organic farming investments for research are absolutely negligible when compared with conventional farming. Research and biological intensification may reduce the gap or even change the outcome favorably for biodynamic farming. This was evidenced as a result of a meta-analysis in which agricultural diversification practices, multi-cropping and crop rotations may reduce or even eliminate this gap (Ponisio *et al.*, 2015). If strategies such as weed, pest and disease management; plant breeding; and soil fertility management are developed specifically for organic systems, production may obviously be improved. In general, conventional farming uses technological packages that facilitate management and diminish labor demand and painfulness.

https://doi.org/10.1017/S1742170518000613 Published online by Cambridge University Press

The development of no-till and weeding methods is the principal demand of organic/biodynamic annual crop farmers. In general, organically grown crops are better able to tolerate weed competition (Seidel *et al.*, 2017). In addition, cover crops may be included during fallow periods in which weeds reproduce and generate seed banks. To date, some projects by universities and partner farmers are being conducted using these two principles, and preliminary results are promising. The expansion of organic/biodynamic farming in Brazil and surrounding countries depends on these approaches becoming viable and replicable.

Logistical factors also significantly affected the costs of biodynamic systems due to the lack of receiving/trading posts close to the farm. It is probable that as biodynamic or organic agriculture develops in the region, interest in processing and trading could regionally absorb production.

Conclusions

Plowing, occasional labor for manual weeding and external transportation increase costs of biodynamic farming and affect financial indicators. Effective operation costs under biodynamic farming were 4.36% higher than those under conventional farming.

Despite the lower productivity (3.63% lower), the minimum necessary production to cover the costs was lower in biodynamic farming due to premium prices (variation of 1254 bags indicated by the LP).

Higher biodynamic trading prices than those of conventional soybean triggered a PEP suitable for covering higher production costs and thus providing higher profitability.

Author ORCIDs. Maurício Ursi Ventura 0000-0002-3536-2568

References

Birkhofer K, Bezemer TM, Bloem J, Bonkowski M, Christensen S, Dubois D and Mäder P (2008) Long-term organic farming fosters below and aboveground biota: implications for soil quality, biological control and productivity. *Soil Biology and Biochemistry* **40**, 2297–2308. Available at https://doi.org/10.1016/j.soilbio.2008.05.007.

Crowder DW and Reganold JP (2015) Financial competitiveness of organic agriculture on a global scale. *Proceedings of the National Academy of Sciences* **112**, 7611–7616.

De Ponti T, Rijk B and Van Ittersum MK (2012) The crop yield gap between organic and conventional agriculture. *Agricultural Systems* **108**, 1–9.

Di Domenico D, Magro CBD, Zanin A and Boschetti F (2015) Viabilidade da cultura da soja orgânica versus soja convencional em uma pequena propriedade rural. Custos e @gronegócio *on line* **11**, 229–248. Available at http://www.custoseagronegocioonline.com.br/numero2v11/K%2012%20soja.pdf (Accessed 12 June 2017).

Forster D, Andres C, Verma R, Zundel C, Messmer MM and Mäder P (2013) Yield and economic performance of organic and conventional cotton-based farming systems–results from a field trial in India. *PLoS ONE* **8**, e81039. Available at https://doi.org/10.1371/journal.pone.0081039.

Jariene E, Vaitkeviciene N, Danilcenko H, Gajewski M, Chupakhina G, Fedurajev P and Ingold R (2015) Influence of biodynamic preparations on the quality indices and antioxidant compounds content in the tubers of coloured potatoes (*Solanum tuberosum* L.). *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* **43**, 392–397.

Jariene E, Levickienė D, Danilcenko H, Vaitkevičienė N, Kulaitienė J, Jakštas V, Ivanauskas L and Gajewski M (2018) Effects of biodynamic preparations on concentration of phenolic compounds in the leaves of two white mulberry cultivars. *Biological Agriculture & Horticulture* **17**, 1–1. Available at http://dx.doi.org/10.15835/nbha4329695.

Luz JMQ, Shinzato AV and Diniz da Silva MA (2007) Comparação dos sistemas de produção de tomate convencional e orgânico em cultivo protegido. *Bioscience Journal* **23**, 7–15. Available at http://www.seer.ufu.br/index.php/biosciencejournal/article/view/6842/4531 (Accessed 29 June 2017).

Mäder P, Fliessbach A, Dubois D, Gunst L, Fried P and Niggli U (2002) Soil fertility and biodiversity in organic farming. *Science* **296**, 1694–1697.

Maneva V, Atanasova D and Nedelcheva T (2017) Phytosanitary status and yield of kamut (*Triticum turgidum polonicum* L.) grown in organic and biodynamic farming. *Agricultural Science and Technology* **9**, 42–44.

Martins EA, Campos RT, Campos KC and Almeida CS (2016) Rentabilidade da Produção de Acerola Orgânica Sob Condição Determinística e de Risco: estudo do distrito de irrigação Tabuleiro Litorâneo do Piauí. *Revista de Economia e Sociologia Rural* **54**, 9–28. Available at http://dx.doi.org/10.1590/1234-56781806-9479005401001.

Matsunaga M, Bemelmans PF and Toledo PEN (1976) Metodologia de custo de produção utilizada pelo IEA. *Agricultura em São Paulo* **23**, 123–139. Available at http://www.iea.sp.gov.br/out/verTexto.php?codTexto=11566 (Accessed 29 January 2017).

McBride WD and Greene C (2009) The profitability of organic soybean production. *Renewable Agriculture and Food Systems* **24**, 276–284. Available at https://doi.org/10.1017/S1742170509990147.

McCarthy B and Schurmann A (2018) Risky business: growers' perceptions of organic and biodynamic farming in the tropics. *Rural Society* **27**, 1–5.

Nabi A, Narayan S, Afroza B, Mushtaq F, Mufti S, Ummyiah HM and Magray MM (2017) Biodynamic farming in vegetables. *Journal of Pharmacognosy and Phytochemistry* **6**, 212–219.

Nemes N (2009) Comparative analysis of organic and non-organic farming systems: A critical assessment of farm profitability. *Organização das Nações Unidas para Agricultura e Alimentação* (*FAO*), Rome, Italy. Available at ftp://ftp.fao.org/docrep/fao/011/ak355e/ak355e00.pdf (Accessed 29 January 2017).

Ortega E (2006) A soja no Brasil: modelos de produção, custos, lucros, externalidades, sustentabilidade e políticas públicas. *Cadernos de Agroecologia* **1**, 831–836. ISSN 2236-7934. Available at http://aba-agroecologia.org.br/revistas/index.php/cad/article/view/1637 (Accessed 29 January 2017).

Picone G, Trimigno A, Tessarin P, Donnini S, Rombolà AD and Capozzi F (2016) (1) H NMR foodomics reveals that the biodynamic and the organic cultivation managements produce different grape berries (*Vitis vinifera* L. cv. Sangiovese). *Food chemistry* **213**, 187–195.

Ponisio LC, M'Gonigle LK, Mace KC, Palomino J, de Valpine P and Kremen C (2015) Diversification practices reduce organic to conventional yield gap. *Proceeding of the Royal Society B* **282**, 20141396. Available at http://dx.doi.org/10.1098/rspb.2014.1396.

Post E and Schahczenski J (2012) Understanding organic pricing and costs of production. *Butte: National Sustainable Agriculture Information Service*. Available at https://www.carolinafarmstewards.org/wp-content/uploads/2012/12/2-ATTRA-Understanding-Organic-Pricing-and-Costs-of-Production.pdf.

Reganold JP and Wachter JM (2016) Organic agriculture in the twenty-first century. *Nature Plants* **2**, 15221. Available at https://www.researchgate.net/signup.SignUp.html (Accessed 10 February 2017).

Ronque ERV, Ventura MU, Soares Júnior D, Macedo RB and Campos BRS (2013) Viability of the holding of the strawberry crop in Paraná-BR. *Revista Brasileira de Fruticultura* **35**, 1032–1041. Available at http://dx.doi.org/10.1590/S0100-29452013000400014.

Sandhu HS, Wratten SD, Cullen R and Case B (2008) The future of farming: the value of ecosystem services in conventional and organic arable land. An experimental approach. *Ecological Economics* **64**, 835–848. Available at https://doi.org/10.1016/j.ecoleco.2007.05.007.

Secretaria da Agricultura e do Abastecimento do Paraná––SEAB/DERAL (2017) Custos de Produção. Available at http://www.agricultura.pr.gov.br/modules/conteudo/conteudo.php?conteudo=228 (Accessed 25 October 2017).

Seidel R, Moyer J, Nichols K and Bhosekar V (2017) Studies on long-term performance of organic and conventional cropping systems in Pennsylvania. *Organic Agriculture* **7**, 53–61. Available at https://link.springer.com/article/10.1007/s13165-015-0145-z (Accessed 25 July 2017).