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Growth and yield of maize as affected by fertilizer types in the Southern Guinea Savannah, Nigeria

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Abstract

A field trial was carried out at the Teaching and Research Farm, Kwara State University, Malete, in the 2017 cropping season to investigate the growth and yield of maize as affected by fertilizer types. The five fertilizers tested were four organic-based fertilizers (KOBF-1, KOBF-2, Aleshinloye Grade A, and poultry manure), inorganic NPK fertilizer, and the control without soil amendment. The fertilizers, except poultry manure, were applied at the rates of 100 kgN/ha and the treatments arranged in a Randomized Complete Block Design (RCBD) with three replicates. Application of poultry manure, which was applied at 10 t/ha, was found to be superior compared to all other treatments in all the parameters measured. The three formulated organic-based fertilizers were Aleshinloye Grade A (a commercially available fertilizer formulated with household wastes and cow dung), KOBF-1 and KOBF-2 (Kwara Organic-Based Fertilizers in development by Kwara State University and formulated with poultry manure and tithonia plants). Aleshinloye Grade A produced inferior growth and yield and yield components of maize compared to the other organic-based fertilizers. The control took a significantly longer number of days to tasseling and silking (62 and 68 days, respectively) compared to the other treatments. The results indicated that, in terms of overall grain yield in kg/ha, poultry manure produced the highest yield (4,633 kg/ha), followed by the inorganic fertilizer (4,096 kg/ha), then KOBF-1 and KOBF-2 with similar values (3,163 and 2,923 kg/ha, respectively), followed by Aleshinloye Grade A (2,160.00 kg/ha). The control treatment gave the least grain yield (1,148.20 kg/ha). The organic fertilizers tested all proved to be effective in raising yields. Organic fertilisers have known ecological and environmental benefits and are recommended for inclusion in the development of national fertilizer programmes for sustainable crop production.

Keywords: Organic-based fertilizer, inorganic fertilizer, poultry manure, tithonia, corn, grain yield, Africa.

Introduction

Maize (Zea mays L.) is an important cereal crop in tropical and sub-tropical agro-ecological zones, particularly in West Africa. It is the preferred staple food for about 50% of the sub–Sahara Africa population including 120 - 140 million farm families and children (IITA, 2009; CIMMYT-IITA, 2010). As a versatile crop, it is cultivated in virtually all the

agro-ecological zones of Nigeria as a commercial crop, and to meet staple food demands and the supply of raw materials for agro-allied industries (IITA, 2009; Iken & Amusa, 2004).

Nigeria, like other countries having a tropical climate, is characterized by high rainfall and insolation with the attendant problems of nutrient leaching and a low level of organic matter in the soil, both of which limit maize production (Azeez et al., 2006). Soil fertility depletion is a constraint on food security in Africa. The poor nutrient status of most soils in Nigeria necessitates the use of fertilizers for improved crop yield. Unfortunately, the use of inorganic fertilizer is gradually becoming problematic due to its rising cost and its adverse effects such as increase in soil acidity, reduction of soil organic matter, degradation of soil physical properties, and an increased rate of soil erosion due to instability of soil aggregates (Avery, 1995; Palm & Sanchez, 1991). Organic manures are a cheaper source of plant nutrients in maize production and the use of organic manures increases the nutrient density of maize (Naikwade, 2014). In view of such issues, the use of fertilizer that is organic-based has been advocated in recent times.

Organic-based fertilizers are obtained from plant and animal residues. Studies carried out on these fertilizers have shown their potential in crop growth as well as in the sound management of tropical soils (Olowoake, 2014). Olowoake & Adeoye (2010) have observed that several types of organic materials and residues in Nigeria can be processed, packaged and made available as organic-based fertilizers at a relatively cheaper rate compared to synthetic fertilizers for sustainable crop production. Among several organic-based fertilizers available in the market, Sunshine Grades A and B and Aleshinloye Grade A have been evaluated and found to promote crop growth and yield. To expand the range of available organic-based fertilizers in Nigeria, poultry manure and the aerial part of tithonia (Tithonia diversifolia L.) plant were combined with available organic residues, in two formulations, and called Kwara State University (Kwasu) Organic-based Fertilizers (KOBF-1 & KOBF-2).

The choice of tithonia is based on reported effects of tithonia alone on growth and yield of crops (Achieng et al., 2000; Jama et al., 2000). The studies recognized tithonia as a weed having vigorous growth habits and with the potential of raising the status of major elements in nutrient-depleted soils, and hence it could be considered an affordable component in formulating organic-based fertilizers. Earlier studies on existing organic-based fertilizers have shown their potential in boosting crop growth and yield in tropical soils. However, there is no available information on KOBF after its formulation; hence, research was therefore initiated to study the response of maize growth and yield as affected by KOBF in comparison with other fertilizers.

Materials & methods

Study location

The study was carried out at the Teaching and Research Farm of the Kwara State University, Malete located on Latitude 8.71^{o}N and Longitude 4.44^{o}E in the Southern Guinea Savannah agro-ecological zone of Nigeria. The climate of the study location is characterized by distinct wet and dry seasons. The wet season commences in March or April and terminates in October with a dry spell in August. The dry season starts in October and lasts till March or April. Meteorological data of the study location during the cropping season of 2017 is presented in Table 1.

Collection and analysis of soil, poultry manure and organic-based fertilizers

Sample of the soil at the experimental site was collected at a depth of 30 cm for determination of physico-chemical properties. Dried poultry manure and KOBF were taken to the laboratory for analysis. The nutrient compositions of the experimental site soil, KOBF, Aleshinloye Grade A, and poultry manure are presented in Table 2.

Table 1. Meteorological data of the study location during 2017

Relative Humidity	Relative Humidity (%)	Relative Humidity (%)	Relative Humidity (%)
January	2.2	27.06	20.96
February	0	28.54	21.78
March	33.50	30.60	25.01
April	12.73	29.15	25.08
May	8.44	27.62	24.65
June	12.32	27.03	23.83
July	4.30	29.09	23.57
August	18.74	25.01	22.65
September	20.27	25.66	22.41
October	12.73	26.85	23.24
November	0	28.05	23.14
December	14	27.79	21.75

Source: Lower Niger River Basin Development Authority, Ilorin, Hydrology Section, 2017.

Table 2. Composition of the experimental site soil, organic-based fertilizers, and poultry manure

	Experimental site soil	KOBF-1	KOBF-2	Aleshinloye Grade A	Poultry manure
Physical properties					
Sand (%)	58.69				
Silt (%)	19.31				
Textural class	Sandy loam				
Chemical properties					
pH (H_2O)	6.29	6.57	6.48		6.1
Organic carbon g/kg	1.54	3.24	3.59		5.02
Available P mg/kg	8.48	4.34	5.55	0.8	6.02
Total N g/km	1.82	8.50	4.41	1.2	1.08
Exchangeable bases					
K (mg/kg)	0.88	3.72	3.21	2.9	0.98
Na (mg/kg)	1.98	1.72	1.28		2.87
Mg (mg/kg)	1.82	2.26	1.21		1.52
Mn (mg/kg)	1.02				2.09
Zn (mg/kg)	2.87				2.98
Cu (mg/kg)	0.87				3.02
Ca (mg/kg)	2.46	10.53	8.48		3.44
Fe (mg/kg)	3.01				-

KOBF-1 = Kwasu Organic-Based Fertilizer type 1
KOBF-2 = Kwasu Organic-Based Fertilizer type 2

Treatment combinations

The treatments tested in this study were: KOBF type 1 (KOBF-1), KOBF type 2 (KOBF-2) (two organic fertilizers based on the plant tithonia, and formulated by the Kwara State University with the view to possible future commercialisation), Aleshinloye Grade A (a commercially available organic-based fertilizer produced by Oyo State Government, Nigeria), poultry manure (which is readily available to farmers), inorganic NPK fertilizer, and the control without soil amendment. The treatments were arranged in a Randomized Complete Block Design (RCBD) and replicated three times.

Cultural practices

The experimental site was ploughed and harrowed twice. Each plot size measured 4.0 m x 4.0 m with 0.5 m between plots and 1.0 m between blocks. Planting was carried out at intra- and inter-row spacings of 0.75 m and 0.50 m, respectively, with two plants per stand. Poultry manure was applied at two weeks before planting while KOBF, Aleshinloye, and NPK were applied at 3 and 6 weeks after planting (WAP). Pendimethalin [N-(ethylpropyl)-3, 4 dimethyl-2,6- dinitrobenzeneamin] mixed with atrazine (80WP) were applied at the rates of 1.5 litre and 2.0 kg/hectare, respectively, as pre-emergence herbicide immediately after planting. This was supplemented with manual hoe weeding at 5 WAP to keep the experimental site weed free. Dichlorvos (dichlorovinyl dimethyl phosphate, DDVP) insecticide was applied at four and six WAP against army worm infestation.

It should be noted that the two herbicides (atrazine and pendimethalin) and the insecticide (dichlorovos) are excluded under organic certification and their use is restricted in other jurisdictions due to health concerns; the use of atrazine has been banned in Europe for well over a decade.

Data collection and analysis

Ten tagged plants at the two innermost rows of each plot were sampled and the following data collected: plant height and number of leaves per plant at 4 and 8 WAP, leaf area and stem girth per plant at 8 WAP, days to 50% tasselling and silking, and number of cobs per plant. Cob length and circumference, number of grains per cob, weight of one thousand grains and aggregate grain yield were also taken. Data collected were subjected to analysis of variance (ANOVA) using SAS statistical package and the treatment means, where significant, were separated by means of Duncan's Multiple Range Test at 5% level of probability.

Results

Climatic elements during the period of the experiment

Rainfall, temperature and relative humidity observed during the period of the experiment were adequate for maize cultivation. Statistics obtained from the hydrology section of the Lower Niger River Basin Development Authority, Ilorin, a few kilometers from the experimental location, shows that, in 2017, rain commenced in March and lasted till October. Relative humidity ranged between 21.8% and 25.1%, and temperature, between 25.0^{o}C and 30.7^{o}C.

Analysis of soil, organic based fertilizers, and poultry manure

Table 2 shows the physical and-chemical properties of the experimental site soil and the nutrient compositions of the organic-based fertilizers (KOBF-1 & 2 and Aleshinloye) and

poultry manure used in this study. The soil was sandy loam and slightly acidic with pH in water of 6.9, low in N (1.82 mg/kg), with 8.48 mg/kg and 0.88 mg/kg for available P and exchangeable K, respectively. Analysis of the KOBF fertizers indicated the following major nutrients: KOBF-1: N (8.5 mg/kg), P (4.3 mg/kg), K (3.7 mg/kg) and KOBF-2: N (4.4 mg/kg), P (5.6 mg/kg), K (3.2 mg/kg) in addition to other vital micro-nutrients. These values are all higher than Aleshinloye Grade A (Table 2).

Growth parameters

Irrespective of fertilizer type, vegetative growth (plant height, number of leaves, leaf area, and stem girth) of maize increased with the application of soil amendments at the two sampling periods (Table 3). Among the treatments, poultry manure was superior to the others in terms of number of leaves and plant height, except number of leaves at 8 WAP. The two formulated KWASU Organic-based Fertilizers were also superior to Alesinloye fertilizer in the number of leaves and plant height at 4 and 8 WAP. In turn, KOBF-1 was superior to KOBF-2 in the growth parameters measured, except for plant height at 4 WAP. Significantly lower numbers of leaves and plant height than the other treatments tested were recorded at the control treatment (Table 3).

The applications of poultry manure and the inorganic fertilizer were superior for stem girth and leaf area per plant compared to other treatments. The lowest leaf area and stem girth were recorded at the control treatment. Days to 50% taselling and silking did not follow similar trends compared with other growth parameters. The number of days to tasselling and silking in the control were more than the other treatments. There were no significant differences in number of days taken to tassel and silk between poultry manure and inorganic fertilizer treatments (Table 3).

Table 3. Effects of fertilizer type on vegetative growth parameters and days to 50% taselling and silking of maize.

Treatments	No. of leaves plant^{-1}		Plant height plant^{-1}		Stem girth (cm)	Leaf area plant^{-1} (cm^2)	Days to 50% taselling	Days to 50% silking
	4 WAP	8 WAP	4 WAP	8 WAP	8 WAP	8 WAP		
KOBF-1	11.78c	15.34c	76.33d	149.30b	26.47c	340.0b	57.33d	63.0d
KOBF-2	11.44d	14.55d	86.34c	129.2c	23.86d	264.5c	58.0d	65.33b
Aleshinloye Grade A	10.89e	14.53d	53.17e	72.7d	21.50e	255.9d	59.33b	65.0bcd
Inorganic fertilizer (NPK)	12.67b	16.18a	87.89b	150.01b	41.48a	346.4a	56.33c	63.37d
Poultry manure	13.0a	16.0b	95.17a	160.40a	30.82b	346.5a	56.33c	63.33d
Control	10.11e	14.89e	53.17f	100.9e	16.81f	228.4e	61.67a	68.33a

Values in the same column with the same letter(s) are not significantly different at 5% probability level.
KOBF-1 = Kwasu Organic-Based Fertilizer type- 1.
KOBF-2 = Kwasu Organic-Based Fertilizer type -2.

Yield

Yield and yield parameters were significantly influenced by the fertilizer types tested. The application of 10t/ha poultry manure was found to be superior to the other treatments in yield and yield components, except for inorganic fertilizer on cob length (where there was

no significant difference) (Table 4). The longest and thickest cobs were produced with poultry manure, while inorganic fertilizer produced a similar cob length, the cob circumference was significantly lower, compared to poultry manure (Table 4). Among the three other organic-based fertilizers, KOBF-1 was superior in yield and yield components. The lowest number of grains per cob (142) and weight of one thousand grains (172.6g) were recorded for the control treatment.

Table 4 : Effects of fertilizer type on grain yield and yield components of maize.

Treatments	Cob length (cm)	Cob circumference (cm)	Number of grains cob^{-1}	Weight of 1000 grains (g)	Grain yield (kg/ha)
KOBF-1	12.29b	9.30b	253.3c	266.2b	3,163.15c
KOBF-2	11.60c	7.90d	217.95d	224.3c	2,923.33c
Aleshinloye grade A	8.08d	8.04c	218.0d	195.6d	2,160.00d
Inorganic fertilizer	14.64a	9.29b	403.0b	242.3b	4,096.23b
Poultry manure	14.62a	9.51a	455.6a	293.3a	4,633.10a
Control	5.95e	5.87e	142.0d	172.6e	1,148.20e

Values in the same column with the same letter(s) are not significantly different at 5% probability level.
KOBF-1 = Kwasu Organic-Based Fertilizer type 1.
KOBF-2 = Kwasu Organic-Based Fertilizer type 2.

The results showed that, in terms of overall grain yield in kg/ha (Table 4 and Figure 1), poultry manure produced the highest yield (4,633 kg/ha) followed in order of by the inorganic fertilizer (4,096.23), with KOBF-1 and KOBF-2 giving similar values (3,163 and 2,923 kg/ha, respectively), which were greater than Aleshinloye Grade A (2,160 kg/ha). The control treatment gave the least grain yield (1,148 kg/ha) (Table 4).

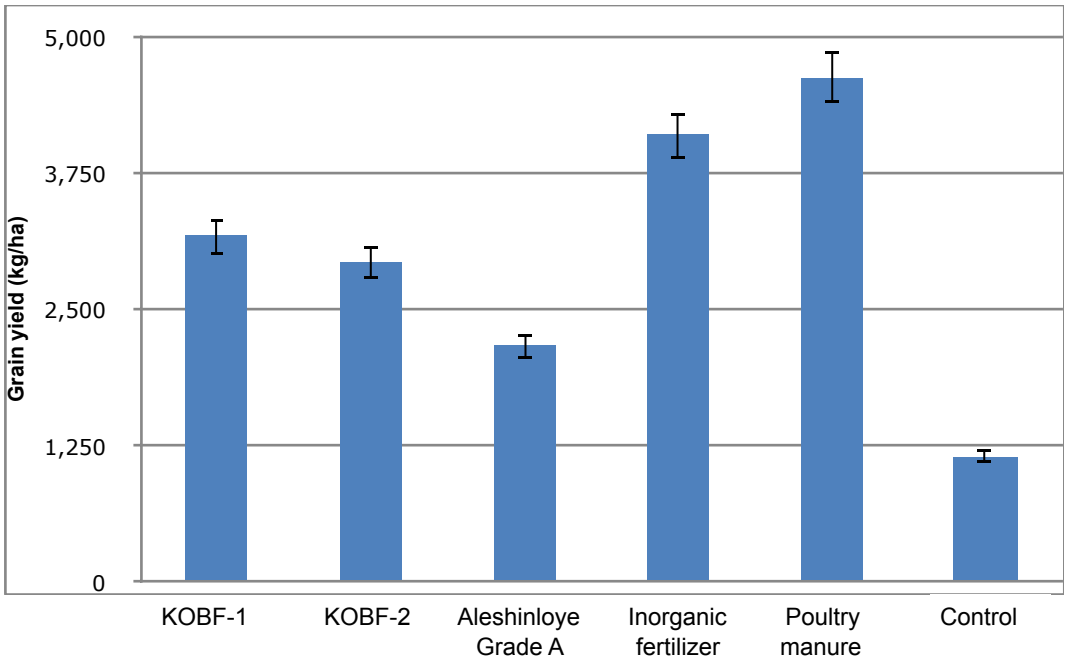

Figure 1. Maize grain yield as affected by fertilizer types.

Discussion and conclusion

The inherent low nutrient status of the experimental site suggests the need for soil amendment in order to achieve optimum crop growth and yield. The observed soil nutrient levels in the experimental site are below the recommended critical values for the Guinea Savannah ecological zone of Nigeria (Aduloju, 2004; Olowoake & Ojo, 2014). This poor nutrient status could be attributed to continuous farming in the study area. The study area has been under cultivation of various arable crops in the previous years and as expected the nutrients are lost through plant uptakes. Chhogyel et al (2015) have reported that the application of organic fertilizers leads to improved grain yields and to sustainable soil and farm productivity.

The positive response of maize growth and yield to the application of various fertilizer types as observed in this study can be attributed to adequate nutrients supplied by the applied soil amendments. Earlier studies (Garge & Bahla, 2008; Abdulmaliq et al., 2015; Afe & Oluleye, 2016) have reported the superiority of poultry manure over inorganic fertilizers on the growth and yield of crops. Poultry manure has excellent and balanced essential macro- and micro-nutrients, which are made available for plant use during their growing periods. In another study, Maheshbabu (2007) stated that manure acts as a nutrients reservoir and when decomposed the nutrients present are gradually released during the entire crop growing period, thus improving the growth and yield of the crop. Similarly, in another study, Amanullah et al (2008) recognized poultry manure as a good alternative to synthetic fertilizer. Fasina (2016) has identified the need to encourage Nigerian farmers to adopt organic fertilizers and in preference to inorganic fertilizers. Paull & Hennig (2016) have reported the under-performance of the African continent as a whole in achieving recognition for organic agriculture.

Improved growth and yield of maize with the application of organic-based fertilizer as observed in this study is consistent with reported works of Olowoake & Ojo (2014), Olowoake et al. (2016), and Olowoake & Lawal (2016), on the response of okra and grain amaranth to organic-based fertilizer. The superiority of the KOBF fertilizers over the Aleshinloye Grade A could be attributed to differences in the rate of release of nutrients by component materials used in the formulation of these organic-based fertilizers. Aleshinloye fertilizer is formulated from household wastes and cow dung whereas KOBF is formulated from poultry manure and tithonia plants. According to Abdulmaliq (2016), nutrients are released about three weeks earlier in poultry manure than in cow dung, suggesting that the rate of nutrient release from the component organic materials used in the formulation of the organic-based fertilizers tested in the current work probably differs. In another study, Masariambi et al. (2010) reported the superiority of poultry manure over cow dung in plant height and the number of leaves per plant in red lettuce (Lactuca sativa L.).

Effects of tithonia alone on growth and yield of crops have been reported (Achieng et al., 2000; Jama et al., 2000). The studies recognized tithonia as a weed having vigorous growth habits and an affordable alternative to expensive synthetic fertilizers, with the potential of raising the status of major elements in nutrient-depleted soils.

Both the organic-based fertilizers and the inorganic fertilizer (NPK) were found to enhance the growth and yield of maize. Among the fertilizer types tested, the KOBF fertilizers appreciably enhanced maize growth and yield, and therefore, are

recommended for consideration in the development of national fertilizer programmes for sustainable crop production. In the meantime, poultry manure, which is readily available to farmers, proved to be the most efficacious fertilizer for raising yields, compared to the other organic and inorganic fertilizers tested (at the application rates of the present study).

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Drivers of growth and sustainability for organic products: The case of Australia

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Abstract

The growth of organic products around the world is incontestable. Across the globe, and especially in developed markets, consumption of organic products has been growing even during difficult times such as the global financial crisis and doing so at by almost double digits. Alongside these developments, the Australian organic industry has equally been booming over the last decades. Demand continues to outstrip supply and as such, the Australian organic industry has resorted to imports of organic products to meet this demand. Reasons for heightened consumer interest in organic products range from perceived health benefits, chemical-free, superior nutrient density, food safety, relative freedom from pesticides and chemical residues, environmental equilibrium and other 'non-economic' factors. This industry, once driven by 'lifestyle' and ideology, has adopted more mainstream measures and given rise to wider acceptance across the broader farming community. The most enduring factor is that organic production is driven by the consumer thirst for these products. In some quarters, there is a view that this growth is not sustainable due to price premiums, lower yields, competition from conventional products and the debate about the greater nutritiousness of organic products. This paper primarily explores the drivers of organic products and whether they can be economically sustainable using the case of Australia as the point of reference.

Keywords: green, demand, supply, consumer behaviour, consumers.

Introduction

Organic products around the globe have witnessed significant levels of growth in the last decade (MarketLine 2017). In Australia the organics sector has witnessed a decade of double-digit growth in terms of production as well as in consumption (AO, 2017). In 2000, the value of the industry in Australia was A$250 million (Lockie et al., 2002) while in 2014 it reached a value of A$1.72 billion (AO, 2014). This expenditure on organics needs to be placed in proportion and it is still only a small fragment of the $54 billion conventional agriculture industry in Australia (Gray, 2015). Australia maintained 1.6% of the global market size (GOT, 2015). Within the Australasian region, Australia leads in terms of total sales value of organic products. Although there is strong growth for organic products, and here we mean primarily organic foods and beverages, conventional food and beverages are certainly not declining in consumption. The question one could ask is whether organic

production and consumption can continue this sustained growth level and how will it do this?

Consumer acceptance of organic products has come a long way in only a short period. Despite being more costly and not necessarily equally accessible as conventional food, growth in this segment has continued and has created what can be termed as market differential (Hidalgo-Baz et al., 2017). Many reports (AO, 2017; Euromonitor, 2017a,b; MarketLine, 2017) continue to support the proposition of continued short and medium term growth, as organic foods become more widely accepted and as organic products branch out beyond food and beverages. Previously organic products were primarily limited to fruit, vegetables and dairy but are now branching out to wider segments including wine, beef as well as non-food segments such as oils and cosmetics (McCarthy 2016).

Sub-dividing the organic industry into thirteen categories, O'Mahony & Lobo (2017) provide a clearer picture of the value-added component of the Australian organic industry. Valuable as this is, the authors fail to provide an explanation for the drivers of this growth nor do they indicate the sustainability for the double-digit growth in organic production and sales in Australia during the last decade (AO, 2017). This paper in part seeks to fill this void and provide a clearer understanding of the drivers of this growth and primarily the concern about the sustainability of organic products and especially organic food. Part of this analysis is to explore the drivers of organic products and examine the economic and consumer sustainability factors inherent within this industry.

In Australia, organic products initially emerged as a cottage and boutique industry mostly on the back of lifestyle needs by many wishing to change their location and style of living (Mascitelli 2013) and/or by those with ideological perspectives (Paull 2013). Over the last two decades, the drivers of organic food have shifted from lifestyle production towards industrial-scale production of organic foods. In some of the literature the survival and sustainability of organic food is claimed to be dependent on "whether it can be or become economically competitive with conventional agriculture" (De Ponti et al., 2012, p.1). This paper, partially utilising the recent literature, takes issue with this recurrent theme on the sustainability of organic food and whether the sustainability of organics is decided at the farm gate or in the retail stores and whether this counter position is really the best approach to understanding sustainability.

Meanings and implied meanings of organic products

The existence and understanding of organic production and consumption has very recent beginnings and Australia is as much part of this early tradition as are other markets. Paull (2013) refers to Australia as a fast follower of developments that occurred elsewhere in the organic space. The term 'organic' has a rather simplistic meaning and agreement is universal as to its meaning even from its array of different stakeholders in the organic industry. The term 'organic' is rooted in another term referred to as 'bio' which emanates from the Greek word 'bios' meaning life or way of living (Essoussi & Zahaf, 2008). The discourse relating to organic food is usually centred on farming or production practices. As such, emphasis on biological, natural, environmentally friendly and limited (or no) use of synthetic chemicals in production systems are all common terminology used when articulating the characteristics of organic food.

A holistic definition of the term is offered by the US Department of Agriculture (USDA). It states:

> "Organic food is produced by farmers who emphasise the use of renewable resources and the conservation of soil and water to enhance environmental quality for future generations. Organic meat, poultry, eggs and dairy products come from animals that are given no antibiotics or growth hormones. Organic food is produced without using most conventional pesticides" (USDA, 2005).

Beyond the meaning of organic, comes another equally complex matter of certification of what is organic and whether a product meets the criteria of being 'organic'. In providing this legal requirement, certification bodies, throughout the world, have defined the industry, created rival branding labels and also created a market which is at times misunderstood and resented. Equally important is the recognition of organic by government, agriculture and statistics entities. In Australia, the organic industry is self-regulated, with seven certifying bodies, mostly in competition with each other. The largest and most influential are Australian Organics (AO) and the National Association for Sustainable Agriculture, Australia (NASAA).

The Australian organic market – Drivers and challenges

Organic production and consumption is not a field with a strong literature presence with this more pronounced in relation to Australia. As a distinct field it has only recently received acknowledgement by the industry and in so far as scholarly research is concerned is still primarily in its infancy (Paull, 2013). Organic is also a new phenomenon to government and its various branches including Departments of Agriculture, statistics agencies and official measures. Superficially, the literature indicates that organic products are destined to become more 'mainstream', and will contribute to some extent to sustainable agriculture (De Ponti et al*.,* 2012; Rigby & Caceres, 2001). Moreover, organic production will address in limited ways a perceived need for 'safer' food requirements desired by consumer and stakeholders alike (Makatouni, 2002).

The Australian organic market, like many other markets, has evidenced double-digit growth across most organic segments and has done so for the last decade. While it is well known that organic products come from a low base level of production and consumption, the latest survey of the organic industry specifies that organic growth between 2009 and 2014 witnessed an annual growth of 15 per cent. This is against an annual growth of 3.4 per cent in the conventional food sector (AO, 2014). Some market segments such as beef and wine are growing much faster than more established organic sectors such as dairy and vegetables. In some markets, genetically modified products (GMO) can play a disruptive role (Paull, 2015). Added to organic domestic production, which cannot meet the domestic demand, is the need for imported organic products to fill the gap. The industry in Australia calculated in all its facets has a value of $A 1.72 billion. According to one observer (Tonkin, 2014), key external drivers of organic farming in Australia include:

i. Level of annual rainfall;
ii. Public concerns over environmental issues;
iii. Health consciousness;
iv. Real household disposable income;
v. Downstream demand from food manufacturers.

Similar to conventional food production, weather conditions have a large effect on organic agricultural production. Likewise, water availability, pasture availability and production costs play important roles in the production bottom line. The breaking of the drought in Australia in 2010-11 was a milestone for organic primary producers but it also brought challenges of additional weeding (particularly in cereals) and diseases (grape production), which reduced some harvests. In some instances, it has seen some organic operators decertify and abandon their operations (AO, 2014). Public concerns over environmental issues are increasingly aligning with the public emphasis on climate change and environmental sustainability. In some cases, organic products have benefited from the concern over conventional farming degradation and associated environmental impacts both in situ and off-site (Treu et al., 2017). The growth is steady because many Australian consumers are after natural products of high quality and are willing to pay a higher price for these goods.

Who buys organic?

The biggest demand for organic food in Australia is concentrated in the major urban areas, within the high-income earners (McCarthy, 2016). Millennials and Generation Y are a key demographic group that actively consume organic food (AO, 2017). With online purchases as a preferred shopping method, young consumers showed the strongest confidence in specialised organic and wholefood stores (Acosta, 2017).

Using multivariate statistical analysis, Chinnici et al. (2002) identified that the purchase and sensitivity to the price are among the key factors preventing many consumers buying organic foods. Industrial food producers have many incentives to copy high quality organic production, both in terms of profits and reputation. The lack of knowledge divides food consumers into two groups of selection. Health-conscious consumers know that organic food is healthier because pesticides and other toxins are not utilised in the production of these foods (Apaolaza et al., 2018). Skeptical customers may be concerned that they could make a bad purchase from buying products mimicking the labelling utilised by organic producers (Biondo, 2014). Recent literature also evidenced that health orientation yields a positive effect in influencing organic food consumption (Chekima et al., 2017). Some customers would prefer a broader range of products to choose from, since they disapprove of modern technological farming. Some sceptical consumers think that organic is just a fad, and are unsure about its benefits (Wang et al., 2017). Non-organic consumers may consider that organic quality is the same as standard industrially and chemically produced food and they may perceive that organic-food prices are too expensive and, thus, consider such a choice not relevant for themselves (Hidalgo-Baz et al., 2017). Maigné et al (2017) have identified a territorial effect, so that where there is a greater local presence of organic produce, farms, food processors and retailers they reported that there is a greater purchase by consumers of organic products.

The location of organic production

Another indicator of organic industry penetration in a market is the amount of arable land dedicated to that form of farming. Australia, according to agricultural usage, allocates more land to organic food than any other nation in the world. This may seem somewhat logical given it is one of the biggest countries in the world, and therefore it is not surprising that it can also provide more land for organic farming (AO, 2014). The Australian organic industry is continuing to mature and the average size of organic farms

continues to increase, highlighting a trend towards professional farming on a larger scale (albeit still under conventional farm average size for most sectors). This also highlights the expansion of some long-term organic farming families who have purchased additional land and/or farm units to cater for increased demand.

While the Australian organic industry continues to be 'mainstreamed' and professionalised, it remains diverse in terms of operator types and sizes and the number of smaller-sized certified organic operations remains high. This is reflected in the data, which suggests that over 50 per cent of certified organic primary producers operate smaller-scale production farms (AO, 2014). There is a large additional section of the organic industry that is uncertified with smaller-sized farms not needing formal certification to trade (a requirement for export and for the larger retailers in Australia). Organic farm inputs continue to grow in products and businesses. In 2014, 186 businesses had formally registered organic farming inputs (fertilisers, bio-pesticides and crop management inputs) and other approved processing products (AO, 2014).

The Australian organic market future

Organically produced foods and beverages still represent only about one per cent of the total foods and beverages industry value (AO, 2017). The recent release of the Australian organic market report 2017 has highlighted some changing trends for the organic industry nationwide. Some of the key findings from the AO (2017) report include:

- Key perceived benefits of organic products are: free from chemicals and additives, environmentally friendly, free range and non-GMO production;
- Sixty three percent of Australian households purchased one organic product in 2016;
- Impact on the environment was a key motivation for Australian consumers (41%) to start buying organic products;
- Supermarket chains remain big players, though organic shopping outlets are changing, especially among young organic consumers with their preferred shopping method being online and using mobile phone technology;
- Most popular organic category is fresh fruit and vegetables, followed by dairy, home-cooking ingredients, and eggs;
- Organic certification labelling increased the confidence of two-thirds of organic shoppers;
- The top three challenges to purchase organic products are value, trust and access;
- Australian organic market growth is in line with the global growth in organics;
- By 2018, the total value of the Australian Organic market could reach $2 billion dollars (AO, 2017);
- Shoppers in Australia are the sixteenth highest spenders per capita on organic packaged food registering $A26 per capita (Euromonitor, 2017a).

Despite the low market share, the organic industry is unable to meet domestic demand and the double-digit growth will see this industry achieve greater levels in terms of total food supply. The challenge for the Australian organic industry is to produce consistent supply to meet growing demand.

Fruit and vegetables, dairy and home-cooking ingredients are the leading food categories for organic shoppers (AO, 2017). Dairy has for years been the most important segment of

organic production from a consumer standpoints. Australian organic production and consumption is dominated by the presence of dairy products, which make up more than 22 per cent of all organic production (AO, 2014). The dominance of dairy products among all the organic produce categories in Australia is consistent with the trend in China (O'Mahony & Chen, 2013) and other countries around the world (MarketLine, 2014).

As organic farming is subject to thorough inspections the cost of production is higher as compared to non-organic food by 20 - 50 per cent on average. Producing organic food that complies with all restrictions and norms requires a significant investment of time and resources. Surprisingly even during the economic downturn period, the Australian organic market still experienced a steady growth of 15 per cent annually on average (AO, 2014). Lack of supply is also impacted by some sectors having inconsistent or unavailable supply of raw ingredients to deliver on known organic demand. Supply variability, inconsistent product quality and the small scale of many organic farms are seen as holding the organic industry back. As the organic market is small, and fragmented in nature, some organic products can be prone to being oversupplied or undersupplied. For example, the oversupply of organic broccoli and asparagus in 2011 resulted in these two organic vegetables failing to achieve a price premium.

To address the supply issues, some organic farmers have formed regional organic farmer co-operatives to ensure supply is more consistent and to pool resources for marketing and product development. An example of such cooperatives is the Organic Dairy Farmers of Australia, a co-operative of 23 Victorian farmers, which together produce more than 23 million litres of organic milk a year, which is an estimated 75 per cent of the national organic milk supply.

Future trends: expansion beyond organic food and beverages

The original organic industry activity was mostly engaged with organic food and drink (Euromonitor, 2017a,b). Recently this concept has changed with a strong presence of other organic products in many other industries. These include organic vitamins and dietary supplements, organic cosmetics and essential oils, organic wool, cotton, textiles, organic garden and farm inputs, organic toiletries and hygiene products.

Organic vitamins and dietary supplements have been produced over many years ranging from herbs to multivitamins to complex condition-specific formulations in pharmacies and health food stores. The manufacturers of organic vitamins and dietary supplements promise purity, wholesomeness and sustainability as they are manufactured using different production methods from the conventional lines. Herbs are grown without agrochemical input, and extraction is done without conventional solvents. The entrance of Procter and Gamble, a multinational corporation into personal care products, in the organic supplement sector in 2012 reflects how mainstream organic vitamins and dietary supplements are becoming. In the Australian Organic Report for 2014, the non-food and drink segment of organic production increased by 10 per cent on the 2012 production figures (AO, 2104). Other industries, which have expanded into organic, include those, which are in contact with skin, such as cosmetics and essential oils, toiletries, tissue and hygiene products. Particularly, those manufacturers who have produced specific infant need products have much potential for growth in the organic industry. Parents' concern about their child's wellbeing increases the appeal of these organic products. Whilst

parents may cut back in terms of purchases for themselves during periods of economic difficulties, they continue to spend on their children.

The consumer view and millennials – a promising future for organics

The consumer uptake of organic products in the last decade has been extraordinary. Though coming from a lower base level, it has reached fast growing consumption levels in percentage terms as compared to consumption of conventional products. The research conducted by Mobium Group (2017) found that more Australians purchased organic products than ever before. Dairy products are the most frequently purchased organic food, according to Mobium's survey of Australian shoppers in 2016.

More than two out of three Australian households say they bought at least one organic product in 2016 (AO, 2017), reported as 65 per cent in 2012 (AO, 2014). Demand for organic products will continue to be strong as generation Y and Millennials (20 to 30 years old in 2017) are a key demographic of organic consumers for some organic retailers who offer online shopping via mobile phone. Most current organic buyers say that their initial motivation to purchase organic products was related to a positive personal health outcome. For example, 49 per cent of consumers surveyed stated that buying organic was due to "becoming more aware of the impact food, fibre or cosmetics had on personal health" (Mobium Group 2014). The marketing of organic products is not based purely on the nutritional quality of the product. Marketing may also stress the bio-diversity, environmentally friendliness and natural form of the product.

In the Mobium consumer survey, 83 per cent of consumers in 2016 (AO, 2017) indicated that the chemical free aspect was the most important feature of the organic product when deciding on purchasing organic products, up from 80 per cent in 2012 (AO, 2014). Interestingly organic purchases by those not categorised as green or sustainable shoppers, increased from 24 per cent in 2012 to 40 per cent in 2014 (AO, 2014). Most organics purchasers expend 5 per cent or less of household food expenditure on organic products. For example, 44 per cent said that this is their total estimated spend. Overall 64 per cent indicated that they spend 10 per cent or less of their total food budget on organics and over three-quarters (77 per cent) stated that they allocate 20 per cent or less.

As the literature suggests, the primary motivations for consumers purchasing organic products are not solely based on income or demographics (Tonkin, 2014; AO, 2017). Newly developed consumer values around personal, community and environmental wellbeing are equally important indicators for preferences towards organic products. Consumers who regularly purchase organic products have historically been more likely to do so from farmers' markets rather than supermarkets, though this is changing with organic private label offerings being introduced in the major supermarket outlets in Australia such as Woolworths, Coles, and ALDI (Euromonitor, 2014). In the Australian scenario, supermarkets are strengthening as the dominant channel for most current shoppers who purchase organic food products based on their nominated usual place of purchase. Fifty per cent of the respondents say that their usual place of purchase for organic bread items is from a supermarket, with 40 per cent saying that they buy from a bakery, while others indicated that they buy from markets/farmers' markets (AO, 2017). There is evidence of multi-channel participation by many current organic purchasers across all categories.

Another potential direction of development for this market is the creation of specialist shops that offer only certified organic products. This kind of shop is often run by local retailers or even the manufacturers themselves. There are also dozens of online stores of various sizes. Bearing in mind that the e-commerce market is growing at a very fast pace, it is possible to achieve synergies by trading organic food online. Most of the existing bricks and mortar stores offer their products on their web pages also.

Organic food has a close association with direct sales to the public. Relatively large quantities of organic food are sold through farmers' markets. Retailers depend heavily on the quality of their suppliers and some retailers have contracts with their suppliers. Some retailers also strive to offer locally sourced produce. However organic food faces increased competition from the increasing range of products (conventional food) claiming to meet the expectations of socially conscious consumers. For instance, the market share of organic eggs sold in supermarkets has declined as the market share of free-range eggs has grown (Gardiner, 2011). This may reflect shoppers choosing a lower price product that still addresses their animal welfare concerns.

Price premium and its effects on organic consumption

The most evident aspect of organic uptake from the consumer viewpoint is the question of price. The Mobium report (2014) recorded that 82 per cent of those questioned indicated that price was the biggest barrier to purchasing organic products (AO, 2014). What might be of concern to the organic industry is that those who were concerned with the pricing of organic products was 78 per cent reported in the 2012 report and 80 per cent in the 2014 report (AO, 2014). The industry when questioned about price premiums felt this was not a concern and that they felt that the market understood the reasons for the higher prices. According to Tonkin (2014), demand for organic products depends on the levels of household disposal income, where a decline or lower household income can be a threat to the purchase of organic products.

There is a perception that Australian consumers understand and appreciate the benefits associated with organic produce and are drawn to organic products for their chemical-free attributes. However, for some consumers the purchase of organic products is highly dependent on the state of the local economy and consumer confidence. When Australian consumer confidence is relatively strong, this aids good growth in organic products. According to the Mobium Report (2014) price is still considered a major barrier to consumers purchasing organic products and thus aspects of the organic industry are expected to remain volatile until it becomes more mainstream and prices drop closer to those of standard non-organic products. On the other hand, Nielsen reported that:

> "…71 per cent of consumers in the Asia Pacific region are changing their diets to lose weight and 25 to 40 per cent are more than willing to pay a premium for foods that are free from artificial colours, flavours and gluten, low in fat and salt and higher in protein and fibre" (Neilsen, 2015).

Interestingly, during the global crisis of 2008, in Australia organic uptake was not seriously impacted and the organic market recorded a steady increase in demand for organic food and other organic products despite this global down turn. While some conventional food and beverage industries suffered declines during the global recession in 2008 and 2009, organic growth dropped from double-digit growth to around 7 per cent

growth. Between 2011 and 2012, the growth of organic produce rose to 9 per cent (AO, 2014). Global sales of organic products for babies and children are amongst the most recession proof. Food safety and chemical contamination are major factors in the consumer choice despite recessions and difficult economic times.

Organic food is more expensive than products grown in a chemical way by an average of 20-50 per cent (AO, 2017). Organic producers claim the need for a higher price because of higher production costs. Organic farming is subject to greater levels of inspection and controls, and assessment is a process that requires a significant investment of time and resources. To be certified, each organic producer and processor must comply with strict standards and norms, from the production, to preparation, through to distribution. Certification systems for organic farming are the basic guarantee that foods placed on the market and labelled as organic are produced in accordance with the applicable rules on organic farming and are free of contaminants such as pesticide residues and hormones, and no chemical fertilizers and genetically modified organisms were used during the production process. Producers and processors of organic food are required to support their products with appropriate certification.

The majority of organic products sell at a price premium compared with conventionally grown products (O'Mahony & Lobo, 2017). The size of this premium can be significant and can affect demand for organic products. For some products such as wine and grain, organic products tend to be one to two times higher than the price of chemically grown produce. Price premiums for organic foods relate to higher costs in producing and distributing organic foods and the relative level of supply and demand. This price differential is, however, understood and accepted by many consumers. The focus group study undertaken by Chang & Zepeda (2004) on consumer perceptions in Australia of organic food clearly states on the question of price premiums that:

> "In terms of the price differential that exists between organic and conventionally produced foods, most participants thought it is justified because organic farming means more work and lower yields, and many felt it was also more sustainable and more ethical. Many thought price premiums are also justified because they perceived organic products to be healthier, more nutritious and more delicious. Many participants were willing to pay price premiums associated with organic food" (2004, p.164).

Other features of consumer preference for organic products

'Free from' aspects remain the key perceived benefits of organic food in the Australian community, continuing a consistent pattern from 2010. Four out of six leading benefit attributes revolve around what organic food 'does not contain'. These are 'Chemical-free' (80 per cent), 'Additive-free' (77 per cent), 'Hormone/antibiotic-free meat' (60 per cent) and 'Non-GMO' (57 per cent). There are knowledge gaps apparent in the community about the benefits of organic food. For example, 90 per cent of the respondents indicate that 'food being more nutritious' is of 'high' or 'moderate' importance to them, yet only 45 per cent currently believe this is a benefit of organic food, a gap of 45 per cent. Fresh fruit and vegetables was the segment with the highest participation rate amongst organic shoppers in 2014. In particular, 58 per cent of those who said that they bought organic in the past 12 months claimed to have purchased a fruit or vegetable item at least once (AO, 2017).

Of the 21 nominated categories, the dairy segment (milk, yoghurt, cream) recorded the highest growth in participation rate compared with 2012. Forty-one per cent of organic shoppers said that they had purchased a dairy item in the past 12 months, compared with 34 per cent in 2012. Other high growth categories included packaged meals (+7 per cent) and non−alcoholic beverages (+6 per cent) (AO, 2014).

'Fresh fruit and vegetables' is the category most likely to be purchased every month with 48 per cent of those surveyed indicating they buy every 1−30 days. Other high frequency categories were non−alcoholic beverages (47 per cent monthly), dairy (45 per cent), bread/bakery (41 per cent) and eggs (38 per cent) as per Mobium (2014, 2017) reports.

When it comes to perceptions about the organic product ranges on offer, organic/ wholefoods stores are seen by current organic shoppers to provide the best selection across categories. For example, 40 per cent of current category purchasers thought organic/wholefoods stores offered a 'very good' selection of packaged goods, followed by online stores, then Woolworths and Coles. Organic/wholefoods stores were also rated highly for their selection of fresh produce, dairy and meat (Mitchell 2015).

The quest for sustainability and acceptance of organic products

Can the growing organic food production and consumption trend present in Australia survive and continue? As Lockie *et al* (2002) have indicated "it is quite clear that the future of organics will also be very much dependent on the motivations of end consumers" (2002, p.24). The growth figures over the last decade, or so, indicate that this industry growth shows no reason to feel threatened. Moreover, during the global financial crisis, organic consumption data indicates that while conventional food suffered declines, the organic food industry continued its rate of increased production and consumption (GOTG 2016). What therefore may be the threats to this organic industry growth from a non-farming standpoint?

The regulatory framework of organics in Australia has remained stable during the last decade and involves separate policies for exporting and the domestic consumption of organic products. Under the Federal Exports Control Act 1982 and Export Orders, products labelled as organic for export from Australia are 'prescribed goods', and generally must be certified in accordance with the National Standard or with another standard at the same level. The National Standard which was recently updated in 2016 has provisions for auditing and inspection of organic production and processing businesses. Certification must be performed by one of the six organisations accredited with the Australian Government (AUS-QUAL, ACO, BDRI, NCO, OFC and SFPQ). Each accredited certifier can develop and apply its own unique standard, as long as it is compliant with the National Standard (AO, 2017).

Organic products are not legally required to have certified labels to sell in Australia. Certification is not essential for domestic organic trading. However, where the relationship between producers and consumers cannot rely on trust, the National Standards and mechanisms established for the organic export, including accredited certifiers, certification, auditing and inspection, are voluntarily adopted by organic producers and operators. For example, the major supermarkets require certification under the National Standard for their organic home brands (private labels) or other organic produce sold in their stores (AO, 2017). The National Standard remains the most reliable of the

certification pathways in Australia, allowing certified organic products to be sold both internationally and domestically. Australia has high standards of conventional food and this may in the medium to long term provide a constraint on the organic industry.

The growth of organic food is a result of a number of drivers. Some relate to nutrition and health, others to food security. In some markets, like Australia, 'life style' has been a driver especially in the early development of the organic food industry though the Australian organic industry is in transition. It is moving away from the boutique and cottage industry to more economically driven processes, approaches and results. Some decades ago the organic industry was considered to be fragile, ideological, and perhaps non-sustainable. One observer noted in 2001 that "organic agriculture began as an ideology, but can it meet today's needs?" (Trewavas, 2001, p.409). The prolonged period of organic growth over more than a decade in Australia and elsewhere in the world, would indicate that this is an industry which has migrated from its fragile boutique and cottage-industry status to a developing industry.

Although the organic industry continues to attract scepticism from some, and fails to be understood by others, each year it has consolidated and achieved a profile which makes it very difficult to conceive of it somehow disappearing any time soon especially given its present A$1.72 billion turnover (AO, 2014). By expanding to offer a wider array of products it has also consolidated its presence making organic products holistically covering most segments of the human diet and human needs. These are the hallmarks of an evolving and maturing industry.

Organics is an industry which acknowledges that its product is more costly than an equivalent in the conventional category. It justifies this differential on the basis of more certification and quality control and its production being free of the pesticides and chemicals used in conventional food production. The results from the survey from Mobium Report (2014, 2017) indicate that consumers understand the reason for this differential. The health and safety factor are the reasons for paying a little more and especially when it comes to the product destined for infants and young children (Winter & Davis, 2006). This form of differentiation is quite common with many products and attracts little concern. However the ability of conventional products to become more quality focused with retailers driving producers of food to be more 'organic' in their outlook may be a source for concern to the organic industry. The improvement of the quality of conventional food especially in some of the developed markets poses perceived threats. Supermarkets, by offering a selection of organic products, especially in markets where they have significant market share such as Australia, indicate that organic products have a future and that these powerful outlets wish to be part of this growth (AO, 2014, 2017).

A concern, which comes from the organic industry, is the fact that, demand for organic products is outstripping organic supply (AO, 2014). An inability to meet demand through domestic production creates a need for imported products. This indicates to those interested in entering the industry, that increased local supply would benefit from the strong demand from local consumers. This is another signal that the industry is being built on strong foundations.

Over the last decades, organic branding has undergone change and consolidation. Today with the certification bodies, so prominent, organic products have become accepted and better understood in all the retail outlets. Labelling has also played a role here.

Developed markets like Australia are more attuned to environmental and bio-diversity ends which are now playing a greater role in consumer choice than ever before. This is further assurance that organic products have for future sustainability.

There are many outlets for consumers, but supermarkets have a concentrated appeal (AO, 2014). There is sometimes a greater selection of organic food in supermarkets, including private-label products to entice consumers wishing to pay a smaller price premium for organics. The growing involvement of supermarkets in the organic retail market will affect organic farmers in a number of ways. Supermarkets will require consistency in quantity and quality of produce. They will also act as a sizeable buyer that may encourage greater scale and investment in the supply chain. Conversely, given their market size, they may be in a position to exert downward pressure on prices.

Future of Australian organic industry – sustaining growth

Australia has the largest area of organic farmland in the world, at an estimated 22 million hectares, and 17.5 million hectares having full organic certification (Hughes 2014). The majority of this land is comprised of large rangelands for organic cattle production. However, the industry is comprised mainly of small operators, which has contributed to challenges in providing consistency in the quantity and quality of produce. Despite some consolidation of operators over the past five years, the industry remains fragmented and organic farming techniques are sometimes not as productive as chemical farming.

The industry is expected to continue to grow strongly over the next five years, driven by strong demand in domestic and export markets. Over the five years to 2018-19, industry revenue is forecast by IBISWorld to increase by an annualised 8.4 per cent to reach $833.5 million (Tonkin 2014). Over this period, the increasing participation of supermarket chains in the provision of organic products, downward pressure on prices from growing economies of scale in production and benefits from improvements in the certification of organic produce will drive consumer demand. While some supply issues may hamper the industry, a greater level of technology employed by farmers and innovation in products and practices will help organic farmers meet demand.

While the number of organic farmers has not significantly increased despite the rapid growth in the organic industry, it is the consumer side, which may eventually decide and confirm the growing demand for organic products. Supermarkets have responded quickly to an increasing demand for organic products by increasing organic product ranges to improve choice and accessibility. This has resulted in supermarkets accounting for around 60 per cent of all organic sales (Tonkin, 2014). It is clear that major supermarkets such as Woolworths, Coles and ALDI demand larger, more regular and higher quality consistency of organic food. Large retail outlets appear to be moving more and more to assuming that organic products in their outlets adopt a form of mainstream approach.

Over the past five years, larger organic farm businesses have emerged to meet the demands for organic product by large retailers and supermarkets. Woolworths and Coles, the two major supermarkets in Australia, are now selling greater amounts of organic private labels and wider ranges of organic branded products, increasing the customer's accessibility for purchasing organic produce. These supermarkets have private-label organic ranges that include fresh fruit and vegetables, poultry, canned products, and dairy.

Online direct sales that are home delivered to consumers are a significant market for organic products, though their market share may perhaps decline as the supermarkets continue to expand their own product ranges. Farmers' markets have increased their market share. Farmers' markets have been traditionally an informal outlet for organic growers/producers who may have been unwilling or unable to enter into supply contracts with wholesalers and retailers to market their produce (Tonkin 2014).

The growing organic sector offers more business opportunities for organic products (MarketLine 2017). This will lead to a growing evolution from a boutique industry to a more scaled and business approach while still maintaining clear organic credentials and processes (Richards 2013). Retailers, including restaurants, are selling a growing number of organic products as they attempt to attract increasingly health-conscious consumers.

Organic products are free from contamination by pesticides, which can have a big impact on their cost. Without pesticides, the average yield may be less, the produce may be of poorer visual quality, and the risk of losses may be increased. Despite the considerable amount of time and work, organic farmers may not achieve the same yield as achieved with synthetic chemical fertilisers and pesticides. This results in a product, which is healthy but the cost of its production may be significantly higher than if the crops were treated with or stimulated by synthetic chemicals.

The bulk of organic farming is still relatively small with many businesses specialising in producing single products such as raspberries, apples, honey, natural cheese, yoghurt, milk or eggs. These are often produced by hand rather than through industrial processes. The production is time-consuming, resulting in a low output. Although premium prices are charged for organic products, not all industry operators enjoy greater profit margins as their production costs may be higher than the conventionally made products. However, like all developing industries, including those in the organic sphere, the development of more efficient, effective and sustainable modes of organic production will slowly become the norm (Richards, 2013; Jolink& Niesten, 2015).

Over the five years through 2016-17, the average industry profit margin has fallen slightly as competition has increased and input costs have risen. Due to competition, some product categories (including fruit, vegetables and poultry) have been affected by price deflation, which has affected the bottom line of organic industry operators (AO, 2014, 2017).

Most organic farms are small-scale and some farmers may only have part of their acreage farmed organically. Organic farms are also often mixed operations combining livestock with crop growing or horticulture. As a result, there are fewer opportunities to reduce costs through economies of scale in production. The number of organic producers is anticipated to continue its upward trend over the five years to 2016-17, as farmers enter the market to take advantage of growth in the industry. Despite double-digit revenue growth over the five years to 2016-17, the number of enterprises has only grown at an annualised 3.8 per cent, while employment numbers have grown at an annualised 6.7 per cent (AO, 2014, 2017).

Different establishment types service varying markets. As the industry is undergoing rapid change, the type of farmers within the industry is changing. Over the past five years, larger farms have emerged to meet the demand of large retailers such as supermarkets.

However, there is still a large number of smaller farms that service small communities and farmers' markets. As farms increase in size, export capacity is expected to also grow. Exports have increased over the past five years, particularly to East Asia. Imports remain relatively low because they are generally only required to meet shortfalls in domestic supply (AO, 2014, 2017).

Conclusion

The organic industry in Australia has come a long way and from the margins, as it edges closer and closer to the mainstream. Australia's organic farming industry has grown at a robust pace over the past decade. Organic consumers continue to demonstrate that they perceive the organic product as cleaner, safer, without chemicals, and with health benefits. Production factors including origin and traceability of food are increasingly important to Australian consumers. An impact on the environment was a key motivation for shoppers to start buying organic products. The ongoing fear of unhealthy food and in the light of, for example, the Chinese milk scandals, has reinforced the view in the minds of consumers that organic is safer if more expensive including for children and infants. This is an additional stimulus for consumers to continue to purchase and consume these organic products. The awareness of organic certification continues to increase; with the majority of shoppers agreeing that an organic certification mark increases their confidence in purchasing an authentic product. Labelling and packaging was deemed the number one source for gaining product information. In the next five years, it is anticipated that supermarkets chains will remain big players in the organic space, however, the preferred shopping outlets for consumers is evolving, which has resulted in an increase of opportunities for smaller, more focused outlets and alternative retail channels.

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Maps of Organic Agriculture in Australia

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Abstract

Australia is the world leader in organic agriculture, based on certified organic hectares. This has been the case since global organic statistics were first published (in 2000). Australia now accounts for more than half of the world's certified organic hectares (54%). Australia has 35,645,000 certified organic hectares which is 8.8% of Australia's agricultural land. In the present paper, three maps (cartograms, 'maps with attitude') of organic agriculture in Australia are presented. These three maps illustrate the data, at the state and territory level, for (a) certified organic hectares (35,645,037 hectares) (b) certified organic producers (n = 1,998), and (c) certified organic operators (producers + handlers + processors) (n = 4,028). States and territories are resized according to their measure for each attribute. The base-map for Australia, with states and territories coloured according to their state colours (or a variation thereof), is the standard cartographic representation of the country. The three organics maps are density-equalising cartograms (area cartograms) where equal areas on the map represent equal measures (densities) of the parameter under consideration. This mapping protocol creates distorted yet recognisable new maps that reveal where there is a high presence of the parameter under consideration (and the state or territory is 'fat'), or a low presence (and the state or territory is 'skinny'). These three maps visually reveal the uneven distribution of the metrics of organics across Australia, and, on a state by state basis, they suggest unrealised opportunities and potentials.

Keywords: Organic farming, Queensland (QLD), New South Wales (NSW), Australian Capital Territory (ACT), Victoria (VIC, Tasmania (TAS), South Australia (SA), Western Australia (WA), Northern Territory (NT), worldmapper.org, cartogram, cartography.

Introduction

Australia is the world leader in organic agriculture, based on the tally of certified organic hectares (Paull & Hennig, 2016; Willer & Lernoud, 2018) (Figure 1). Every year since global statistics of organic agriculture were first published by Willer & Yussefi (2000), Australia has occupied this lead position. Organic agriculture has grown at 16.5% per annum, in Australia, year on year, for the past 18 years (based on certified organic hectares growing from 1,736,000 ha to 27,145,021 ha as reported by: Willer & Lernoud, 2018; Willer & Yussefi, 2000). In that period, the percentage of agricultural land of Australia devoted to certified organic growing has grown from 0.38% to 6.7% (Willer & Lernoud, 2018; Willer & Yussefi, 2000). Certified organic hectares in Australia are now at 35,645,000 ha (Christie, 2018) which accounts for 8.8% of Australia's agricultural land.

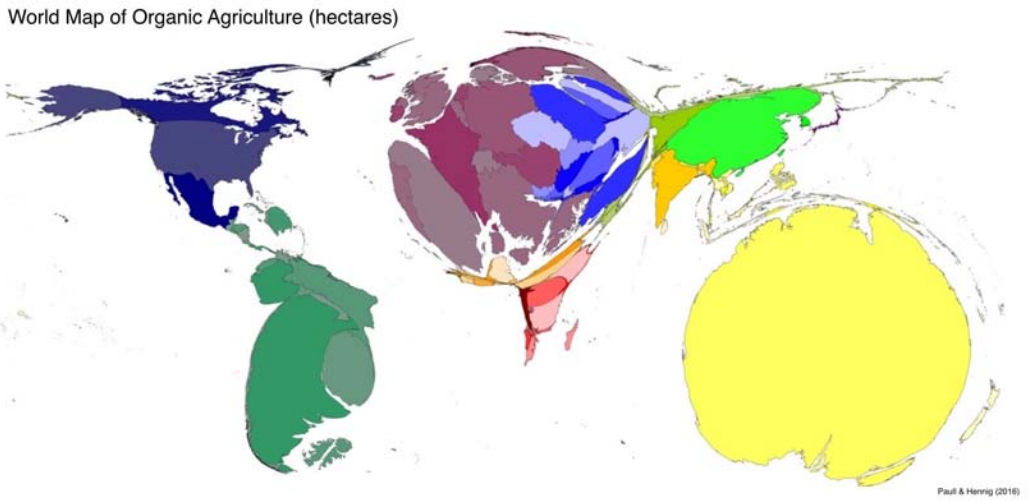

Figure 1. World map of organic agriculture hectares (density-equalizing cartogram) (source: Paull & Hennig, 2016).

In 1912, German chemists, Fritz Haber and Carl Bosch, demonstrated a process for capturing nitrogen from the air ('fixing' nitrogen'). The products of the Haber-Bosch process could be used as fertiliser or for explosives (Charles, 2005; Leigh, 2004). This disruptive technology ushered in an era of industrial-scale warfare, as well as cheap and abundant synthetic fertiliser, and thereby 'chemical farming'. The First World War (1914-1918), gave a massive impetus to the Haber-Bosch process, as the unprecedented military appetite for explosives wreaked havoc across Europe. When the war finally came to an end, the manufacturing facilities were promptly repurposed to produce synthetic fertilizer.

In 1924, Dr Rudolf Steiner spoke against the retreat from traditional and natural farming practices and the uptake of chemical farming. Steiner's ideas were published as the A*griculture Course* (1924). At his course, at Koberwitz (now Kobierzyce, Poland), Steiner called for an agriculture that differentiated itself from that of the prevailing fervour for synthetic chemicals (Paull, 2011). In the following decade, in Switzerland, Dr Ehrenfried Pfeiffer, and others, developed Steiner's ideas, and Pfeiffer's account was published as *Bio-dynamic Farming and Gardening* (1938). Shortly after that, and influenced directly by Pfeiffer and Steiner, Lord Northbourne, an Oxford University trained agriculturalist, coined the term 'organic farming' and published a manifesto of organic agriculture, *Look to the Land*, (1940). He described a contest of 'organic versus chemical farming', a contest that he suggested might be waged for decades or even centuries (Northbourne, 1940; Paull, 2014b).

Australia was an early adopter of the organics ideas of Steiner, Pfeiffer and Northbourne. The Italian artist, Ernesto Genoni, spent 1924 studying with Rudolf Steiner at the headquarters of Anthroposophy, at the Goetheanum, Dornach, Switzerland. Genoni migrated to Australia in 1926. In 1928 he joined Rudolf Steiner's Experimental Circle of Anthroposophic Farmers and Gardeners, which was based at Dornach. This marks the beginning of biodynamics - and hence organics - in Australia (Paull, 2014a).

The world's first association dedicated to the advocacy of organic agriculture, was the Australian Organic Farming and Gardening Society (AOFGS), founded in 1944 in Sydney. The AOFGS adopted Northbourne's terminology of 'organic farming'. The AOFGS journal, *Organic Farming Digest,* successfully disseminated their advocacy for organics across Australia (Paull, 2015).

Cartograms are 'maps with attitude'. They offer a fresh view of a geographic domain and the interplay between cells of that domain (for example, where (a) domain = the world & cells = countries, or (b) domain = a country & cells = states or territories). An area-cartogram (a density equalising cartogram) takes the domain, along with its cells, as a 'bladder' and inflates the cells of the bladder according to some parameter other than the actual territorial area (while conserving the total area of the territorial map, the base map). Area cartograms of global organic agriculture have been published where the domain = 'the world', and the cells = 'the countries of the world' (Paull & Hennig, 2013, 2016).

The Atlas of Organics presented maps of the world of organic agriculture (Paull & Hennig, 2016). The present paper adopts the same process to produce organics maps of Australia (where the domain = Australia and the cells = the states and territories of Australia). This process creates new maps (on the basis of the parameter of interest) that may appear distorted - but that nevertheless retain some familiarity so that they are visually informative and revelatory. In the event that the parameter under examination is distributed within the cells (in the present case, the states and territories) in proportion to the actual territorial area, then there will be no 'distortion' in the cartogram (and it will be no different to the base-map). In the event that the parameter under examination is more densely represented in a cell than in the whole region, then that cell will appear inflated ('fat'). Contrariwise, in the event that the parameter under examination is less densely represented in a cell than in the whole domain, then the cell will appear deflated ('skinny'). In a density-equalising cartogram, the density of the parameter is equally distributed across the map so that equal areas represent equal measures of the parameter under examination (and the total area of the domain, as it appears in the base-map, is conserved).

Methods

Statistics are available for organic agriculture in Australia, reported at the level of states and territories (Table 1). Data are available for six states: Queensland (QLD), New South Wales (NSW), Victoria (VIC), Tasmania (TAS), South Australia (SA), and Western Australia (WA); and two territories: Northern Territory (NT) and the Australian Capital Territory (ACT) (Christie, 2018).

For the purposes of creating the present organics maps, the domain is 'Australia', and the cells are 'the states and territories of Australia'. The Worldmapper algorithm (Hennig, 2013) was applied to the data of Australian organic agriculture to produce three maps.

Three cartograms are presented: (i) organic area (ii) organic producers (iii) organic operators (producers + handlers + processors), as well as a base-map of Australia. The colour of each state or territory is, in each case, the official state or territory colour (or a variation thereof). The organics statistics includes both certified organic and in-conversion organic.

Table 1. Statistics for organic agriculture in Australia (Christie, 2018).

Region	Organic hectares	Organic producers	Organic Operators
QLD	10,667,052	485	852
NSW	3,601,789	615	1,267
VIC	413,925	425	1039
TAS	4,769	72	127
SA	14,102,866	212	421
WA	4,698,791	165	287
ACT	2766	1	8
NT	2,153,079	23	27
Total	**35,645,037**	**1,998**	**4,028**

Results

The base map of Australia appears as Figure 2. The cartograms of organic agriculture are presented as certified organic hectares (Figure 3), certified organic producers (Figure 4) and certified organic operators (Figure 5).

Figure 2. Australia: base-map (six states and two territories).

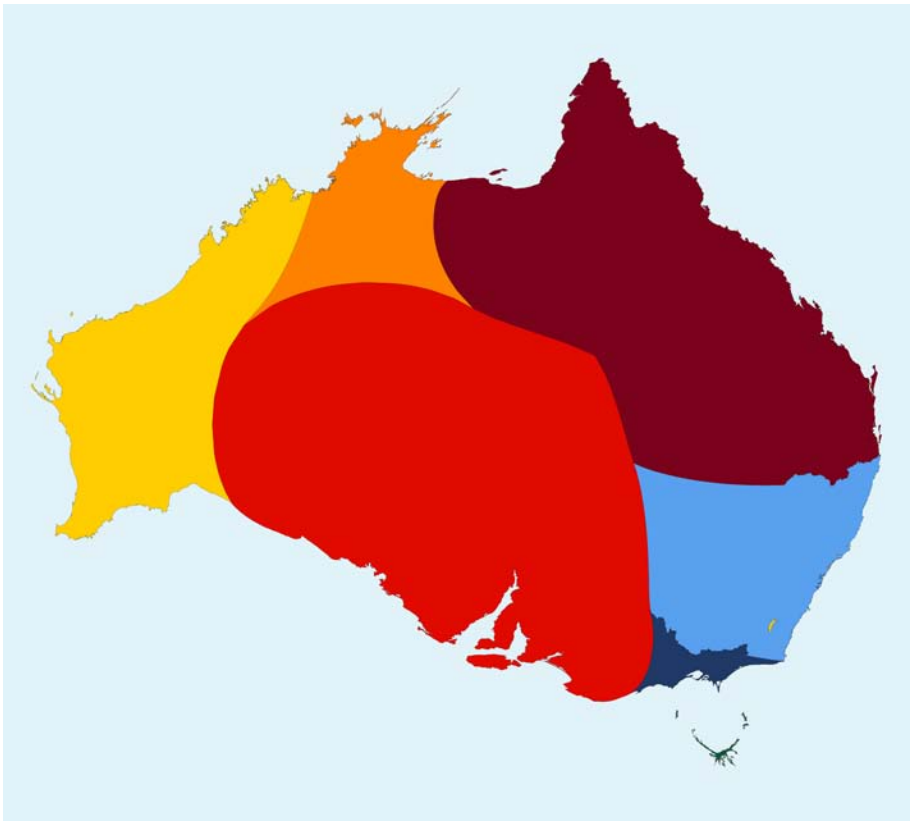

Figure 3. Australia: Certified organic agriculture hectares (n = 35,645,037 hectares).

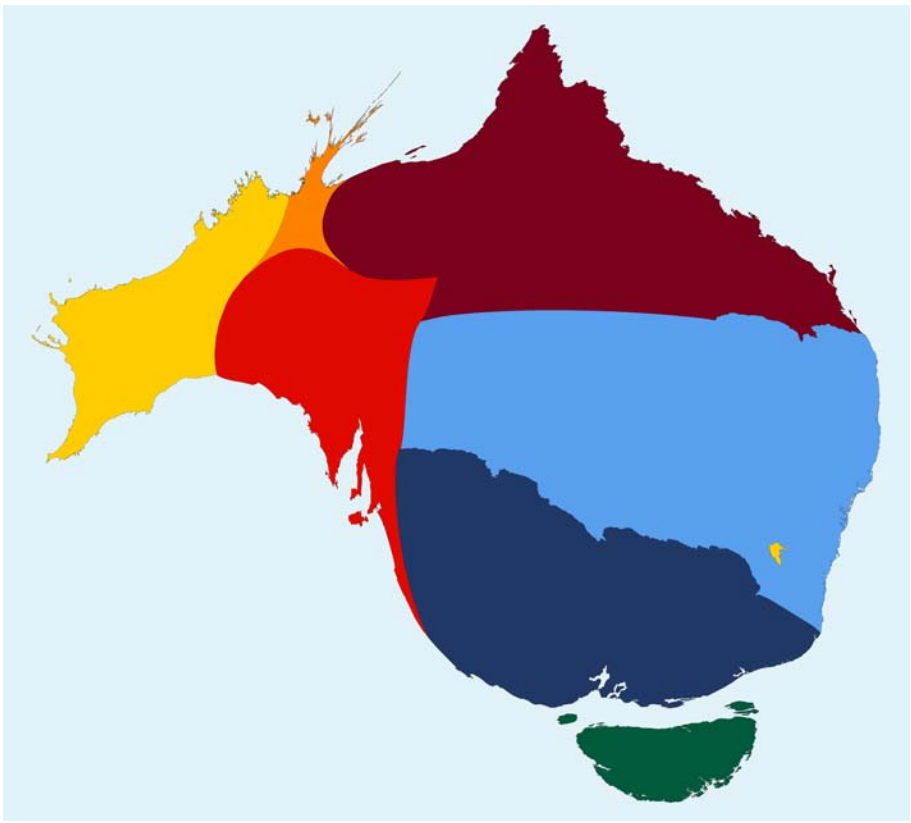

Figure 4: Australia: Certified organic producers (n = 1,998).

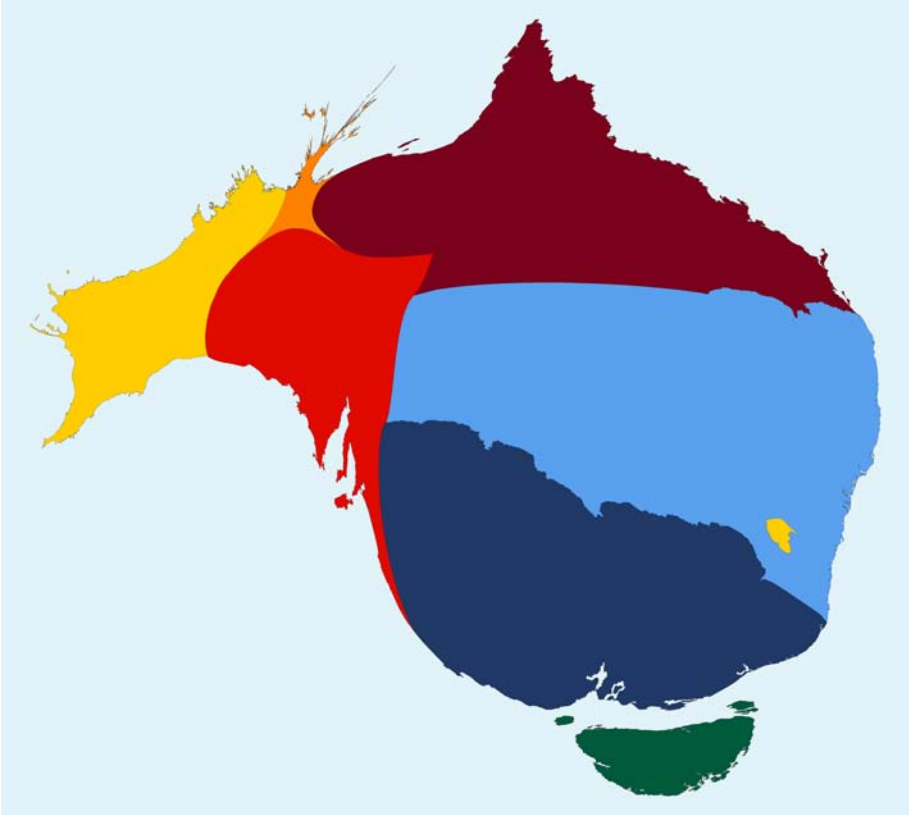

Figure 5: Australia: Certified organic operators (producers+handlers+processors) (n = 4,028).

Discussion and Conclusions

The three maps of organic agriculture in Australia (Figs. 3,4 & 5) demonstrate that organic agriculture parameters are unequally distributed across the states and territories of Australia. The maps make it easy to differentiate the leaders from the laggers. In the event that the metric under consideration (e.g. certified organic hectares) is evenly distributed across the whole country, then the cartogram will be identical to the 'base map' (Fig. 2). Otherwise, states will appear 'fatter' (inflated) or 'skinnier' (deflated). A 'fat' state (a leader) means that the parameter is more dense in that state than it is across the country as a whole. A 'skinny' state (a lagger) means that the parameter is less dense in that state than it is across the country as a whole.

For the map of certified organic agriculture area (Fig. 3), South Australia and Queensland dominate. These states have large swathes of rangeland, with low-carrying capacity, certified as organic and used for cattle. The New South Wales of Figure 3 is comparable to the NSW of Figure 2 which indicates its 'average' performance on this metric. Western Australia, Victoria, and Northern Territory are revealed as under-performers. Historically WA has been a producer of high-volume low-value commodities, whether in mining or agriculture, selling bulk output in the market rather than offering premium-differentiated or value-added product. Victoria and Northern Territory are under-performers on this metric. It is a disappointing result for Victoria given that the State Government has expressed support for organics (Brumby, 2007). ACT and Tasmania are just a vestigial presence for certified organic hectares. For ACT, that is expected since its *raison d'être* is as the seat

of federal governance (it hosts the national capital, Canberra), and agriculture is a modest endeavour in that small territory. It is a disappointing result for Tasmania.

Tasmania is the standout under-performer of Figure 3. Tasmania spawned one of the earliest organics advocacy groups in the world, the *Living Soil Association of Tasmania*, founded in 1946 (Paull, 2009). It had one of the longest-lived organics advocacy groups, the *Organic Gardening and Farming Society of Tasmania* (OGFST) (1972-2009) (Paull, 2013; Stevenson, 2009). Tasmania is an island state with strong biosecurity in place, it actively promotes its image as 'clean and green', and it maintains Australia's most robust moratorium against genetically modified organisms (GMOs). Tasmania is an excellent 'fit' for organic agriculture. It is an agriculture-dependent state, and it is disappointing to see it as a commodity producer and a price-taker rather than as a premium producer of differentiated products and a price-setter. This might be put down to complacency, inertia, lack of vision, absence of Government and institutional interest and/or support, and even to an antagonism towards organics in some quarters. Perhaps with recent inbound Chinese investment, coupled with high demand in China for organic (and premium) produce, a spin-off can be be greater penetration by organics into the agriculture sector of Tasmania and manifested by more organic hectares. Moonlake Investments recently purchased a large cluster of dairy farms in the north west of Tasmania. It is an example of a Chinese-led agricultural operation with plans to export organic milk and dairy products to China (Baker-Dowdell, 2018). Three Moonlake farms are the first farms in Tasmania to achieve organic certification by a Chinese certifier (in 2018). A further three Tasmanian-owned dairy farms in northern Tasmania have also very recently achieved organic certification (certified by Australian certifier NASAA in 2018) and are contracted to supply Australian Consolidated Milk (ACM) (from November 2018). So, although the present results for Tasmania (based on hectares) are disappointing (Fig. 3), perhaps this laggard state is on the cusp of an organics renaissance?

The maps of organic producers and organic operators are quite similar to each other (Figs. 4 & 5) and they are distinctly different from Figure 3. This indicates that the relationship between organic hectares, on the one hand, and organic producers and operators, on the other, is a loose relationship, whereas the relationship between organic producers and operators is quite tight (half of the data for 'operators' is accounted for by the presence of 'producers' in that data set). The eastern states of Australia (QLD, NSW, VIC & TAS) dominate the maps for producers and operators and reveal their leadership on these metrics. SA is the 'average' performer exhibiting a presence comparable to the base-map. WA and NT are the significant under-performers when it comes to organic producers as well as operators (Figs 4 & 5).

Northern Territory is an under-performer on all three metrics, under-performing in terms of certified organic area (Fig. 2), more so for producers (Fig. 4), and even more so for operators (Fig. 5). This indicates unrealised opportunities for growing all aspects of the organics sector for this territory.

The Australian Capital Territory (ACT) is a mere vestigial presence in terms of organic hectares (Fig. 3) but Figure 5, organic operators, demonstrates that a territory of very modest size and one underperforming in terms of area devoted to certified organic agriculture can nevertheless 'punch above its weight' for organic operators. The ACT has the highest personal median income of all of Australia's states and territories (ABS 2018)

and this appears to be one factor creating an opportunity for organics operators to meet a local demand even with a paucity of organic producers within the ACT.

Tasmania exhibits the greatest dissonance across the metrics, under-performing for organic hectares with a mere vestigial presence (Fig. 3), while over-performing for organic producers and operators (Figs. 4 & 5). For Tasmania, the landholding dedicated to organic is disproportionately low, while the number of operators is disproportionately high. This suggests that there is latent potential for substantial growth for organics in the Tasmania as knowledgeable producers and operators holding 'organic values' may have the capacity to grow their own operations and/or engage with other amenable producers.

A limitation of the data, and hence these maps, is that only certified organic entities are accounted for. The use of the terms 'organic farming' and 'organic agriculture', and their associated practices in Australia, long predate the development of organic standards and certification, which (in Australia) is a phenomenon dating from the 1980s (Paull, 2013). In Australia, the use of 'organic' as a qualifier of a farming operation has been in the public domain for eight decades, and it is not a restricted term, as it is, for example, in China (Paull, 2007, 2013). In Australia, a farm is entitled to be organic and call itself 'organic' provided that that is not a misleading or deceptive claim under the Competition and Consumer Act 2010 (previously known as the Trade Practices Act 1974) (CoA, 2010). A producer meeting the conditions of an organic standard (say the standard of one of Australia's certifiers) can legally and with justification call their produce 'organic'. However, organic exports require third-party certification, and Australian supermarkets are unlikely to stock other than third-party-certified organic. Other producers may be organic, by decision or by default, without making any such claim. This all means that certified organic statistics underestimate the size of the organic sector in Australia. Since the uncertified organic sector is unmeasured and there is no reliable estimate of its size (and it appears never to have been estimated), just how much the 'certified organic' statistics underestimate the whole domain of organics is undetermined.

Australia's uptake of organics is impressive, growing at 16.5% per annum year-on-year for the past two decades, it accounts for 8.8% of Australia's agricultural land (versus the global figure of 1.2%, and 21.9% in Austria), and now accounts for 54% of the world's certified organic agriculture land. Yet, there has been no 'engine room' or 'central driver' of this growth. Elsewhere there have been government (e.g. Ireland's DAFM, 2013) and institutional support for organics, but this continues to be lacking in Australia. While governments, universities, and farming organisations in Australia have mostly been absent from the field of organics advocacy, Australian supermarkets are taking fresh initiatives. The ALDI supermarket chain has, from the outset, offered organic products under its home brand of 'Just Organic' and it has in 2018 been vigorously promoting its organics range (ALDI, 2018). The Woolworths supermarket chain has established (in October 2018) the 'Woolworths Organic Growth Fund' to grow the organics sector (Woolworths Group, 2018) and has awarded its first grant to R&R Smith, Tasmania's largest grower of organic apples (TBR, 2018).

Sikkim is the world's first 100% organic state. This northern Indian state demonstrates what can be achieved where there is the political will. The goal was set by the State Government in 2003, it was achieved in 2016 (Chief Minister's Office, 2016). Now, other states of India are seeking to emulate Sikkim's achievement (Paull, 2017). The Australian state most comparable to Sikkim is Tasmania. If there was the political will to 'go organic',

it would be a decision that could potentially double the value of Tasmania's agriculture sector and deliver collateral benefits to health, environment, reputation, employment and tourism.

Australia has natural advantages for being a powerhouse for organics: it is surrounded by ocean (a natural biosecurity barrier); it is territorially vast, it spans more than thirty degrees of latitude (c.10°S to c.44°S); it hosts a great many climatic and growing conditions, with landscapes ranging from verdant to desert; it has a long history of producing premium-quality food and fibre for export; there are a number of Australian states with moratoriums against genetically modified crops (globally, all organic certification excludes GMOs); it is nearby to the fast-growing organic markets of Asia; Australia's produce is counter-seasonal to that of the Northern Hemisphere (the largest market for organics) and this creates an export market advantage. Australia is a 'good fit' for organics and the 91.2% of agricultural land that is currently not certified organic is a measure of the potential for growth.

Acknowledgements

The present paper, *Maps of Organic Agriculture in Australia,* relies on data reported and published by Australian Organic Ltd (Christie, 2018), on global data reported by the Research Institute of Organic Agriculture (FiBL), Switzerland (Willer & Lernoud, 2018), and on the method for producing density-equalising maps proposed by Gastner & Newman (2004) and implemented by the Worldmapper project (worldmapper.org). Open source high resolution image files of the five figures of this paper will be available for download at <www.orgprints.org>.

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