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Dairy cattle management, health and welfare in smallholder farms: An organic farming perspective

Charles Odhong¹*, Raphael Wahome¹, Mette Vaarst², Muhammad Kiggundu³, Sylvia Nalubwama³, Niels Halberg⁴ & Samuel Githigia¹

¹ Department of Animal Production, University of Nairobi, Nairobi, Kenya
² Faculty of Agricultural Sciences, Aarhus University, Tjele, Denmark
³ Faculty of Veterinary Medicine, Makerere University, Kampala, Uganda
⁴ International Centre for Research in Organic Food Systems, Tjele, Denmark

Abstract

Organic production principles aim at achieving good animal health and welfare of livestock. The objective of the present study was to investigate animal management, health and welfare in smallholder dairy farms in Kenya, Africa, and to be able to give recommendations which can guide organic livestock production practices as specified by the International Federation of Organic Agriculture Movements and the East Africa Organic Product Standard. A longitudinal study of 24 farms was conducted to document and assess management practices and their potential effect on animal health and welfare. Observation and documentation of animal housing design, cleanliness, feeding management and types of feed available to the cows, milking management, disease and pest management was done in the Kiambu and Kajiado Counties of Kenya. An analysis was performed for indicators of health and welfare with husbandry type, aspects of the housing system, farm characteristics, and management routines. The average herd size was 3.15 in Kiambu and 3.91 in Kajiado, with all the cows’ zero-grazed. Seventy five percent of the cubicles were small (less than 2.50m²). Many of the farmers sprayed their animals weekly (47%) to control ticks, while all incidences of diseases were treated by a veterinarian. Most of the cattle housing flooring were made of concrete (87%) with only one farmer regularly using bedding for the cows. Cows were mainly fed fresh Napier grass (60%) in Kiambu while natural grasses (43%) was the main feed used by farmers in Kajiado. This study indicated that four major challenges exist for organic dairy cattle management in Kenya, which need to be addressed in future research and development: 1) the use of robust breeds and the breeding strategies; 2) grazing and access to outdoor areas; 3) feeding in terms of stability and self sufficiency of enough nutritious feed; and 4) the handling of diseases and pests using poisons, chemical medicines, along with the development of viable alternative disease handling strategies.

Keywords: Organic agriculture, dairy production, livestock management, Kenya, Africa.

Introduction

Organic agriculture is a holistic approach to agriculture and food systems, which promotes and enhances agro-ecosystem health, including attention to bio-diversity, biological cycles and soil biological activity (FAO, 1999). The growth of organic agriculture
is attributed to increasing consumer demand for products perceived as tastier, healthier and produced in an environmentally sustainable system (Pimentel et al., 2005; Hughner et al., 2007; Reed, 2010). The concept of organic livestock production can be considered as a system of livestock production that better fulfills animal needs (Lund, 2006; Verhoog et al., 2007), promotes the use of organic and biodegradable inputs for production (Chander et al., 2011) and reduces the use of routine, conventional synthetic chemical veterinary treatments (EAOPS, 2007). In addition, it incorporates humans and animals as part of a larger ecological system (Baars et al., 2004; Verhoog et al., 2004).

Organic livestock farming aims at maintaining good animal health and welfare. In this system, animal health is not only viewed as the absence of disease but also as resilience in terms of the animals’ ability to absorb shocks and pressure from the surroundings and to respond so that they do not become diseased. As such, health is a positive characteristic achieved through the application of animal health promotion strategies and practices, rather than the routine use of conventional veterinary medicines (Vaarst & Alroe, 2012). However, the use of veterinary drugs, antibiotics or chemicals are permitted if preventive and alternative practices are unlikely to be effective in curing sickness or healing an injury, and need to be done under the supervision of a veterinarian (EAOPS, 2007). Animal welfare in organic livestock production is multifaceted and many aspects of an animal's life contribute to its welfare. These include good health and productivity, ability to express natural behaviour, absence of pain or stress, presence of positive emotions, and ethical considerations (Duncan, 1996; Fraser & Broom, 1997; Lund, 2006; Haynes, 2008).

Animal health and welfare is influenced by the ways in which livestock production systems are constructed (Vaarst & Alroe, 2012). Kenyan milk production systems are dominated by smallholder farmers. Smallholder dairy farmers, estimated to number about 2 million households, account for more than 80% of the annual total milk production and more than 70% of total marketed milk in Kenya (SDP, 2005; Wambugu et al., 2011). The farms are mainly concentrated in the Kenya highlands (areas with elevation of ≥ 1000m above sea level) where farmers practice integrated crop-dairy production and keep one to five cows which are exotic or crosses of exotic with local breeds and housed in zero-grazing units. (Bebe et al., 2003a; Wambugu et al., 2011; Muriuki, 2011).

The average milk production in smallholder dairy farms is generally low (Owen et al., 2005; Musalia et al., 2007; Lukuyu et al., 2011), and higher productivity is limited by feed scarcity, infectious diseases and parasites, poor animal husbandry practices, and limited access to extension and veterinary services (Aytund et al 2005; Njarui et al., 2011; Onono et al, 2013). Despite these challenges smallholder livestock production on mixed crop–livestock farms is expected to remain dominant in Sub-Saharan Africa for the foreseeable future. Rising incomes, urbanization and preferences by the growing middle classes for a diet that includes livestock products is expected to guarantee income for livestock producers for the foreseeable future (Delgado et al., 1999; Jayne et al., 2003). As a result, the intensification of dairy production by keeping exotic breeds and zero-grazing is widely promoted to meet the increasing demands for dairy products and sustain livelihoods from the limited production resources of land, capital and labour (Bebe et al., 2008). Intensification is expected to influence the way these systems operate and affect the health and welfare of livestock in these systems.
Africa has had a long association with the organics project including having a presence at the founding of the International Federation of Organic Agriculture Movements (IFOAM) (Paull, 2010) yet Kenya has just 4,894 hectares of certified organic agriculture which contrasts with its neighbour, Uganda, with 231,157 ha of certified organic agriculture (Willer & Lernoud, 2015). There is great potential for growth of organics in Africa (Olowoake, 2014) and that is especially so in Kenya.

Taking into consideration the situation of smallholder dairy farming system in the two counties in Kenya (Kiambu and Kajiado) coupled with a literature review on the condition of these systems from other studies, the objective of the study was to explore and analyze the animal management, health and welfare in smallholder farming systems and assess these issues in relation to the recommendations made by IFOAM and the East Africa Organic Product Standard (EOPS). In addressing these objectives, this study aimed at enriching the discussion around organic dairy production and smallholder crop-dairy systems to assist in the identification of viable options in space and time to which efforts on organic dairy development could be focused.

**Materials and methods**

**Study area**

The study was conducted on smallholder dairy farms in Kajiado County (Ngong) and Kiambu County (Dagoretti and Kikuyu), Kenya. The areas are sub-humid and have an annual mean temperature of 10–18°C, a bimodal rainfall pattern higher than 800 mm annually and are ≥1000 m above sea level. Ngong is located 21 kilometres to the South West of Nairobi while Kikuyu and Dagoretti are located 18 and 20 kilometres west of Nairobi respectively. Both regions are characterized by a high number of smallholder dairy farming units due to the availability of a ready market for milk in the city and its environments.

**Selection of farms**

Twenty four farms were selected (13 farms in Kiambu and 11 farms in Kajiado); the sample size was based on the need to adequately understand the production system, available resources and logistical considerations. The longitudinal study evaluated the management practices, animal health and welfare in the farms.

**Data collection**

The data was collected by the first author. Farm monitoring sheets for documenting both the baseline information and the repeated observations were made. The baseline information collected at the beginning of the study include: animal housing, cubicle sizes, land size and land allocation to various enterprises. To assess the animal housing design the following parameters were used: presence and adequacy of roofing, presence, type and state of walls, floor type, presence of resting yards, nature and adequacy of feeding and watering areas. All these were assessed by visual observation and direct measurement. Information related to milk production, feeding, occurrence of animal diseases, treatment, breeding, milking practices, animal housing as well as other farm characteristics were observed and documented during the repeated farm visits. Information on milk production and concentrate feeding, disease occurrences and treatments were recorded using a monthly data card that was given to the farmers each month.
Each farm was visited at least four times, with the first visit in August of 2012 and the last visit in April 2013 to cover the two main seasons experienced in these areas. Feeding management data including type and amount of feed as well as frequency of feeding, type and frequency of mineral supplementation and frequency of watering were obtained by asking the farmer or the worker responsible for feeding the animals.

Milking management, disease management and parasite management data were obtained by observations of how the processes were conducted. These included information on: milking procedure, disease control and prevention measures such as the use of acaricides and vaccinations, and routine practices such as de-worming. The hygiene status of the floor was assessed by evaluation of the frequency of slurry removal and by direct observation by the investigator during farm visits.

Data analysis

Descriptive statistics including analyzing for associations were generated from the data using SPSS for Windows version 14.02 (SPSS Inc., ©1989-2005). Further analysis to assess management of dairy cattle, animal health management and welfare issues in smallholder farms was conducted. Stepwise Cluster Analysis was used to describe the farming system from a set of variables including land size, landholding pattern, land use, housing design, hygiene, calf management, nutrition management breeding and animal health management, and milking practices.

Results

Land holding and land use pattern

There was a significant difference in the average total landholding by smallholder farmers in the two counties. In Kajiado County, the average landholding was 8.23 acres while in Kiambu County the average land holding was 0.74 acres. The average land sizes for pasture, cropping, home/compound and animal housing are shown in Table 1. The animal houses were set up in the backyard near the farmers’ houses and all the dairy cows were raised within the zero-grazing units.

Table 1: Land holding and use on smallholder farms in Kiambu and Kajiado Counties.

<table>
<thead>
<tr>
<th>Type of land use</th>
<th>Kiambu (N=13)</th>
<th></th>
<th>Kajiado (N=11)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (ha)</td>
<td>SD</td>
<td>Mean (ha)</td>
<td>SD</td>
</tr>
<tr>
<td>Land for home/compound</td>
<td>0.19</td>
<td>0.05</td>
<td>0.49</td>
<td>0.29</td>
</tr>
<tr>
<td>Land for animal house</td>
<td>0.14</td>
<td>0.07</td>
<td>0.18</td>
<td>0.06</td>
</tr>
<tr>
<td>Land for cropping</td>
<td>0.36</td>
<td>0.17</td>
<td>3.25</td>
<td>2.47</td>
</tr>
<tr>
<td>Land for cut and carry grass</td>
<td>0.30*</td>
<td>0.20</td>
<td>2.20</td>
<td>1.61</td>
</tr>
<tr>
<td>Land not cultivated</td>
<td>-</td>
<td>-</td>
<td>2.78**</td>
<td>2.88</td>
</tr>
<tr>
<td>Total land holding</td>
<td>0.74</td>
<td>0.28</td>
<td>8.23</td>
<td>6.70</td>
</tr>
</tbody>
</table>

*, ** only two and eight respondents in Kiambu and Kajiado respectively.

Fifteen percent of the dairy farmers in Kiambu County had land allocated for growing pasture within their farms, with an average of 0.3 acres, while in Kajiado County, all of the farmers had land allocated to growing pasture, with an average of 2.20 acres. Thirty
percent of the farmers in Kiambu County grew pasture along the hedges of their farms but this did not constitute a significant land allocation. Seventy three percent of the farmers in Kajiado had land not cultivated or allocated to a specific enterprise, with an average of 2.78 acres. The cows were not grazed in any of the farms and feed was cut and carried to the cattle in all enterprises.

**Housing design and hygiene**

Table 2 shows the details of the structures used to house the cows. In both counties taken together, 87% of the animal house flooring was made of concrete. In both counties taken together, 75% of the cubicles were small compared to the recommended size of 1.2m by 2.1m in the extension manual for animal housing (MoLD, 2007). One of the 24 farmers used saw dust/wood shavings as bedding in the cubicles. Thirteen percent of the farms did not have specific cubicles dedicated to milking their cows and used one of the cubicles otherwise used as a resting area for milking. None of the farms had a dedicated calving area or a sick pen.

Table 2: Details of the cow housing system on the farms in Kiambu and Kajiado Counties.

<table>
<thead>
<tr>
<th>Parameter detail</th>
<th>Kiambu (N=13)</th>
<th>Kajiado (N=11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Cow shed flooring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>○ Concrete</td>
<td>12 (92.3%)</td>
<td>9 (81.8%)</td>
</tr>
<tr>
<td>○ Soil</td>
<td>1 (7.7%)</td>
<td>2 (18.2%)</td>
</tr>
<tr>
<td>ii. Milking area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>○ Available</td>
<td>11 (84.6%)</td>
<td>10 (90.9%)</td>
</tr>
<tr>
<td>○ Not available</td>
<td>2 (15.4%)</td>
<td>1 (9.1%)</td>
</tr>
<tr>
<td>iii. Bedding in the cubicles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>○ Saw dust/wood shaving</td>
<td>0 (0%)</td>
<td>1 (9.1%)</td>
</tr>
<tr>
<td>○ No bedding</td>
<td>13 (100%)</td>
<td>10 (90.9%)</td>
</tr>
<tr>
<td>iv. Cubicle size</td>
<td></td>
<td></td>
</tr>
<tr>
<td>○ Small size</td>
<td>10 (76.9%)</td>
<td>8 (72.7%)</td>
</tr>
<tr>
<td>○ Adequate/ large sized cubicles</td>
<td>3 (23.1%)</td>
<td>3 (27.3%)</td>
</tr>
<tr>
<td>v. Ratio of number of cow to the number of cubicles in the animal house</td>
<td></td>
<td></td>
</tr>
<tr>
<td>○ 1:1 – 1:1.9 (cows/cubicles)</td>
<td>4 (30.8%)</td>
<td>5 (45.5%)</td>
</tr>
<tr>
<td>○ 1:2 - 1:2.9 (cows/cubicles)</td>
<td>4 (30.8%)</td>
<td>2 (18.2%)</td>
</tr>
<tr>
<td>○ &gt;1:3 (cows/cubicles)</td>
<td>5 (38.5%)</td>
<td>4 (36.3%)</td>
</tr>
</tbody>
</table>

In most cases the animals were soiled with slurry on various areas of their bodies. In all the cows examined, the limbs, the flanks and the udder were soiled. The main cause of soiling on the animal was accumulation of slurry in the cow house. Removal of slurry and cleaning of the cow housing floors was done at least once per day in 77% and 64% of the farms in Kiambu County and Kajiado County respectively. In the other farms, it was done only occasionally, either once every two days or once per week.
Grazing and outdoor access
All the adult dairy cows were housed in zero grazing units during the course of the study. For calves, 21% of the farms grazed them within the compound during the day and they were housed overnight.

Herd structure
There was no significant difference in the average herd size in both Counties (Table 3). The majority of the studied households owned between 1 and 3 cattle. Milking cows constituted the highest number in the herd structure in Kiambu County while in Kajiado County milking cows and calves were equal in number (Table 3). The only breed of dairy cattle kept by the farmers was Holstein-Friesian and no farmer kept a bull in the herd.

Table 3: Herd structure of visited farms at the beginning of the study.

<table>
<thead>
<tr>
<th>Types of cattle/ Herd size</th>
<th>Kiambu (N=13)</th>
<th>Kajiado (N=11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Number ± SD</td>
<td>% in herd structure</td>
<td>Average Number ± SD</td>
</tr>
<tr>
<td>Milking cows</td>
<td>1.35 ± 0.65</td>
<td>43.9</td>
</tr>
<tr>
<td>Dry cows/ Heifers</td>
<td>0.69 ± 0.63</td>
<td>22.4</td>
</tr>
<tr>
<td>Calves</td>
<td>1.00 ± 0.58</td>
<td>33.7</td>
</tr>
<tr>
<td>Average Herd size</td>
<td>3.15 ± 0.80</td>
<td>-</td>
</tr>
</tbody>
</table>

Calf management
Ninety two percent of the farms had calves at least one time during the period of the study. Calves were housed separately and away from adult animals on all the farms. All farmers fed their calves twice daily; this was done soon after milking. The amount of milk fed to the calf varied from farm to farm and with the age of the calves. Other than milk, calves were mainly fed natural grass or Napier grass or dry crop residues. Protein supplementation for calves was only done regularly on 8% of the farms (which were located in Kajiado).

The age of weaning from milk varied between farms with 38% of the farms weaning the calves at between 11 and 12 weeks while 25% of the farms weaned their calves at between 9 and 10 weeks. Of the farms that weaned their calves earlier, 8% continued to feed calves with pellets till the calves were more than 12 weeks old. Eighty three percent of the farms had a calf pen for keeping the calves. 58% of the calf pens were raised floors made of timber slatted floors, while the others had floors on the ground. Bedding for the calf pens were provide in 17% of the farms. The sizes of the pens in all the farms were similar with an approximate size of between 1.8m² and 3m². All the calves in the farms were dehorned before three months. Anaesthesia was used in all cases during dehorning.

Milk production and milking practices
Milking was done in parlours in 71% of the farms. Concentrates were used by 75% of the farmers in both regions and were only fed during milking. The estimation of commercial concentrates (dairy meal) for feeding milking cows ranged between 2 to 4 kg per day.
All of the cows were milked twice per day, in the morning at 0600 - 0800hrs and in the evening at 1700hrs to 1900hrs. Hand milking was the only method used for milking on all the farms. Only 13% of the farmers washed their hands with a detergent before milking while 6 farmers did not wash their hands before milking (Table 4). Udder and teat washing with water was done before milking by all the farmers in both counties. In 50% of the farms observed fore-milking was not conducted. 71% of the farmers used milking jelly to soften the teat before milking. Milk was stored and transported in aluminium cans on 75% of the farms, while other farmers mainly use plastic jars during milking. 33% of the farms used detergent for dipping the teats of the cows after milking. Hand washing and order of fore-milking were not consistently practised on most of the farms.

**Breeds and breeding management**

All cows in the study were exotic breeds. Artificial insemination was the only method of breeding used by the farmers. The farmers observed the animals and called the inseminator when a cow was in heat. Artificial insemination services were mainly offered by private individuals who provided advice to farmers on the best bulls. The main criterion for sire selection for most of the farmers was improving milk production.

**Table 4: Milking Procedure in Kiambu and Kajiado Counties.**

<table>
<thead>
<tr>
<th>Parameter detail</th>
<th>Kiambu (N=13)</th>
<th></th>
<th>Kajiado (N=11)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>%</td>
<td>Number</td>
<td>%</td>
</tr>
<tr>
<td>i. Hand washing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>○ Wash hand before milking with soap/disinfectant</td>
<td>1</td>
<td>7.7</td>
<td>2</td>
<td>18.2</td>
</tr>
<tr>
<td>○ Washing hands with water only</td>
<td>6</td>
<td>46.2</td>
<td>5</td>
<td>45.5</td>
</tr>
<tr>
<td>○ No hand washing</td>
<td>5</td>
<td>38.4</td>
<td>1</td>
<td>9.1</td>
</tr>
<tr>
<td>○ Inconsistent practice in milking procedure</td>
<td>1</td>
<td>7.7</td>
<td>3</td>
<td>27.2</td>
</tr>
<tr>
<td>ii. Order of fore-milking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>○ Fore-milking before cleaning</td>
<td>1</td>
<td>7.7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>○ Cleaning before fore-milking</td>
<td>1</td>
<td>7.7</td>
<td>5</td>
<td>45.4</td>
</tr>
<tr>
<td>○ No fore-milking</td>
<td>5</td>
<td>38.5</td>
<td>3</td>
<td>27.3</td>
</tr>
<tr>
<td>○ Inconsistent practice in order of milking</td>
<td>6</td>
<td>46.1</td>
<td>3</td>
<td>27.3</td>
</tr>
</tbody>
</table>

**Disease and pest management**

All the farmers in both study sites used acaricides preventively on their farms. The majority of the farmers used acaricides once every week, 38% and 55% in Kiambu and in Kajiado counties respectively. Table 5 shows the detailed frequency of acaricide use in both counties. Hand spraying was the only method of application used in both regions. 62% of the farm in Kiambu County and 36% in Kajiado County did not practice routine de-worming for calves or other cattle during the period of the study (Table 5).
During the 8 months of the study, one case of East Coast Fever was reported in Kajiado. Four cases of mastitis were reported of which three of the cases were in Kiambu County. In all cases the treatments were conducted by a Veterinary Officer from the respective location at the expense of the farmers.

Table 5: Helminths and tick control practices in the farms.

<table>
<thead>
<tr>
<th>Parameter detail</th>
<th>Kiambu (N=13)</th>
<th>Kajiado (N=11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Frequency of application/use of acaricides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>○ Weekly</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>○ Once every 2 weeks</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>○ Once a month</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>ii. Frequency of de-worming</td>
<td></td>
<td></td>
</tr>
<tr>
<td>○ Once every 3 months</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>○ Once every 5-6 months</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>○ None</td>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>

Feeding management

Zero-grazing was the method of cattle rearing practiced by all of the farmers. There was a difference in the type of feed given to the animal in the two counties. In Kajiado the farmers mainly fed assorted species of green grasses followed by Napier grass during the wet season. During the dry season between December and February hay was the most common feed for the dairy cattle. Hay which was mainly used in Kajiado during the dry season was purchased from the agro-veterinary shops around the area.

In Kiambu, the most common feed during the wet and dry season was Napier grass. In Kiambu, there were a number of farmers who grew Napier grass for sale to dairy cattle farmers. However, the second most important feed resource during the wet and dry seasons in Kiambu and Kajiado Counties were different species of grasses collected from various sources and hay respectively. In Kiambu, maize stover also contributed a significant amount of the feed at the beginning of the dry season. The maize stovers used for feeding the cows were mainly purchased from other farmers.

Animal feed was mainly sourced on the farms from Kajiado, while in Kiambu the farmers employed a farm worker who collected feed from various sources including road side and hedges. Mineral salt block was available in 5 out of all the 24 farms visited. Water was fed to the cows ad libitum. There was a supply of clean tap water in both regions.

Discussion

Land holding and use

The results show similar landholding patterns and use in smallholder dairy farming systems in Kenya compared to other tropical countries. Most smallholder farmers own less than 5 ha and allocate most of the lands to crop production rather than pasture.
production (Lanyasunya et al., 2006; Njarui & Mureithi 2006; Waithaka et al., 2006; Musalia et al., 2007; Lukuyu et al., 2011). Decreasing land sizes in densely populated highlands where most of these farming systems are located makes zero-grazing an important strategy through which smallholders intensify their production.

Small land sizes make it difficult for the farmers to produce sufficient feed for the dairy cattle. As a result, the farmers must rely on feed from other external sources which may vary in quality and quantity depending on the seasons and may not necessarily be organic. The challenge of land also makes it difficult for smallholder farmers to design production systems that can meet the basic requirements of animal health and welfare. Changes to incorporate the animal health and welfare needs of the animals based on the organic standards and principles may involve a trade-off between dairy production and other critical aspects like crop production. To establish the merits or demerits of substituting one enterprise for another a critical analysis on the profitability and practicality of the competing enterprises needs to be done. Meeting the animal health and welfare under smallholder systems will require a review of how these production systems are constructed.

Farm structures and hygiene

Dairy cattle in this study were housed all the time. The design of housing in this study was such that most of the floors were made of concrete and lacked bedding, the cubicle sizes were small and the cow to cubicle ratio was low in many farms. Thus the housing structures in most of the farms were not ideally suited for the cows. The farm structures were not only risks to the welfare and health of the cows. The length and width of cubicles impede comfortable lying down and movement of cows yet cows show a strong motivation to lie down (Cooper et al., 2007). Without comfortable and easily accessible lying area, cows will have difficulty in lying, entering and rising (Nguhiu-Mwangi et al., 2008). As a result, cows may spend more time standing or lying. This increases risk of injuries thus affecting cow health and welfare.

Lack of bedding on concrete floors as observed in the study increases the risk of cows slipping or falling. Cows in such conditions have to alter their gait to lower friction while walking (Phillips & Morris, 2000). This can lead to injury and a disinclination to walk, making the cows less likely to visit the feeding area despite a motivation to do so, possibly reducing feed intake and production. Concrete floors have been associated with an increased occurrence of hoof lesions due to claw horn disruption compared to straw yards (Frankena et al., 1992, Somers et al., 2003).

The organic standard does not specify the minimum space requirements for dairy cattle or the stocking density. However, farmers are required to provide animals with bedding where it is appropriate, clean the holding areas regularly, provide living conditions that avoid abnormal behaviour, injury and disease according to the natural behaviour of the animals. To be able to fulfil this requirement structural adjustment of the farms will be required. These changes involve re-designing of the cow housing, changes in the flooring systems and changes in the management of the cow environment. These adjustments may be capital intensive and the question many farmers would ask is whether the additional expenses to cater for the health and welfare needs of the cows can be financially justified. One of the major challenges in making these additional investments is
lack of information on the benefits of these investments on the animal's health and welfare and the economic gains to the farmers.

**Grazing and outdoor access**

In this study, all cows were zero-grazed. This creates a major conflict in relation to the organic principles and recommended practices. The goals of organic principles are that dairy animals should be managed in a way that allows the expression of natural behaviour and according to their natural behavioural needs. This includes letting the animal have sufficient space for free movement according to their natural behaviour (EAOPS, 2007) and to graze because this is a natural way of feeding for ruminants. Access to outdoor areas and freedom of choice that allows an animal to express individual preferences is also considered to constitute the concepts of naturalness (Lund 2006; Waiblinger et al., 2004; Verhoog et al., 2007). The EAOPS permits the bringing of fodder to the animal if it is a more sustainable way to use land resources than grazing. However, under such conditions regular outdoor runs must be provided.

Providing for the health and welfare needs of the dairy cows in smallholder production systems require that some farmers purchase (or lease) more land while others will need to allocate more land to dairy production. These changes may require additional capital to invest in purchasing more plots of land and additional labour to ensure that grazing areas or areas for outdoor runs are managed effectively to enhance the health and welfare needs of the cows.

However, there are no specific guidelines that can to be used to evaluate compliance on a number of issues that directly affect animal health and welfare based on the East African Organic Product Standards. For example the EAOPS do not give detailed guidelines on what “sufficient space for free movement” is or what “regular outdoor run” means to ensure that animal health and welfare is not compromised. It is suggested that the standards need to provide definite details for farmers to be able to understand and implement. Since there may be little risk of dairy cow losing organic status as a result of lack of sufficient space the farmers may not see the need for implementing these requirements.

**Calf management**

In organic dairy production natural living for calves involves cow-calf contact and natural milk feeding from a cow (suckling). Suckling also enables the cow to express natural behaviour and ensures natural communication between the cow and the calf (Grondahl et al., 2000; Flower & Weary, 2003). Calves in this study were isolated from their mothers within the first two weeks of birth and were either bucket fed or bottle fed until they were weaned. However, this is much better than the way in which calf management is practiced in most European countries where calves are separated from the cows within a few hours after birth (de Passille et al., 2008). This type of calf feeding is the most common practice by smallholder farmers with zero-grazing units (Bebe, 2008; Lukuyu et al., 2011).

Organic feeding standards require calves to be fed with maternal milk or organic whole milk from their own species. Feeding of vitamins, trace elements and supplements from natural sources is also permitted. The organic standards do not define specific time period for weaning and only state that: “Animals shall be weaned only after a minimum
time that takes into account the natural behaviour and physical needs of the animal”. In cows, natural weaning has been found to occur from 6 months (Webster, 1994) up to 12 months (Reinhardt & Reinhardt, 1981). Various studies have shown that natural weaning provides welfare benefits of health, psychological wellbeing and natural behavioural expression for both the calf and dam (Solano et al., 2007; Wagenaar and Langhout, 2006; Wagner et al., 2012).

The variation observed in the amount of milk fed to calves across different days shows that there is no specific feeding management strategy in the farms, yet feeding is the key component in the replacement management procedure within farms in the successful raising of healthy calves (Radostitis, 2001). Lukuyu et al. (2011) observed that the most important constraint to optimum feeding in calves were low milk production by dams and the competition for milk for use in the household and for sale.

The other challenge in calf rearing was lack of bedding and dirty calf pens in most of the farms and this affected the welfare of the calves and could be associated with numerous calf diseases such as gastroenteritis and pneumonia. These two diseases accounted for 44% of calf mortality in farms around Nairobi (Gitau et al., 2010). The diseases lead to huge economic losses and deprive the farms of replacement stock for their herds.

Feeding management
The quantity and quality of feed is a major contributor to animal good animal health and welfare. To support animal health and welfare, feeding is required to meet the physiological conditions of the animals. The East African Organic Product Standard requires that diets for dairy cows must derive a minimum of 60% of the dry matter intake (DMI) from organic feedstuff daily. Access to fresh fodder through grazing is preferred and preserved fodder may only be used where fresh fodder is not available.

Organic production views animals in the farm as part of the system and thus recommends that at least 60% of the feed shall come from the farm itself or be produced in cooperation with other organic farms. In Kajiado, farmers produced most of the feed on their own and did not use chemical fertilizers in the grasses that were fed to the cows. However, during the dry season farmers relied on hay which was purchased from the local agro-veterinary shops. It was therefore difficult for farmers to determine how the purchased feed was produced. In Kiambu, feed was sourced from outside the farm throughout the year. The main source of feed was purchased fodder from neighbouring farmers who specialized in fodder production and collecting feed from various sources by the farm workers. In Kiambu, maize stover was purchased from farmers who were not organic farmers.

The organics standard provides specifications for farmers who are unable to graze their animals to use preserved feed of known organic status (EAOPS, 2007). A great challenge for such a farmer will be to get such organic feed for their dairy cows. This is due to lack of traceability of the source of feed and the production method. Incorporation of maize stover produced by non-organic farms will also need to stop since production of maize in most parts of the country involves the used of chemical fertilizers and pesticides.

The amount of concentrates fed to the animal varied from one farm to another. Previous studies show that the quantity of concentrates offered to dairy cattle in smallholder farming systems was generally low (Njarui et al., 2011). The amount of concentrate fed
depended on the abilities of the farmers to buy the concentrate. Production and feeding of protein-rich crops has been recommended as a method to reduce the necessity of commercial concentrates in smallholder production systems. The greatest challenge to supplementing the protein requirement through this method is the lack of sufficient land to grow the protein rich-crops in smallholder farmers. This means that even if protein rich crops are to be used as a substitute, smallholder farmers would still have to buy the crop from other farmers. There is a need to develop practical solutions to ensure adequate feed for dairy cows in smallholder systems.

**Use of poisons and chemical medicine in disease management**

The occurrences of disease in the farms involved in this study were relatively low with only one case of East Coast Fever and four cases of mastitis. However, East Coast Fever, anaplasmosis, babesiosis, trypanosomosis and contagious bovine pleuropneumonia are some of the cattle diseases reported to be endemic in smallholder production systems (Muraguri et al., 2005; Zilberman et al., 2011). The use of pharmaceuticals are discouraged in organic dairy production and may only be used under the supervision of a veterinarian and where it is the best way to reduce suffering, to save life or restore health. A guideline is given on the withholding periods after treating animals with synthetic veterinary drugs or antibiotics.

In this study, the use of acaricides was a routine practice. Routine use of acaricide is common in smallholder farming systems (Maingi & Njoroge, 2010; Wesonga et al., 2010). To conform to the requirement of the organic standard, alternatives to chemical methods of controlling ticks should be adopted in smallholder farms, for example, hand picking of ticks (Rubaire-Akiiki et al., 2006). The routine use of acaricide against ticks is used as a preventive measure to tick-borne diseases which are a major cause of losses in smallholder farms. Given the important role played by dairy cattle in the livelihood of most of the farmers, loss of an animal is considered too risky unless there are effective alternative tick control methods, or insurance is in place against losses, should they change their practices.

The organics standards do not provide any conditions that may lead to the removal of organic status of an animal based on the use of synthetic drugs for disease treatment or parasite control even under repeated treatments (EAOPS, 2007). Though the flexibility in the organic standards concerning the maintenance of organic status regardless of the number of treatments provides an opportunity for smallholder farmers faced by numerous disease and pest challenges, this may lead to non-compliance and make use of these synthetics the norm rather than an exception. Since maintaining health is an integral part of animal welfare more work needs to be done to develop methods of disease control that are acceptable in organic production.

**Breeding management and breeding objectives**

Holstein-Friesian was the only breed kept by farmers in this study with artificial insemination being the only method of breeding used in the farms. The smallholder farmers keep exotic breeds as a key aspect of their intensification strategy in order to increase milk production (Murage & Ilatsia, 2011). Holstein-Friesian is considered as a ‘high maintenance’ animal requiring high energy concentrate and regular veterinary treatment. Exotic breeds have higher nutritional demand, low milk, poor adaptability and
low production efficiency in smallholder production systems (Kahi et al., 2000; Wakhungu, 2000).

Most cows kept by smallholder farmers are sourced from commercial herds which may have different sets of objectives. The farmers who use artificial insemination (AI) use the same breeding bulls as conventional farms with the aim of increasing milk production. The choice of AI bull to use is usually determined by the farmer or based on advice from the AI service providers. This is unlikely to change in the near future since the dairy sector in Kenya depends on conventional breeding programmes in Kenya, Europe and USA as the main sources of breeding bulls.

Selection of animals should be based on the requirements of the production system or environment because it plays a role in safeguarding animal health and welfare. In organic livestock production, breeding should not only focus on increased milk production but also consider other important traits required to meet the health and welfare needs of the animal in smallholder systems including resistance to diseases, adaptation to the local environment and utilization of available feed resources. Animals that are genetically adapted to specific conditions are more productive and the cost required for production is lower (Simm et al., 2004).

Correct breeding and selection of appropriate dairy breeds should be viewed as a preventive health strategy for organic dairy systems (Marley et al., 2010). Long term consideration during breeding and selection may help fulfil the requirements of organic production. Recognition of the role of organic production at the policy level will also play an important role in the future development of organic dairy production since most policies instead advocate for intensification of productivity by increasing animal output and productivity (Devendra, 2001; Bebe et al., 2002).

**Human choices related to animal farming**

Human factors strongly determine our behaviour towards animals, animal production and animal welfare (Boivin et al., 2003). This is because the decisions in the farms are dependent on the farmers and have major implication on animal health and welfare. These decisions include the number of cows to keep, the size of cubicles to build and animal management in general. This study showed that in most farms there were low animal to cubicle ratio, small sized cubicle, lack of bedding, dirty loafing areas and cubicles in most of the farm. Ensuring good animal welfare depends on the ability of the farmers to recognize discomfort and ailments facing the animals and taking remedial actions on the causes of discomfort or ailments. Improving the animal welfare situation in the farms studied will require the farmers to make critical decisions concerning the stocking rates, management and structural changes.

The principles of fairness link human and animal relation as part of animal welfare. Vaarst & Alroe (2012) outlined the interfaces between naturalness and human care giving and how the two can be viewed to constitute the concept of animal health and welfare in organic animal farming. The interface of human care giving involve taking responsibility for the animals in the farms that they are not suffering and that they do not experience pain, distress, injuries, frustration, disease, hunger, or thirst. Farmers should be interacting gently and with care with animals in daily life and create a framework which allows naturalness and makes it possible to observe the animals sufficiently without
necessarily interfering. In organic livestock production farmers have an obligation to care for the needs of the animals to guarantee their health and welfare.

Conclusion
The management of cows in smallholder farming systems has an effect on their health and welfare status. Managing these systems is dependent on the way in which the components of the system are organized and the availability of resources. Meeting the provisions of organic dairy production will require adjustments within the smallholder farming system and it is our view that this is achievable in some farms. However, the unique characteristics of each farm needs to be considered when assessing and developing strategies to improve animal health and welfare because smallholder farmers are not a homogenous group. Implementation of strategies developed may require additional resources.

Farmers frequently have poor attitudes towards issues related to animal welfare. There is a need to address the perceptions and attitudes of the farmers and how it affects their relation to the cows within the farms. Training farmers in organic principles will not only safeguard the health and welfare of dairy cattle in these farms but it also has the potential to improve the profitability of the dairy enterprises. Future research to integrate organic dairy production with smallholder farms should focus on addressing the challenges of diseases, pests and feed which are major sources of health and welfare concerns in these systems.

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Odhong’, Wahome, Vaarst, Kiggundu, Nalubwama, Halberg & Githigia


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The first high yielding saline tolerant rice variety suited to the Kaipad tidal farming ecosystem of Kerala, India, and suited for flood prone and water scarce environments: ‘Ezhome-1’

Vanaja, T.*1, Neema, V.P.*1, Mammootty, K.P.*1, Balakrishnan, P.C.1 & Jayaprakash Naik, B1.

1College of Agriculture, Padannakkad, Kerala Agricultural University, Kerala, India
2 Pepper Research Station, Panniyur, Kerala Agricultural University, Kerala, India
*email: vtaliyil@yahoo.com

Abstract

Kaipad is a saline prone naturally organic tidal rice farming tract of North Kerala, India, fringed by mangroves. It is an integrated organic farming system in which rice cultivation and aquaculture are practiced together. Poor yielding traditional cultivars having undesirable characteristics but tolerant to salinity and having good cooking and nutritional qualities are cultivated in various Kaipad fields of Kerala. Development of high yielding, non-lodging rice varieties for the Kaipad ecosystem with favourable qualities has long been a demand of the local farmers. Here we report the development of the first high yielding rice variety suited to the Kaipad ecosystem, ‘Ezhome-1’, having the favourable traits demanded by farmers. This new variety was developed by adopting the combined strategy of conventional breeding linked with novel strategies of organic plant breeding and participatory plant breeding and growing the entire filial generations and with early trials in the target area of farmers, unlike in conventional breeding programmes. In addition to the saline Kaipad ecosystem it is also suited for non–saline flooded and non-flooded ecosystems as well, unlike the land races of Kaipad. It is a long duration variety during the Kharif season and a short duration variety during Rabi season with red kernel colour, a trait much preferred by people of Kerala state in India, and having cooking and nutritional qualities akin to Kaipad land races.

Keywords: Saline tolerance, salinity tolerance, abiotic stress, tidal farming, naturally organic tract, Pokkali, India.

Introduction

Salinity is one of the major abiotic stresses that threaten the food supply in the world. Explosive increase in world population, deterioration of arable land, and the uncertain availability of quality irrigation water are forcing crop production into more and more
marginal environments facing abiotic stresses (Sharma & Goyal, 2003). In future, one cannot expect a major increase in land area available for cropping. At the same time, cultivated area is declining fast in most of the developing countries. It is estimated that half of the world’s farms have been damaged by salt (Pearse, 1987).

Breeding for salt tolerance is a more promising, energy efficient, economic and socially acceptable approach than major engineering processes or soil amelioration which are beyond the reach of marginal farmers. In spite of a significant amount of research on the effect of salinity on plants, there has been little success in putting salt resistant plants into farmers’ field (Flowers & Yeo, 1995). As rice is one of the major food crops, the development of new cultivars with enhanced salt stress-tolerance and well suited for both saline and non-saline areas can have an important effect on global food production. Soil salinity tolerance of rice is a complex trait of several physiological characters (Flowers & Yeo, 1988) and research on the development of rice varieties tolerant to salinity is meagre.

Kaipad is the saline prone tidal farming rice production tract of Kerala, India, like the Pokkali tract of South Kerala. The Kaipad system of rice cultivation is an integrated organic farming system in which rice cultivation and aquaculture are practised together in coastal brackish water marshes which are rich in organic matter. Rice farming is carried out in a peculiar way in Kaipad, purely in a natural way relying on the monsoon and the sea tides. Most of the Kaipad fields either lie fallow or produce low yields. Traditional cultivars tolerant to low and medium salinity are cultivated in various Kaipad fields of Kerala.

The average rice yield of these local cultivars is about 2000 Kg ha⁻¹ making commercial rice cultivation in this region unprofitable. Then non-realization of the potential of high yielding rice varieties for this rain fed shallow low land was the major reason for the low productivity and the shrinkage of Kaipad fields. The traditional cultivars are susceptible to lodging, because of its poor culm strength and excessive culm length. Further, lodging is of staggered mode on all sides which makes harvesting a tedious task, especially salient in the present scenario of the shortage of farm labourers. Further, the grain qualities of traditional cultivars are poor with awn on grains, long bold, and heavy shattering of grains. Panicles of these cultivars are long but low in the number of grains.

However, these cultivars are resistant to all pests and diseases in the natural field conditions of Kaipad and the cooked rice is very delicious and also nutritionally rich. Development of saline tolerant high yielding varieties with favourable grain and cooking qualities for the Kaipad ecosystem has been the demand of the farmers for a long time. Here we report the development of the first high yielding rice variety of the unique Kaipad ecosystem through a challenging breeding project which began in 2003.

Materials and methods
A combined strategy of pedigree breeding, organic plant breeding techniques (Bueren, 2003) and a farmer participatory breeding approach (Morris & Bellon, 2004) was followed during the variety development programme. The entire experiment was conducted directly at the target area, of saline sea coastal problem area, to harvest the genetic potential under field conditions. Inter-varietal hybridization was carried out between high yielding saline susceptible varieties, namely ‘Jaya’ and ‘Mahsuri’ which are under
cultivation at the proximity of Kaipad fields, and the popular saline tolerant traditional land races of Kaipad, such as ‘Kuthiru’ and ‘Orkayama’ which have multiple favourable traits including salinity tolerance, biotic stress tolerance, excellent cooking and nutritive qualities and which have not been exploited so far in breeding programmes (Vanaja & Mammothty, 2010). All the filial generations as per pedigree breeding, and yield trials, were raised as on-farm trials in the Kaipad fields, ensuring the participation of farmers in the selection process of promising progenies from the segregating filial generations as per strategies of participatory plant breeding, unlike in conventional breeding programmes where farmer participation is done at the farm trial stage only.

The F$_2$ filial generation comprising six thousand two hundred ninety two progenies was raised in the field adjacent to the saline problem area having intruded slight salinity (2dS m$^{-1}$) and organic rice farming practices. Only 1028 progenies survived in the slight salinity. Single plant pedigree selection was followed in the F$_2$ generation. All of the F$_2$ progeny surviving the slight saline condition were carried forward to the F$_3$ generation in the problem area of Kaipad. From the F$_3$ generation onwards, all advanced filial generations were evaluated directly in the target area having medium salinity. Fourteen high yielding stabilized rice cultures were evaluated in replicated yield trials in saline Kaipad fields along with local lodging check (Kuthiru) and non-lodging Pokkali check (Vytilla 6).

The Pokkali tract in Kerala is similar to the Kaipad tract but differs in soil structure and rice genotypes cultivated. Further, different yield trials were also conducted in the Pokkali tract and non-saline wetlands to test the suitability of cultures in non-saline areas. The design of yield trials was random block design (RBD) with three replications. The promising cultures were also screened under National Saline Alkaline Screening trials of AICRP also. Pests and disease scoring were done under the natural saline field condition of Kaipad and also under artificial infection in the non-saline wet land condition of Regional Agricultural Research Station, Pattambi, Kerala, India. The standard evaluation system for rice (IRRI, 1988) was used for describing the cultures.

The efficiency of breeding for salt tolerance was perceived to be low because of the evident genetic complexity of the trait, large genotype x environment interactions, and the problem of controlling relevant environmental variables during field based selection (Flowers & Yeo, 1995). Hence, in order to improve the suitability of the varieties produced to specific local farming situations, the new approach of farmer participatory varietal selection (Bennet & Khush, 2003) was integrated to develop high yielding varieties suited for Kaipad rice fields.

Participatory Plant Breeding (PPB) is a strategy to integrate an end user based participatory approach (Morris & Bellon, 2004). It is based on a set of methods that involve close farmer-researcher collaboration to bring about plant genetic improvement within a crop. It is expected to produce more benefits than the traditional global breeding model in situations where a highly centralized approach is inappropriate. Participatory plant breeding methods are designed to incorporate the perspective of farmers usually by inviting farmers to participate in selection within the unfinished segregating material exhibiting a high degree of genetic variability. Realizing the fact that modern varieties developed for favourable production conditions have not always diffused readily into marginal environments, the procedures like selection of parents and segregating progenies were done in the target area of farmers. We regard the participation of farmers
is imperative when crops are grown in agriculturally difficult and environmentally challenging situations.

By involving farmers in the genetic improvement process, plant breeding programmes will be able to produce better varieties that will be adopted more widely and generate greater benefits in aggregate. PPB provides a means of assessing so-called ‘subjective traits’. In food crops these include taste, aroma, appearance, texture, and other characteristics that determine the suitability of a particular variety for culinary use. These traits are difficult to measure quantitatively because they are a function of human perceptions.

**Results and discussion**

A sustained research effort adopting new frontiers of crop improvement resulted in the development of an array of high yielding saline tolerant rice cultures for the first time to the unique ecosystem of the *Kaipad* (Vanaja *et al* 2009). Thereafter, these diverse rice cultures were tested in various farm trials in the saline *Kaipad* ecosystem, the saline *Pokkali* ecosystem, with saline screening trials of AICRP and also in non saline wetlands of North Kerala. The details of performance of Culture JK70 which was released under the name ‘Ezhome-1’ for commercial cultivation in Kerala state of India are summarized below.

**Grain yield**

The pooled data of preliminary and comparative yield trials and pedigree of saline tolerant *Kaipad* rice cultures are given in Table 1. A preliminary evaluation trial was conducted separately for both non-lodging and lodging genotypes. A comparative evaluation trial was conducted for good performing non-lodging and lodging genotypes together. In comparative yield trials, five non-lodging cultures, namely, JK 70, JO 345, MK 22, JO 532-1 and JO 583, and one lodging culture, JK 59, showed significantly higher yield performance compared to that of *Kaipad* and *Pokkali* check varieties. These cultures have wide genetic bases because one of the parents is a local cultivar having abiotic and biotic stress resistance.

The mean grain and straw yield of ‘Ezhome-1’ (Culture JK 70) in farm trials in *Kaipad* tracts during *Kharif* seasons are given in Table 2. Culture JK 70 showed a 70% greater yield than the local check ‘Kuthiru’.

The yield performance of ‘Ezhome-1’ in National Saline Alkaline Screening trials of AICRP is given in Table 3. In alkaline soils, alkaline normal soils, coastal saline soils and in coastal saline normal soils, compared to coastal check (CST 7-1), ‘Ezhome-1’ showed higher yield performance. This variety was also high yielding in saline *Pokkali* tracts of South Kerala with a yield potential of 4.4tones/ha.
Table 1. Saline tolerant *Kaipad* rice cultures in PYT and CYTs in farmer’s field.

<table>
<thead>
<tr>
<th>SL No</th>
<th>Genotypes</th>
<th>Parentage</th>
<th>Pooled PYT Grain yield (t/ha)</th>
<th>Pooled CYT Grain yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Non-lodging genotypes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MK 22</td>
<td>Matsuri x Kuthira*</td>
<td>6.61*</td>
<td>5.69*</td>
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<tr>
<td>2</td>
<td>MK 146</td>
<td>- do-</td>
<td>2.26</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>MK 162</td>
<td>- do-</td>
<td>1.08</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>JK 23</td>
<td>Jaya x Kuthira</td>
<td>0.99</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>CK 43</td>
<td>*Orkayama x Kuthira</td>
<td>5.73</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>JK 67</td>
<td>Jaya x Kuthira</td>
<td>1.11</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>JO 560-2-1</td>
<td>Jaya x Orkayama</td>
<td>1.08</td>
<td>-</td>
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<td>8</td>
<td>JK 74</td>
<td>Jaya x Kuthira</td>
<td>6.03</td>
<td>-</td>
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<tr>
<td>9</td>
<td>JO 583</td>
<td>Jaya x Orkayama</td>
<td>7.30</td>
<td>4.70*</td>
</tr>
<tr>
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<td>JK 76</td>
<td>Jaya x Kuthira</td>
<td>4.98</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>JK 70(Eshome-1)</td>
<td>- do-</td>
<td>7.54</td>
<td>6.04*</td>
</tr>
<tr>
<td>12</td>
<td>JO 532-1</td>
<td>Jaya x Orkayama</td>
<td>6.89</td>
<td>6.23*</td>
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<tr>
<td>13</td>
<td>JO 556</td>
<td>- do-</td>
<td>1.33</td>
<td>-</td>
</tr>
<tr>
<td>14</td>
<td>JO 345</td>
<td>- do-</td>
<td>7.20</td>
<td>5.86*</td>
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<tr>
<td>15</td>
<td>Vyttila 6</td>
<td>Non-lodging Pokkali</td>
<td>1.91</td>
<td>2.58</td>
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<tr>
<td></td>
<td>C D (%)</td>
<td></td>
<td>0.93</td>
<td>-</td>
</tr>
<tr>
<td>16</td>
<td>Lodging genotypes</td>
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<td></td>
<td>JK 46</td>
<td>Jaya x Kuthira</td>
<td>3.20</td>
<td>-</td>
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<tr>
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<td>JK 59</td>
<td>- do-</td>
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<td>4.91*</td>
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<td>KO 5</td>
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<td>1.35</td>
<td>-</td>
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<tr>
<td>19</td>
<td>JK 15</td>
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<td>7.33</td>
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<tr>
<td>20</td>
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<td>Kuthira x Orkayama</td>
<td>1.68</td>
<td>-</td>
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<tr>
<td>21</td>
<td>JO 32-2</td>
<td>Jaya x Orkayama</td>
<td>1.03</td>
<td>-</td>
</tr>
<tr>
<td>22</td>
<td>CK 45</td>
<td>Orkayama x Kuthira</td>
<td>3.23</td>
<td>-</td>
</tr>
<tr>
<td>23</td>
<td>MK 61-1</td>
<td>Matsuri x Kuthira</td>
<td>4.70</td>
<td>-</td>
</tr>
<tr>
<td>24</td>
<td>JO 91</td>
<td>Jaya x Orkayama</td>
<td>3.08</td>
<td>-</td>
</tr>
<tr>
<td>25</td>
<td>CK 38</td>
<td>Orkayama x Kuthira</td>
<td>4.97</td>
<td>-</td>
</tr>
<tr>
<td>26</td>
<td>JK 58-1</td>
<td>Jaya x Kuthira</td>
<td>1.03</td>
<td>-</td>
</tr>
<tr>
<td>27</td>
<td>JK 58-2</td>
<td>- do-</td>
<td>1.30</td>
<td>-</td>
</tr>
<tr>
<td>28</td>
<td>Vyttila -1 (Pokkali lodging check)</td>
<td>lodging Pokkali check</td>
<td>2.01</td>
<td>-</td>
</tr>
<tr>
<td>29</td>
<td>Kuthira (Kaipad lodging local check)</td>
<td>local check-lodging</td>
<td>2.10</td>
<td>2.10</td>
</tr>
<tr>
<td></td>
<td>C D (1%)</td>
<td></td>
<td>0.72</td>
<td>2.05</td>
</tr>
</tbody>
</table>

* Land races of *Kaipad* ecosystem; * Within a column, means followed by the same alphabet character do not differ significantly from each other: PYT: Preliminary Yield Trial; CYT: Comparative Yield Trial.
Table 2. Mean grain yield and straw yield of culture JK 70 in multi location/farm trials during Kharif seasons.

<table>
<thead>
<tr>
<th>Name of culture/variety</th>
<th>Mean Grain yield (t/ha)</th>
<th>Mean Straw yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2008 a</td>
<td>2009</td>
</tr>
<tr>
<td>JK 70 (Ezhome-1)</td>
<td>3.45</td>
<td>3.40</td>
</tr>
<tr>
<td>Kuthiru (local check)</td>
<td>2.12</td>
<td>1.93</td>
</tr>
</tbody>
</table>

a Pooled over 8 locations; b Pooled over 5 locations.

Table 3. Mean grain yield of ‘Ezhome-1’ in National Saline Alkaline Screening trials of AICRP.

<table>
<thead>
<tr>
<th>Name of culture/variety</th>
<th>Mean yield under different situations(Kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IET No</td>
</tr>
<tr>
<td>‘Ezhome-1’</td>
<td>22604</td>
</tr>
<tr>
<td>Coastal check (CST 7-1)</td>
<td>--</td>
</tr>
</tbody>
</table>

a Mean of 4 locations (Kanpur, Karnal, Karaikal & Lucknow).

b Mean of 4 locations (Nawagam, Annamalainagar, Trichy & Masodha).

c Mean of 3 locations (CRRI, Canning & Machilipatnam).

d Mean of 3 locations (Chinsurah, Panvel & Navasari).

e Mean of 2 locations (Karnal & Gangavati).

A peculiarity of ‘Ezhome-1’ unlike traditional land race (male parent of ‘Ezhome-1’) is that it performs well in non-saline wetland tract also, with an average grain yield of 5.0 - 6.0 t/ha under organic management with the same duration as that in Kaipad fields, 135 - 140 days and 110 - 115cm height during the Kharif season. The gene recombination due to hybridization might have changed the genetic assembly from stress induced yield enhancement to epigenetic yield enhancement. In addition to the resistant nature of ‘Ezhome-1’ to the tidal flood condition of saline Kaipad, it can tolerate flooded/submerged conditions of non-saline wetland tracts immediately after sprouting and at early seedling stages during the Kharif season with an average grain yield of 4.0 t/ha under organic management.

At seedling stage submergence it decays at the beginning but later rejuvenates when the water level subsides. Another special trait of ‘Ezhome-1’ is that it shows reduced duration of 90-95 days, reduced height (70-75cm) and comparatively less yield (2.5 - 3.0 t/ha under organic management) during the Rabi season which is preferred by those farmers who need a short duration variety in the areas where there is a water shortage.
Cooking and nutritive qualities

As quality is more important in organic agriculture, the cooking and nutritive qualities of the variety is evaluated in detail. Sensory evaluation for cooking qualities showed that ‘Ezhome-1’ possesses superior taste and appearance as cooked rice appealing to both consumers and millers. Cooking and nutritive traits of ‘Ezhome-1’ are given in Table 4. Most of the cooking qualities are on par with the traditional land race ‘Kuthiru’.

Table 4. Cooking and nutritive qualities of ‘Ezhome-1’.

<table>
<thead>
<tr>
<th>Item</th>
<th>Ezhome-1 (Cul. JK70)</th>
<th>Kuthiru (Kaipad check)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooking qualities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume expansion</td>
<td>3.4</td>
<td>3.5</td>
</tr>
<tr>
<td>Kernel elongation ratio</td>
<td>1.45</td>
<td>1.52</td>
</tr>
<tr>
<td>Water uptake</td>
<td>1.60</td>
<td>1.69</td>
</tr>
<tr>
<td>Cooking time required (minutes)</td>
<td>47</td>
<td>49</td>
</tr>
<tr>
<td>Alkali spreading value</td>
<td>4.3</td>
<td>4.0</td>
</tr>
<tr>
<td>Amylose content</td>
<td>26.4</td>
<td>25.0</td>
</tr>
<tr>
<td>Taste, texture, aroma and appearance of cooked rice as per sensory evaluation</td>
<td>Delicious and non-sticky like ‘Kuthiru’. Color, texture, flavor, and appearance are more acceptable and appealing than ‘Kuthiru’. Cooked rice is swollen and tender unlike the split and hard nature of that of ‘Kuthiru’.</td>
<td>Delicious with acceptable and appealing appearance, and non-sticky. Cooked rice is hard and split.</td>
</tr>
<tr>
<td>Nutritive qualities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe content (mg/Kg)</td>
<td>59.8</td>
<td>121</td>
</tr>
<tr>
<td>Zn content (mg/Kg)</td>
<td>12.9</td>
<td>21.1</td>
</tr>
<tr>
<td>Ca (mg/Kg)</td>
<td>194</td>
<td>154</td>
</tr>
<tr>
<td>K (mg/Kg)</td>
<td>10519</td>
<td>8359</td>
</tr>
<tr>
<td>Crude fiber (% by wt.)</td>
<td>10.6</td>
<td>10.7</td>
</tr>
</tbody>
</table>

The cooking qualities of the traditional land race ‘Kuthiru’ is very much appreciated by the Kaipad farmers. Cooked rice of ‘Ezhome-1’ is delicious and non-sticky like ‘Kuthiru’. Colour, texture, flavour, and appearance are more acceptable and appealing than ‘Kuthiru’ (Table 4). Cooked rice is swollen and tender unlike the split and hard nature of that of ‘Kuthiru’. The nutrient quality analysis showed that ‘Ezhome-1’ possesses a higher content of Ca and K than the traditional land race, ‘Kuthiru’. Fe and Zn content are greater in the traditional land race (Table 4).
Pest and disease resistance

There is no incidence of pests and diseases in the saline Kaipad ecosystem, this may be partly due to the high potassium content of soil and salinity induced biotic stress tolerance. When screened at wet land conditions of RARS Pattambi it is revealed that ‘Ezhome-1’ is resistant to some pests (gall midge, leaf folder and case worm) and moderately resistant to others pests (whorl maggot, stem borer, blue beetle) and diseases (sheath blight, blast and bacterial leaf blight) (Tables 5 & 6).

Table 5. Reaction of Cultures JK 70(‘Ezhome-1’ to important pests when screened at non-saline wet land condition of RARS, Pattambi.

<table>
<thead>
<tr>
<th>Culture/ Local variety</th>
<th>Gall midge (%) SS</th>
<th>Leaf folder (% DL)</th>
<th>Whorl maggot (% DL)</th>
<th>Case worm (% DL)</th>
<th>Stem borer (% WE)</th>
<th>Blue beetle (% DL)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 DAT</td>
<td>50 DAT</td>
<td>30 DAT</td>
<td>50 DAT</td>
<td>30 DAT</td>
<td>50 DAT</td>
</tr>
<tr>
<td>JK 70(‘Ezhome-1’)</td>
<td>0</td>
<td>7.5</td>
<td>0.62</td>
<td>3.0</td>
<td>13.5</td>
<td>5.4</td>
</tr>
<tr>
<td></td>
<td>30 DAT</td>
<td>50 DAT</td>
<td>30 DAT</td>
<td>50 DAT</td>
<td>30 DAT</td>
<td>50 DAT</td>
</tr>
<tr>
<td>Kuthiru(local land race)</td>
<td>0</td>
<td>4.6</td>
<td>1.90</td>
<td>6.3</td>
<td>22.2</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>30 DAT</td>
<td>50 DAT</td>
<td>30 DAT</td>
<td>50 DAT</td>
<td>30 DAT</td>
<td>50 DAT</td>
</tr>
</tbody>
</table>

*In Kaipad ecosystem there is no pest attack; < 10% infection = resistant; 10 - 30% infection = moderately resistant; > 30% infection = susceptible.

Table 6. Reaction of ‘Ezhome-1’to important diseases when screened at non-saline wet land condition of RARS, Pattambi.

<table>
<thead>
<tr>
<th>Culture/ Local variety</th>
<th>Sheath blight</th>
<th>Brown spot</th>
<th>BLB</th>
<th>Blast</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Ezhome-1’</td>
<td>3.0</td>
<td>3.7</td>
<td>1.7</td>
<td>3.0</td>
</tr>
<tr>
<td>Kuthiru</td>
<td>1.0</td>
<td>4.0</td>
<td>1.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Score 1 = resistant., Score 2 & 3 = moderately resistant., (20% infection = score 5; 10% infection = score 3).

Besides the proven yield potential, pest and disease tolerance, and other desirable characteristics of ‘Ezhome-1’ to saline and flooded areas, it possesses desirable grain qualities including awn-less, fair shattering and medium bold grains, unlike the awned, shattering and bold grains of traditional landraces.

Salient characteristics of ‘Ezhome-1’

Agronomic and physico-chemical traits of ‘Ezhome-1’ in comparison with the Kaipad land race, ‘Kuthiru’, are given in Table 7. As it is an organic variety developed for a naturally organic tract adopting the concepts and strategies of organic plant breeding, when we do cultivation in non-saline Kaipad tract, the management should be organic. It is a long duration variety (130-135days) having high grain and straw yield with a high harvest index and tolerant to low to medium salinity (4-6 dS m⁻¹).

Unlike ‘Kuthiru’, it has intermediate plant stature (110cm) (Figure 1) with strong and sturdy culm with wide angle orientation, and hence tolerant to lodging. Panicle is compact
Vanaja, Neema, Mammootty, Balakrishnan & Jayaprakash Naik

with 150 grains panicle\(^{-1}\). Healthy flag leaf and stay green index during reproductive stage shows its photosynthetic ability and efficient source sink relationship.

Table 7. Agronomic and physico-chemical traits of ‘Ezhome-1’ in comparison with local land race, ‘Kuthiru’ of the Kaipad ecosystem.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>‘Ezhome-1’</th>
<th>‘Kuthiru’ (Lodging Kaipad land race)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average grain yield (t/ha):</td>
<td>3.5</td>
<td>2.2</td>
</tr>
<tr>
<td>In saline Kaipad soil during Kharif</td>
<td>6.0</td>
<td>Not cultivated</td>
</tr>
<tr>
<td>In non-saline wetland Kharif Rubi</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>Straw yield (t/ ha)</td>
<td>13.74</td>
<td>6.45</td>
</tr>
<tr>
<td>Harvest index</td>
<td>0.35</td>
<td>0.25</td>
</tr>
<tr>
<td>Plant height (cm)</td>
<td>100-110</td>
<td>140-145</td>
</tr>
<tr>
<td>Kharif</td>
<td>75-85</td>
<td>NA</td>
</tr>
<tr>
<td>Rubi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration (days)</td>
<td>135-140</td>
<td>120-125</td>
</tr>
<tr>
<td>Kharif</td>
<td>90-95</td>
<td>NA</td>
</tr>
<tr>
<td>Rubi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of tillers plant(^{1})</td>
<td>18-20</td>
<td>7-10</td>
</tr>
<tr>
<td>No. of panicles plant(^{1})</td>
<td>21 – 23</td>
<td>10 – 13</td>
</tr>
<tr>
<td>Panicle length (cm)</td>
<td>25.5</td>
<td>27.1</td>
</tr>
<tr>
<td>Panicle type</td>
<td>Compact</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Grains panicle (^{-1})</td>
<td>150</td>
<td>90</td>
</tr>
<tr>
<td>1000 grain weight (g)</td>
<td>29.2</td>
<td>21.2</td>
</tr>
<tr>
<td>Lodging habit</td>
<td>Non-lodging because of strong and sturdy culm</td>
<td>Staggered lodging at the time of flowering on all sides because of its poor culm strength and excessive culm length</td>
</tr>
<tr>
<td>Kernel colour</td>
<td>Red</td>
<td>Red</td>
</tr>
<tr>
<td>Lemma and palea colour</td>
<td>Straw</td>
<td>Brown furrows on straw back ground</td>
</tr>
<tr>
<td>Awning</td>
<td>Awn less</td>
<td>Long &amp; partly awned</td>
</tr>
<tr>
<td>Shattering</td>
<td>Fair shattering</td>
<td>Highly shattering</td>
</tr>
<tr>
<td>Hulling %</td>
<td>79.1</td>
<td>81.1</td>
</tr>
<tr>
<td>Milling % (in lab)</td>
<td>76.9</td>
<td>74.8</td>
</tr>
<tr>
<td>(in commercial mill)</td>
<td>69.0</td>
<td>60.7</td>
</tr>
<tr>
<td>Head rice recovery %</td>
<td>62.0</td>
<td>68.9</td>
</tr>
<tr>
<td>Length of grain (L) (mm)</td>
<td>8.2</td>
<td>8.7</td>
</tr>
<tr>
<td>Breadth of grain (B) (mm)</td>
<td>3.0</td>
<td>2.3</td>
</tr>
<tr>
<td>L/B ratio</td>
<td>2.76</td>
<td>2.63</td>
</tr>
<tr>
<td>Classification</td>
<td>Medium</td>
<td>Medium</td>
</tr>
</tbody>
</table>

*In Kaipad ecosystem due to branching habit of tillers, number of panicles are seen more than tillers.
Figure 1. Ezhome-1 rice crop in Kerala.

Conclusion

One of the major reasons some farmers have moved away from the Kaipad tidal farming ecosystem has been the unfavourable characteristics of the locally available cultivars. ‘Ezhome-1’, the first high yielding rice variety, with favourable grain, cooking and nutritional qualities, suited to this saline prone naturally organic tract. It is equally suitable and high yielding in non-saline flooded as well as non flooded wetlands during Kharif season. The non-lodging nature of the variety helps in easy harvest both manually and using machine. Its reduction of duration from 135days during Kharif to 90 days during Rabi, makes it suitable as a crop in areas where there is shortage of water during the third crop season.

The entire development stages of the variety were conducted in farmers’ fields adopting Participatory Plant Breeding. This emerging strategy in the area of plant breeding to integrate end user based participatory approach involves close farmer-researcher collaboration to bring about plant genetic improvement within a crop, and the farmers are very much convinced about the yield potential and suitability of this variety to Kaipad saline flooded conditions. Farmer participation ensured revival of rice cultivation in Kaipad without much extension effort and helped in easy and early adoption of the variety. As there are increasing demands for organic rice across the world market, development of this type of rice variety, suited to organic production systems, is timely.

Development and commercial release of the high yielding ‘Ezhome-1’ rice variety of Kaipad contributes to transforming these vast, less productive, saline prone, naturally organic tracts into an arable and highly productive farming land which will lead to enhancement of nutritional and livelihood security, in addition to aiding the food security of small and marginal farmers of rural Kerala. This project demonstrates the value of breeding varieties specifically suited to organic agriculture and in involving farmers in the process.
Acknowledgements

We gratefully acknowledge Dr. P. Raji and Dr. K. Karthikeyan of RARS, Pattambi of Kerala Agricultural University for disease and pest screening.

References


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Soil microbial counts and the performance of lowland rice (Oryza sativa L) under two water regimes and two organic soil amendments

Ngawang Chhogyel1,4,*, Oscar B. Zamora2 & late Bayani M. Espiritu3

1 Graduate School, University of the Philippines, Los Banos, Philippines; 2 Crop Science Cluster, University of the Philippines Los Banos, Philippines; 3 Agricultural Systems Cluster, University of the Philippines Los Banos, Philippines; 4 RDC Bajo, Department of Agriculture, MoAF, Royal Government of Bhutan.

* email: cngawang11@gmail.com

Abstract
A field experiment was conducted at the University of the Philippines, Los Banos, Philippines from September 2010 to January 2011 to evaluate soil microbial counts and the performance of lowland rice under two water management regimes and organic soil amendments. Organic amendments had positive effects on grain yield. Cow manure and mungbean green manure produced a grain yield of 3.62 t ha⁻¹ and 3.45 t ha⁻¹ respectively which was significantly higher than the unfertilized control (3.10 t ha⁻¹). The NPK chemical fertilizer applied at 120-30-30 t ha⁻¹ gave a grain yield of 4.90 t ha⁻¹, which was higher than those obtained from the two organic fertilizers. The organic fertilizers had significant positive effects on the microbial counts (bacteria, fungi and actinomycetes) which play a key role in nutrient cycling and improvement of soil quality. On the other hand, owing to the improved rooting environment, non-flooded treatment favoured higher production of productive tillers compared to the flooded treatment. This resulted in better crop performance in terms of crop growth, development and yield attributes compared to its flooded counterpart. Though flooding treatment is generally considered detrimental to crop performance, the application of organic amendments augmented crops with positive crop responses in terms of grain yield and its components. The flooded treatment resulted in a grain yield of 3.65 t ha⁻¹ with cow manure and 3.58 t ha⁻¹ with mungbean green manure treatments. This indicated that the management of water and organic amendments in lowland rice farming could lead to sustainable soil and farm productivity, which could potentially avert the degradation of natural resources.

Keywords: crop growth, grain yield, flooding and non-flooding water treatment, microbes, organic sources.

Introduction
Organic agriculture in the Philippines accounts for 96,317 hectares which is 0.81% of its agricultural land (Willer, Lernoud & Kilcher, 2013). Although it has started off a low base, there has been a rapid uptake of organic agriculture in the Philippines, with organically managed hectares increasing over 550 times over a decade, with only Uruguay and India
having a faster uptake over the decade (Paull, 2011). Organic farming systems aim at maintaining soil and water resources in order to sustain soil fertility and crop yield. With an increasing demand for rice and a decline in soil quality and productivity, tropical lowland rice soils are an intensively exploited soil resource.

The technology farming systems developed to achieve higher levels of production to meet market demands have led to the development of high yielding crop varieties that are highly responsive to external inputs of chemical fertilizers and water resources (IRRI, 2008). This has serious ecological, economic and social repercussions on poor farmers especially on those of the underdeveloped and developing countries. Modern farming has resulted in environment degradation and loss of soil quality which play a significant role in sustaining farm productivity. The consequences of modern chemical-based crop intensification have driven, as a response, the adoption of organic production principles and practices which emphasize the protection of soil, plant, animal and human health while ensuring sustained food production for the present and future generations (Willer et al., 2013).

Organic rice production systems use organic soil amendments which help maintain soil fertility and support soil biological diversity that in turn generates the bulk of soil organic matter (SOM) that is indispensable for the promotion of growth environment, nutrient cycling and plant growth. The integrated interactions of soil organisms and SOM improve the rhizosphere ecosystem and increase the diversity of beneficial organisms promoting root growth (PCARRD, 2008; Uphoff & Kassam, 2009). Soil quality and soil health are most often related to organic matter which are the source of food for soil microbes which in turn interact with soil animals in the biotransformation of organic material into the soil nutrient pool.

Compost and other organic amendments are a valuable source of plant nutrients and soil organic carbon. SOM supports efficient plant growth and development by releasing nutrients through the decomposition process. It helps supply essential plant nutrients required by the crop (SIPPO, 2002). Research on the use of organic sources such as green manures, composts, farm yard manures, poultry manures, vermicompost, etc. have yielded beneficial results in rice production (Mao, 2000; Naing et al., 2010; Sarwar, et al., 2008). Mungbean and Sesbania green manure has been extensively used for increasing rice yield as well as for improving the soil. The addition of organic soil amendments has produced increased nutrient status of soil and improvements in crop yield. Positive responses of rice yield to organic manure application have been reported (Naing et al., 2010; Sarwar, 2008; Myers, 2000; SIPPO, 2002).

Crop response to flooded and non-flooded water conditions could be affected by the type and levels of organic treatments. Under flooded condition, reduced levels of oxygen could impair root growth and physiological processes (Uphoff 2006; Dobermann, 2003). Under non-flooded conditions, there will be more oxygen for better rooting characteristics that help increase efficiency in the uptake of water and minerals with increased metabolism. Use of organic amendments with improved water management has shown positive effects on crop performance as well as on soil properties (SIPPO, 2002; Uphoff, 2006; Doberman, 2003; Uphoff & Kassam, 2009). Escasinas (2009) has reported that non-flooded water management in rice has resulted in higher grain yield in addition to saving water.
Chhogyel, Zamora & Espiritu

Organic crop production also offers scope for climate change adaptive practices. It has the potential to reduce air pollution, sequester CO$_2$, enhance water availability, and improve soil through the recycling of organic residues. Soils rich in organic matter can contribute to achieving climate-change mitigation objectives by improving input use efficiency through its integrated effect on soil properties and substitution of chemical fertilizers. This experiment set out to evaluate the performance of lowland rice and soil microbial counts under two water regimes and two different organic fertilizer sources.

Materials and Methods

A field experiment was conducted at the Central Experiment Station, UP Los Banos (Philippines) from September 2010 to January, 2011. The experiment was conducted at two separate experimental areas:

(1) at an organically maintained field which was reserved exclusively for experiments related to organic farming by the University which does not allow the use of chemical fertilizers; and

(2) at a chemical field (adjacent to the organic field) where chemical farming practices have been used for long period of time.

Basic soil properties of the chemical and organic fields are presented in Table 1.

The design of the experiment was a split-plot in a randomized complete block design (RCBD) with three replications and plot sizes of 5 x 10 m$^2$. The experiment involved a series of destructive plant samplings and the plot size facilitated operations such as harrowing or rotovation of the plots at the time of transplanting. The two water regimes (flooded and non-flooded/saturated conditions) were laid as the main plots, while fertilizer sources (cow manure and mungbean green manure for the organically managed field & cow manure, mungbean green manure, and synthetic fertilizer for the chemically managed field) were the sub-plots. The individual treatment plots were separated by a thick bund (45cm broad bunds) with 25-30 cm riser height to prevent the intrusion of water and nutrients into adjacent plots. The results of the experiment were analyzed using ANOVA, and comparison among treatment means were based on Least Significant Difference (LSD) at 5% level using linear model of SAS version 9.1.

Table 1. Basic soil status of the organic and chemical fields (plots) used in the experiment.

<table>
<thead>
<tr>
<th>Basic soil properties</th>
<th>Organic field</th>
<th>Chemical field</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>5.6</td>
<td>5.6</td>
</tr>
<tr>
<td>N %</td>
<td>0.23</td>
<td>0.2</td>
</tr>
<tr>
<td>P ppm</td>
<td>3.7</td>
<td>2.26</td>
</tr>
<tr>
<td>K cmol</td>
<td>0.93</td>
<td>0.8</td>
</tr>
<tr>
<td>OM %</td>
<td>4.39</td>
<td>3</td>
</tr>
<tr>
<td>CEC cmol+/kg</td>
<td>38.26</td>
<td>37</td>
</tr>
</tbody>
</table>

Experimental materials

An early maturing rice variety, NSIC RC-144 (103 days after sowing (DAS)), non-photoperiodic, short statured, high yielding commercial rice variety was used in the
experiment. This is a rice variety that has been selectively bred to perform under synthetic chemical management.

Decomposed cow manure and mungbean green manure were used as organic sources in the study. The farmyard manure was applied at 4.79 t ha\(^{-1}\) at 10 days prior to transplantation. Mungbean was seeded at the rate of 60 kg ha\(^{-1}\) and grown for 35 days, then chopped and plowed into the soil and left for 10 days before the transplanting of rice. The herbage yield from the mungbean was 20 kg/plot which is equivalent to 4.0 t/ha. Before transplanting, the plots were harrowed using a rotary tiller machine. NPK Nutrient content of the cow manure and mungbean green manure used in the experiment is presented in Table 2.

Table 2. NPK Nutrient content of the organic fertilizers.

<table>
<thead>
<tr>
<th>Organic manure</th>
<th>N(%)</th>
<th>P(%)</th>
<th>K(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow manure</td>
<td>2.5</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Mungbean green manure</td>
<td>2.67</td>
<td>0.37</td>
<td>3.43</td>
</tr>
</tbody>
</table>

**Cultural management practices**

The nursery was raised using the wet bed method and the seedlings were grown for 21 days and were then transplanted into the field spaced at 20 x 20 cm with two plants per hill. Land preparation and application of organic amendments were done 10 days prior to transplanting of rice. Full P and K basal doses and one third of N were applied 10 days after transplanting while the rest of the N split doses were applied at mid-maximum tillering stage (35-40 DAT) and panicle initiation (50-55 DAT) as top dressing. Weeding was done manually starting from three weeks of transplanting.

**Soil Sampling and Analysis**

Random soil samples were collected from the field from a depth of 0-20 cm for analysis. The soil samples were processed and analyzed at the Soil and Agro-ecosystems Laboratory, Agricultural Systems Cluster of the University of the Philippines, Los Baños following standard procedures and methods.

Soil analysis for microbes (bacteria, fungi and actinomycetes) were carried out using the Most Probable Number (MPN) method in which dilution and plating techniques were used involving microbial growth media viz. nutrient broth, dextrose agar and glycerol agar for bacteria, fungi and actinomycetes, respectively. Microbial colony forming units (cfu) of fungi, actinomycetes, and bacterial growth were detected after incubating for 5-7 days. Microbial count and changes in microbe populations were studied at three different crop stages, at transplanting, active tillering, and after the harvest.

**Results**

**Total dry matter production (TDM)**

The application of different fertilizers had a highly significant affect on TDM production in both the organic and chemical plots. Until 25 days after transplanting (DAT), there was no significant difference in TDM production among the fertilizer treatments but significant differences were observed from 35 DAT onwards (Figures 1 & 2). From 35 to 77 DAT, there was significant increase in TDM but started to decline at 77 DAT in both the fields.
Plants with cow manure had a significantly higher TDM than those with mungbean green manure and the control in the organic field. On the other hand, chemical fertilizers resulted in higher TDM over the other fertilizer sources. Similarly, there was a significant effect of the two water regimes on TDM production (Table 3). Flooding had a negative effect on the TDM. The interaction between water regimes and organic fertilizer sources was not significant.

Figure 1. Total dry matter production as influenced by different fertilizers at various growth stages in the organic field. Vertical bars show LSD (p=0.05).

Figure 2. Total dry matter production as influenced by different fertilizers at various growth stages in the chemical field. Vertical bars show LSD (p=0.05).
Crop growth rate (CGR)

The influence of different fertilizer sources on CGR was highly significant in both organic and chemical treatments at 35-49 DAT and 49-63 DAT (Figures 3 & 4). After 49-63 DAT, there was a gradual decline in CGR but the organic sources resulted in significantly higher CGR as compared to the unfertilized control in the organic field (Figure 3). The highest CGR values obtained in the present experiment were 33.0 g m\(^{-2}\) d\(^{-1}\) for the plots in the organic plots applied with cow manure and 34.6 g m\(^{-2}\) d\(^{-1}\) for the plots in the chemical field applied with chemical fertilizer. Chemical fertilizer and cow manure did not show a significant difference but chemical fertilizer gave the highest values of CGR in the experiment.

The GCR also showed a significant response to water management at 35-49 and 49-63 DAT (Table 4) in the organic field, and a similar pattern was exhibited in the chemical field. The interaction between fertilizer treatments and two water regimes did not show any significant effect.

![Figure 3](image-url)

**Figure 3.** Crop growth rate as affected by different fertilizers at different growth stages for organic field. Vertical bars shows LSD (p=0.05).

Table 3. Plant total dry matter (TDM) production (g m\(^{-2}\) d\(^{-1}\)) as influenced by two different water management measures in organic and chemical fields*.

<table>
<thead>
<tr>
<th>Water management</th>
<th>49 DAT</th>
<th>63 DAT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organic field</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flooded condition</td>
<td>551.17b</td>
<td>805.94a</td>
</tr>
<tr>
<td>Saturated condition</td>
<td>619.72a</td>
<td>835.03a</td>
</tr>
<tr>
<td>Pr&gt;F</td>
<td>0.0459</td>
<td>0.0593</td>
</tr>
<tr>
<td><strong>Chemical field</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flooded condition</td>
<td>581.70b</td>
<td>818.30b</td>
</tr>
<tr>
<td>Saturated condition</td>
<td>633.00a</td>
<td>857.50a</td>
</tr>
<tr>
<td>Pr&gt;F</td>
<td>0.0416</td>
<td>0.0374</td>
</tr>
</tbody>
</table>

*Column means followed by a common letter are not significantly different at 5% LSD level.
Figure 4. Crop growth rate as affected by different fertilizers at different growth stages for chemical field. Vertical bars shows LSD (p=0.05).

Table 4. Crop growth rate (g m\(^{-2}\) d\(^{-1}\)) as influenced by water management in the organic field*.

<table>
<thead>
<tr>
<th>Water management</th>
<th>35-49 DAT</th>
<th>49-63 DAT</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flooded condition</td>
<td>28.4b</td>
<td>15.78d</td>
<td>22.09</td>
</tr>
<tr>
<td>Saturated condition</td>
<td>32.78a</td>
<td>19.66c</td>
<td>26.22</td>
</tr>
<tr>
<td>Mean</td>
<td>30.59</td>
<td>17.72</td>
<td></td>
</tr>
<tr>
<td>Pr&gt;F</td>
<td>0.0500</td>
<td>0.0475</td>
<td></td>
</tr>
</tbody>
</table>

*Means followed by common letters within the columns and across rows are not significantly different based on LSD 5% level.

**Microbial counts**

Populations of microbes (bacteria, fungi and actinomycetes) differed both with water and fertilizer treatments during different crop stages (at transplanting, active tillering and after the harvest). Use of cow manure and mungbean green manure had a significant effect on the soil microbial population which forms the most basic and most important component in the organic residue mineralization. At all the three crop stages, bacteria were the most dominant microbe and the least was the fungi (Figure 5). The trends in population changes in both fields were similar.

In the organic plots, the microbial populations were much higher than those in the chemical plots. The differences were more pronounced under non-flooded (saturated) conditions as compared to the flooded conditions. At tillering stage in the organic plots, the bacterial, fungal and actinomycete populations were 3.64 \times 10^7, 4.46 \times 10^6, and 3.81 \times 10^6 cfus under flooded condition while it was 4.29 \times 10^7, 6.19 \times 10^6, and 5.92 \times 10^6 cfus under non-flooded conditions. The bacterial, fungal and actinomycete population at the same crop stage in the chemical plots were 4.38 \times 10^7, 3.79 \times 10^6 and 2.82 \times 10^6 cfus.
under flooded condition with $3.83 \times 10^7$, $5.28 \times 10^5$ and $4.93 \times 10^6$ cfus under the non-flooded condition.

Figure 5. Change in microbial populations with growth stage of rice as affected by the application of different fertilizer treatments (a=bacteria, b=fungi and c= actinomycetes).

The microbial populations after the crop harvest were higher in the organic plots under both flooded and non-flooded conditions (Table 5). Thus, saturated treatment favoured microbial growth resulting in significantly higher microbe populations than those of the flooded treatments at both the active tillering stage and after crop harvest. There was a significant reduction in microbial populations from the initial to active tillering stage, then followed by a sharp rise after harvest (Figure 5).
Table 5. Microbial populations at tillering and after harvest as affected by water management in organic and chemical fields*.

<table>
<thead>
<tr>
<th>Water management</th>
<th>Tillering stage (cfu g⁻¹)</th>
<th>After the harvest (cfu g⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bacteria (x10⁷)</td>
<td>Fungi (x10⁵)</td>
</tr>
<tr>
<td>Organic field</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flooded condition</td>
<td>3.64b</td>
<td>4.46b</td>
</tr>
<tr>
<td>Saturated condition</td>
<td>5.29a</td>
<td>6.19a</td>
</tr>
<tr>
<td>LSD</td>
<td>1.30</td>
<td>1.70</td>
</tr>
<tr>
<td>Chemical field</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flooded condition</td>
<td>4.38a</td>
<td>3.79b</td>
</tr>
<tr>
<td>Saturated condition</td>
<td>3.83a</td>
<td>5.28a</td>
</tr>
<tr>
<td>LSD</td>
<td>4.96</td>
<td>2.16</td>
</tr>
</tbody>
</table>

*Column means followed by same letters are not significantly different at 5% LSD level.

Grain Yield and yield components

There was a highly significant effect of different fertilizer treatments on the grain yield and its components in both the organic and chemical plots. In the organic plots, cow manure and mungbean green manure gave grain yields of 3.62 t ha⁻¹ and 3.45 t ha⁻¹ respectively. The grain yield from these two organic fertilizer sources were 3.25 t ha⁻¹ and 3.34 t ha⁻¹ in the chemical plots. Cow manure and mungbean green manure, gave significantly higher grain yields than the unfertilized controls (Table 6). Chemical fertilizer application in the chemical plot resulted in the highest grain yield at 4.9 t ha⁻¹.

Table 6. Grain yields (t ha⁻¹) and yield components as affected by different fertilizers under organic and chemical fields*.

<table>
<thead>
<tr>
<th>Plots</th>
<th>No of panicles hill⁻¹</th>
<th>1000 grain weight (g)</th>
<th>Productive tillers hill⁻¹</th>
<th>Grain yield (t ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic plot</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cow manure</td>
<td>14.80a</td>
<td>25.61a</td>
<td>13.66a</td>
<td>3.62a</td>
</tr>
<tr>
<td>Green manure</td>
<td>13.50a</td>
<td>24.47a</td>
<td>12.33a</td>
<td>3.45a</td>
</tr>
<tr>
<td>Control</td>
<td>9.80b</td>
<td>22.43b</td>
<td>8.33b</td>
<td>3.10b</td>
</tr>
<tr>
<td>LSD</td>
<td>1.747</td>
<td>4.239</td>
<td>2.389</td>
<td>0.179</td>
</tr>
<tr>
<td>Chemical plot</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cow manure</td>
<td>14.20b</td>
<td>26.66b</td>
<td>13.33ab</td>
<td>3.25b</td>
</tr>
<tr>
<td>Green manure</td>
<td>12.80b</td>
<td>26.86b</td>
<td>11.33b</td>
<td>3.34b</td>
</tr>
<tr>
<td>Chemical fertilizer</td>
<td>18.60a</td>
<td>30.06a</td>
<td>15.16a</td>
<td>4.96a</td>
</tr>
<tr>
<td>Control</td>
<td>9.50c</td>
<td>19.60c</td>
<td>9.00c</td>
<td>2.85c</td>
</tr>
<tr>
<td>LSD</td>
<td>2.40</td>
<td>2.825</td>
<td>1.839</td>
<td>0.492</td>
</tr>
</tbody>
</table>

*Column means followed by common letters in a column within plots are not significantly different at 5% LSD level under different parameters.

The yield response to water treatment was significant and the non-flooded condition had higher values of productive tillers and 1000 grain weight which contribute to ultimate grain yield (Table 7). The cow manure and green manure under non-flooded condition registered a grain yield of 3.65 t ha⁻¹ and 3.58 t ha⁻¹ whereas the two fertilizer sources resulted to just 3.59 t ha⁻¹ and 3.32 t ha⁻¹ under the flooded water regime (Table 7).
Table 7. Percent filled grains and grain yield (t ha⁻¹) as affected by two different organic fertilizer sources and water management treatments.

<table>
<thead>
<tr>
<th>Fertilizer sources</th>
<th>% Filled grains</th>
<th>Grain yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flooded condition</td>
<td>Non-flooded condition</td>
</tr>
<tr>
<td>Cow manure</td>
<td>82bc</td>
<td>87a</td>
</tr>
<tr>
<td>Green manure</td>
<td>78cd</td>
<td>84ab</td>
</tr>
<tr>
<td>Control</td>
<td>71de</td>
<td>75cd</td>
</tr>
<tr>
<td>LSD</td>
<td>7.061</td>
<td>0.179</td>
</tr>
</tbody>
</table>

*Column means followed by a common latter are not significantly different at 5% LSD level under different parameters.

Discussion

**Total dry matter (TDM) production**

Significantly higher TDM in cow manure as compared to those with mungbean green manure and the control in the organic field showed that organic manure has potential for increasing grain yield in lowland rice. Rahman et al (2007) have also showed that proper manuring produced maximum plant dry matter with luxuriant growth and highest number of tillers plant⁻¹ in rice. The lower initial crop response to different organic fertilizers at early growth stage could be due to initial transplantation shock and delay in decomposition and release of nutrients from the organic sources of fertilizers. From 35 to 77 DAT, the significant increase in TDM production could be due to active vegetative growth and tillering. There was a reduction in TDM at the later growth stages contributed by rapid senescence of leaves coupled with a decline in photosynthetic efficiency of older leaves.

In the chemical field, chemical fertilizers with readily available NPK had supported plants with higher TDM over the rest of the fertilizer treatments. This TDM production was highest with 1259.75 g m⁻² (Figure 2). Application of N fertilizers improved dry matter production and overall plant performance in rice (Amin et al, 2006).

Flooding at different growth stages significantly reduced TDM compared to the non-flooded saturated field. The significantly higher TDM under non-flooded condition could be attributed to increased production of tillers. Under such conditions, rice produces more tillers increasing biomass and subsequently contributing to grain yield. Keeping the soil saturated but not flooded continuously in the SRI production system resulted in increased plant biomass production with increased number of tillers (Uphoff & Kassam, 2009; Uphoff, 2006; Sato, 2005). This led to increased LAI (Zulkarnain et al, 2009) increasing efficiency in harvesting solar radiation. Maximum difference between water treatments in TDM was obtained at 45 DAT and 63 DAT which coincided with maximum tillering and increased crop growth in both the organic and chemical fields (Table 3).

The lowest TDM in both cases were recorded in the unfertilized control. TDM production is a function of photosynthetic efficiency of plants which determine the ultimate grain yield, and is affected by various factors such as genetic, nutritional, temperature and environmental factors. Grain yield in rice increases with enhanced dry matter production (Wu et al, 2008; Amin et al, 2006; Hasanuzzaman et al, 2010).
Crop growth rate
The higher crop growth rate at the initial stages (35-49 and 49-63 DAT) of growth could be due to the full development of plant canopy and attainment of reproductive age. Rice plants showed reduced CGR at a later stage coinciding with grain filling and gradual senescence of older leaves. The decline in CGR after attaining maximum values towards crop maturity is due to tiller mortality and leaf senescence (Hasanuzzaman et al, 2010). A lower CGR in mungbean as compared to two other fertilizer sources could be attributed to lower biomass production. Continuous rain during the cropping period hampered growth and development of mungbean. Mungbean was found to be sensitive to waterlogged conditions and it is best suited for rice cultivation with short duration (Toomsan et al, 2000).

The significant difference in CGR at different stages of crop could be due to differences in tillering under flooded and non-flooded saturated conditions. Higher crop biomass corresponded to higher CGR under non-flooded condition with increased tillering. Organic amendments improve the soil physico-chemical properties and biological properties which are directly related to crop growth and its physiological processes (PCARRD, 2008; Uphoff 2002). The crop growth patterns in both the fields were similar.

Microbial counts
Increased populations of bacteria and other microbes are healthy signs of soil quality. One way of improving soil quality is through the application of manures. The higher presence of microbial populations at all three crop stages in organic plots indicated the positive effects of organic manures on the soil quality. This corroborated the findings of Krishnakumar et al (2005) and Tetsuya et al (2010) who showed increased bacterial population in rice paddies when organic manures were applied. Cow manure and mungbean green manures are good sources of nutrients especially N,P,K,S and carbon which are required by the microorganisms (SIPPO,2002; Sarwar, 2008).

Studies on microbes in lowland rice as well as upland conditions revealed that bacteria were the most dominant species (Gaythry, 2002; Mamaril, 2009). The Community Biodiversity Development and Conservation program (CBDC, 2001), a non government organization which initiated various organic programs in the Philippines has reported that green manures were increasingly being used for improving soil through biological nitrogen fixation in lowland rice paddies. It also stated that animal manures were important sources of organic fertilizer with high NPK content and these organic fertilizers were good for growth and multiplication of microorganisms which recycle nutrients required by the plants. At harvest, cow manure was most effective in maintaining microbial populations and it accounted for the highest counts of microbes compared to those of the other fertilizer treatments.

SRI experiments recorded higher total bacterial counts under non-flooded treatments compared to chemical flooding in India (Gaythry, 2006, as cited by Uphoff, 2006). The effect of water management on microbial count during active tillering and after the crop harvest indicated that chemical flooding is detrimental for growth of soil microorganisms while non-flooded soil condition with organic manure resulted to higher microbial counts. Flooding is detrimental for aerobic microbes reducing their population at tillering stage but which rise again after the harvest. The rise in the populations after harvest could be due
to favourable environment and the availability of food sources at that stage due to the residual organic materials.

Organic fertilizers release nutrients at a slow rate making these nutrients available for the microbes even after crop harvest. The absence of standing water coupled with sufficient residual nutrients in soil could favour growth of microbes. According to Satyanarayana et al. (2002), the application of organic materials could result in a substantial amount of residual N and other nutrients in the soil for the succeeding crop which could favour enhanced soil microbial properties. Lower levels of soil microbes in chemical plots as compared to organic plots could be due to intensified chemical farming and its negative effects on soil physico-chemical properties such as poor soil aeration, compaction, loss of structures and depletion of changes in soil nutrient levels.

Higher microbial populations under reduced water condition could promote increased rate of decomposition that could result into better crop growth benefitting from favourable soil microbial properties. In general, there was a gradual change in the populations of microbes indicating phase changes in the soil environment. The nutrient level and environmental conditions could play a crucial role in the growth of microbes implying that healthy soils support microbial growth which has positive effects on the overall plant performance.

**Yield and yield components**

The effects of different fertilizer sources were significant on grain yield and its components. This increased grain yield in both the organic manure and chemical fertilizer applied plots was attributed to significantly higher numbers of panicle hill$^{-1}$, number of productive tillers hill$^{-1}$ and 1000 grain weight than those in the unfertilized control (Table 6). These results corroborate the findings of Sarwar et al. (2007) who showed that farm yard manure has a potential to increase rice and wheat yield in Pakistan. Usman et al. (2003) reported that application of up to 20 t ha$^{-1}$ farmyard manure in lowland rice increased tillering giving maximum panicle bearing heads which was further supported by Naing et al. (2010). Farmyard manure and green manure significantly increased the number of productive tillers in rice and wheat in rice-wheat farming system in Pakistan and also produced heavier grains (Sarwar, 2008) resulting in a significantly higher grain yield over the control.

Mungbean green manure is very feasible for rice offering good nitrogen fixing capacity and short biomass production cycle (Myers et al, 2000). Some researchers have inferred that rice yield response was better when NPK chemical fertilizer was supplemented with organic manures. The overall yield performance involving different fertilizer sources in both organic and chemical plots indicated a narrow yield gap between them. Among the different fertilizer sources, the application of chemical fertilizer in the chemical plots was most effective in increasing the grain yield and its attributes. The variety in the present experiment was developed for its response to chemical fertilizers.

The yield attributes under the two water regimes showed that non-flooded saturated soil conditions favoured higher tillering leading to higher yield than flooded condition. Increased tillering under non-flooded saturated conditions was an important factor governing crop performance. Non-flooding led to better root growth, favouring more tiller production (Uphoff & Randriamiharisoa, 2002). This supposedly led to a parallel increase in the number of productive tillers hill$^{-1}$ with higher 1000 grain weight. All such
positive factors resulted in a higher grain yield under non-flooded condition. The same trend was reported by Uphoff (2001) and Uphoff & Kassam (2009) in their experiments related to SRI. Mao (2000) further supported this view from his experiment involving alternate wetting and drying (AWD) techniques.

The interaction between different fertilizers and water management was significant on grain yield in the organic field. Cow manure in flooded condition gave significantly higher grain yield than the green manure and unfertilized control that were not significantly different from each other. In saturated conditions, the two manures produced statistically similar grain yields but were significantly higher than those of the unfertilized control. Maximum grain yield of 3.59 t ha$^{-1}$ was obtained in those plots applied with cow manure under flooded conditions and 3.65 t ha$^{-1}$ from saturated conditions, whereas from green manure applied plots, grain yields were 3.32 t ha$^{-1}$ in flooded conditions and 3.58 t ha$^{-1}$ in saturated conditions. The lowest grain yield of 2.8 t ha$^{-1}$ was obtained in the unfertilized control condition.

**Conclusion**

Both water management and different fertilizers had significant impacts on the plant growth, development and yield performance of lowland rice. The non-flooded saturated condition resulted to significantly higher values of crop physiological parameters such as TDM production and CGR. The higher values for these parameters under such field conditions could be attributed to increased production of tillers which contribute to increased biomass and subsequently crop yield. These increases were, in turn, attributed to improved rooting environment. Such plant responses in the non-flooded condition indicated better root growth and increased nutrient uptake efficiency leading to higher production of tillers, which in turn positively contributed to better yield components and grain yield.

Cow manure and mungbean green manure as organic fertilizers performed significantly better than the unfertilized control in terms of TDM production, crop growth and yield performance. The effects of the two manures were similar on both physiological and agronomic parameters governing final yield. Cow manure produced the highest grain yield of 3.62 t ha$^{-1}$ while it was 3.45 t ha$^{-1}$ for green manure, and unfertilized control recorded the lowest grain yield of 3.1 t ha$^{-1}$ indicating that organic manures were effective in increasing the grain yield over the control. On the other hand, the application of recommended NPK chemical fertilizer which readily supplies available nutrients had significantly higher grain yield (4.9 t ha$^{-1}$) over those of the organic manures.

Organic fertilizers were superior to NPK chemical fertilizers in terms of their effects on soil microbes which are the indicators of favourable soil quality. Soil organisms play important roles in nutrient recycling through the processes of decomposition and mineralization. Positive effects on these organisms could mean that the organic fertilizers have a huge potential in lowland soil with proper water management strategies. Organic fertilizers could be applied as fertilizer sources to improve the lowland soil fertility without much affecting the crop performance as they could supply plant nutrients through slow release over time.

It should noted that the rice variety used in the present experiment was bred for good performance under a chemical fertiliser regime. Attention could usefully be applied to the selection and breeding of rice varieties specifically suited for growing under organic conditions and considering the requirements of organic agriculture production practices.
Acknowledgements

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Organic farming: The arrival and uptake of the dissident agriculture meme in Australia

John Paull
School of Land & Food, University of Tasmania, Australia
j.paull@utas.edu.au, john.paull@mail.com

Abstract
Just four years elapsed between the coining of the term ‘organic farming’ and the founding of an association devoted to the advocacy of organic farming. The world’s first association devoted to the promotion and proliferation of organic agriculture, the Australian Organic Farming and Gardening Society (AOFGS), was founded in Sydney, Australia, in October 1944. It is a geographically surprising sequel to the coining of the term ‘organic farming’ by Lord Northbourne and its first appearance in war-time Britain. Northbourne’s manifesto of organic farming, Look to the Land, was published in London in May 1940. When the AOFGS published a periodical, the Organic Farming Digest, it was the first association to publish an organics advocacy journal. The present paper addresses the question of how the ‘organic farming’ meme arrived in Australia. Candidates for influencing the founders of the AOFGS were (a) Lord Northbourne’s 1940 book, and/or (b) perhaps the derivative periodical Organic Farming and Gardening published in the USA by Jerome Rodale with its first issue dated May 1942, and (c) perhaps also the earlier book, Biodynamic Farming and Gardening by Dr Ehrenfried Pfeiffer which was published in 1938 in multiple editions (in London, New York, Italy, Switzerland and the Netherlands) which set out to introduce biodynamic agriculture to a broad audience. The archives and records of the AOFGS have not been located, and, in their absence, newspapers of the period 1938 to October 1944 (and through the period of the AOFGS, i.e. October 1944 to January 1955) were searched for references to these three potential sources of influence. Pfeiffer and/or his book received two mentions in the Australian press in the pre-AOFGS period (in 1939 and 1942). Rodale and/or his periodical were not reported in the Australian press in the pre-AOFGS period. Northbourne and/or his book were reported in the Australian press as early as July 1940, and up the founding of the AOFGS, there were 14 Northbourne mentions in the Australian press (all of them favourable or neutral) across four states: South Australia (SA) (n=6); New South Wales (NSW) (n=4); Western Australia (WA) (n=3); and Queensland (QLD) (n=1). The conclusion drawn is that in adopting the term ‘organic farming’, the AOFGS was informed primarily, and perhaps exclusively, by Northbourne’s book Look to the Land.

Keywords: Organic agriculture, biodynamic agriculture, Lord Northbourne, Ehrenfried Pfeiffer, Jerome Rodale, Colonel Harold White, Australian Organic Farming and Gardening Society (AOFGS), Organic Farming Digest, WW2, Sydney.
Introduction

Four years elapsed between the coining of the term ‘organic farming’ and the founding of the world’s first association dedicated specifically to the advocacy of organic farming (Paull, 2008). The term ‘organic farming’ was coined by Lord Northbourne and it first appeared in his manifesto of organic agriculture, Look to the Land, published in London in May 1940 (Figure 1). The book, published in the early days of World War II, introduced the world to not just the term ‘organic farming’ but also to its rationale and philosophy.

A surprising and unexplained event is how and why a term coined in wartime England (WWII) took root half a world away. The Australian Organic Farming and Gardening Society (AOFGS) was founded in Sydney in October 1944. It was the first society in the world to style itself as an ‘organic’ association. It was the first association to publish an ‘organic’ farming periodical (Organic Farming Digest) (Figure 4). The AOFGS was also the first association in the world to develop a set principles of ‘organic farming (Paull, 2008). At the time of writing, no archives of the AOFGS have been located.

Northbourne was well aware that a differentiated agriculture needed a distinctive name and that it needed advocacy. He framed “organic farming” as a dissident agriculture in contestation with the prevailing “chemical agriculture” of his day. For Northbourne there was a battle of agricultural philosophies: “organic versus chemical farming” (1940, p.81). Northbourne had been impressed with Ehrenfried Pfeiffer’s 1938 book Bio-Dynamic Farming and Gardening (Figure 2). He travelled to Switzerland to urge Pfeiffer to present a conference on biodynamic agriculture to a British audience. Pfeiffer was, at the time, the leading advocate of biodynamics. Pfeiffer had ‘outed’ biodynamics to a broad audience by publishing Bio-Dynamic Farming and Gardening (1938) (Paull, 2011c). An outcome of Northbourne’s visit to Pfeiffer was the Betteshanger Summer School and Conference on Bio-Dynamics Farming, which Northbourne hosted at his farm in Kent and at which Pfeiffer was the key presenter (Northbourne, 1939; Paull, 2011b). Within months of the Betteshanger Biodynamics Conference, Britain and Germany were at war, so the window of opportunity for successfully spruiking Germanic agricultural ideas was slammed shut (Pfeiffer was German, Rudolf Steiner was Austrian). Northbourne reframed the Steiner/Pfeiffer call for an agriculture free of synthetic inputs and in harmony with the cosmos for an Anglo audience. He stripped out the overt mystical and anthroposophic trimmings and distanced its Steinerian provenance.
"Look to the Land" was an organics manifesto that Northbourne was temperamentally and experientially ideally positioned to write. He was a gifted wordsmith, a visionary thinker, a spiritually grounded individual, a graduate and lecturer in agriculture of Oxford University, the Chairman of Swanley Horticultural College, a Governor of the agricultural Wye College, as well as an experienced farmer. "Look to the Land" presented the rationale for an agriculture that was an alternative to chemical farming and which he dubbed ‘organic farming’.

After the Betteshanger Conference, Pfeiffer migrated to the USA and was mentor to Jerome Rodale. In titling his book, *Bio-Dynamic Farming and Gardening*, Pfeiffer coupled ‘farming’ with ‘gardening’. Rodale followed Pfeiffer’s lead in titling his own periodical *Organic Farming and Gardening* (Figure 3). Although Northbourne was himself a keen gardener and he wrote of “our national love of gardening” and that “Our love of gardening can blossom into something greater” (1940, p.107) he nevertheless did not himself couple the terms ‘farming and gardening’ in his book. In this, Northbourne did not follow Steiner’s lead (Steiner founded the Experimental Circle of Anthroposophic Farmers and Gardeners in 1924) however he did cite Pfeiffer’s *Bio-Dynamic Farming and Gardening* in his “Select Bibliography” (p.196).

Jerome Rodale was an early adopter of Northbourne’s ‘organic farming’ meme. Rodale was a publisher with a record of harvesting British material and appropriating, repurposing and repackaging it for an American audience (Jackson, 1974; Rodale, 1965). The first issue of his periodical *Organic Farming and Gardening* was dated May 1942. It was the world’s first periodical devoted to the advocacy of organic agriculture and the timing places it as a candidate for influencing the establishment of the AOFGS.

Rodale was mentored by Pfeiffer. Pfeiffer had migrated from Switzerland to the USA (Selawry, 1992). Pfeiffer’s biodynamics book introduced a global audience to Rudolf Steiner’s biodynamic agriculture. The book fulfilled Steiner’s injunction, of his Agriculture Course presented at Koberwitz (now Kobierzyce, Poland) to put his “hints” to the test and develop them to a form suitable for publication (Steiner, 1924). Pfeiffer’s book appeared in five languages, English, French, Italian, German and Dutch (1938a, 1938b, 1938c, 1938d, 1938e).

Rodale and the AOFGS were early adopters of Northbourne’s ‘organic’ terminology and in this they were ahead of their contemporaries. Eve Balfour and Albert Howard, for example, and other contemporary authors on kindred themes were slower in the uptake. Eve Balfour quoted Northbourne extensively in her book *The Living Soil* (1943) with pages 14 to 17 of her book being a lengthy direct quote from *Look to the Land* (although it is barely differentiated in her text as a quotation and a reader may easily miss the, incorrectly dated, attribution to Northbourne). Balfour’s book did not include a mention of ‘organic’ farming or agriculture and when the Soil Association was founded in London, the Memorandum and Articles of Association (Douglas, 1946) made no mention of ‘organic’. Similarly, Albert Howard did not use the term ‘organic farming’ or derivatives in his books.
including *Farming and Gardening for Health and Disease* (Howard & Howard, 1945). Howard’s book was republished as *The Soil and Health: Farming and Gardening for Health and Disease* (Howard, 1945b) and has more recently been oddly retitled by the University Press of Kentucky as *The Soil and Health: A Study of Organic Agriculture* (Howard, 1945a) despite the fact that Howard’s text makes no mention of “organic” farming or agriculture.

The AOFGS was founded in October 1944. After a decade of national organics advocacy it was wound up on 19 January 1955. The key vehicle of advocacy for the AOFGS as well as the major expense of the society was their periodical, the *Organic Farming Digest*. The first issue appeared in April 1946, which was just as soon as wartime restrictions on paper supplies were lifted finally enabling publication. The Society however failed to find a viable business model and the financial strain of publishing a periodical eventually led to the demise of the Society. The final issue of the periodical, by then titled *Farm & Garden Digest* (incorporating *Organic Farming Digest*), was the 29th issue and dated December 1954. The Society was wound up at a meeting of 19 January, 1955 at the Primary Producers’ Union Office, Sydney (Paull, 2008).

The present paper investigates the arrival, reception and uptake in Australia of the organic farming meme and seeks to distinguish between two potential candidates, Northbourne (1940) and Rodale (1942), as the genesis of the AOFGS, and to determine whether Pfeiffer (1938) perhaps also played a role.

**Methodology**

The National Library of Australia (NLA) maintains the largest archive of Australian publications and newspapers. The online data base of the NLA, Trove (trove.nla.gov.au), includes 882 digitised newspapers (NLA, 2015). The NLA digitised newspapers are from Australian Capital Territory (n=8), New South Wales (n=324), Northern Territory (n=8), Queensland (n=66), South Australia (n=59), Tasmania (n=43), Victoria (n=323), Western Australia (n=49), and National (n=2). The NLA database of digitised titles is the primary source of material for the present research. No archive of the Australian Organic Farming and Gardening Society (AOFGS) was located and that is consistent with previous research (Jones, 2010; Paull, 2008).

The NLA newspapers were searched for the period from 1 January 1938 up to 19 January 1955 (these dates were chosen because Pfeiffer’s book appeared in 1938 and the AOFGS was wound up on 19/1/1955). The results were sorted into two periods, pre-AOFGS and after the founding of the AOFGS; this was operationalised as pre 14 October 1944 and post 14 October 1944 on the grounds that the first identified public appearance of the AOFGS was on this date (Jeremy, 1944) and the Society was wound up on 19 January 1955 (Paull, 2008). The newspapers of all Australian states and territories were searched (viz.: National, ACT, NSW, NT; Qld; SA; Tas; Vic; and WA). All article categories
were searched (viz.: Article; Advertising; Detailed Lists, Results, Guides; Family Notices; and Literature). All article lengths were searched. Searches were not case sensitive.

Items searched:
(a) Pfeiffer mentions: items mentioning Ehrenfried Pfeiffer and/or his book *Bio-Dynamic Farming and Gardening* (1938a) and/or bio-dynamic and/or biodynamic;
(b) Northbourne mentions: items mentioning Lord Northbourne and/or his book *Look to the Land* (1940). Mentions of the social or political life of Lord Northbourne were excluded;
(c) Rodale mentions: items mentioning Jerome Rodale and/or Rodale Press and/or his periodical *Organic Farming and Gardening* (1942); and
(d) Organic Farming mentions: items mentioning ‘organic farming’ and/or organic agriculture’ and/or derivative terms viz. ‘organic farm’ and ‘organic farmer’.

**Results**

Prior to the founding of the AOFGS (i.e. pre 14 October 1944) there were no Organic Farming mentions in the Australian press (Table 1, Figure 5). There were no Rodale mentions (Table 1). There were two Pfeiffer mentions (viz. Cairns Post, 1942; Queensland Country Life, 1939) (Table 1). There were 14 Northbourne mentions and these included reviews, articles, and advertisements for the book (Tables 1 & 2). Northbourne mentions appeared in the press in four states (NSW, n=4; SA, n=6; Qld, n=1; WA, n=3) from July 1940 to September 1944, i.e. up to a month prior to the launch of the AOFGS (Table 2).

In the period of the life of the AOFGS (i.e. from 14 October 1944 to 19 January 1955) there were 25 Pfeiffer mentions, 9 Northbourne mentions, 9 Rodale mentions, and 353 Organic Farming mentions (Table 1, Figure 5).

Figure 5. Number of mentions of Organic Farming in the Australian press before and during the life of the AOFGS.
Within two months of its publication in London, Northbourne's *Look to the Land* was available in Australia (Table 2). The first mention of *Look to the Land* in the Australian press was the announcement of “Books Received” on 13 July 1940 in the leading newspaper of South Australia (Advertiser, 1940a). A favourable review of *Look to the Land* appeared the following month (Advertiser, 1940b) (Table 2).

Table 2. Mentions of Northbourne in the Australian press prior to the founding of the Australian Organic Farming and Gardening Society (AOFGS).

| DATE            | TITLE                                              | NEWSPAPER, STATE              |
|-----------------|**************************************************|*********************************|
| 13 July 1940    | Books Received: General (Advertiser, 1940a)        | The Advertiser, SA             |
| 24 August 1940  | The Land Problem (Advertiser, 1940b)               | The Advertiser, SA             |
| 4 December 1940 | Man and the Soil (Macleay Chronicle, 1940)         | The Macleay Chronicle, NSW     |
| 21 September 1940 | Land-Love (SMH, 1940)  | The Sydney Morning Herald, NSW |
| 4 December 1940 | Man and the Soil (Macleay Chronicle, 1940)         | The Macleay Chronicle, NSW     |
| 2 August 1941   | Rigby’s for Books (Rigby Ltd., 1941)               | The Advertiser, SA             |
| 6 September 1941| New Books and Publications (Alberts Bookshop, 1941)| The West Australian, WA        |
| 8 November 1941 | Books of the Week: “Look to the Land” by Lord Northbourne (Palette, 1941) | News, SA                      |
| 22 November 1941| Life & Letters (West Australian, 1941)             | The West Australian, WA        |
| 27 November 1941| The Farm Bookshelf: When The Soil Dies (Martingale, 1941) | The Western Mail, WA          |
| 25 March 1943   | Soil and Humus (Mount Barker Courier, 1943)        | The Mount Barker Courier & Onkaparinga & Gumeracha Advertiser, SA |
| 6 January 1944  | Food Front Plan (Queensland Country Life, 1944)    | Queensland Country Life, Qld   |
| 3 February 1944 | Nemo’s Horticultural Notes (Nemo, 1944)            | The Murray Pioneer, SA         |
| 16 September 1944 | The Rule of Return (Farmers' Friend, 1944) | Northern Star, NSW             |

*Australian Organic Farming and Gardening Society (AOFGS) founded c.14 October 1944*
Northbourne's book was well received in the Australian press. Reviews were all favourable. They appear to have drawn most of their material from Chapter 1. None of the accounts of Northbourne's book mention his core tenet of 'organic farming' and none mention his framing of the agricultural contest of the times as 'organic versus chemical farming'. Nevertheless, the early Australian accounts of Northbourne's book were thoughtful reviews which retain their salience to this day and make for interesting reading; a selection follows.

The first review of *Look to the Land* in the Australian press reported:

Lord Northbourne attacks the subject of the biological sickness of the world by saying that the economic and spiritual sicknesses of the world are aspects of one and the same phenomenon. As agriculture is the basis of man's existence on this planet, so must agriculture depend on the soil.

He then discusses the properties and potentialities of the soil, emphasising the fact that soil is 'living.' Any discussion of this kind naturally leads to the problem of soil erosion, which is set out in the light of alarming statistics from America and interesting facts from China. Lord Northbourne blames the folly of those who, in their endeavour to 'get rich quickly,' exhaust the land on which they depend.

He complains that our present financial system is partly responsible for the evils he deplores; he says that it tends to drive people to the cities, and is placing intolerable burdens on future generations. The remedy suggested for soil erosion is a strict adherence to 'the rule of returns.' What has been taken from the land must be put back in some form, if the fertility of the soil is to be maintained.

Lord Northbourne has little faith in social legislation or the activities of great public bodies: he insists, however, on the necessity for a change of heart in the individual and a realisation of the importance of the family as a social unit. He wants to see families returning to 'the good earth' and settled on self-contained farms.

Lord Northbourne is himself a considerable landowner and has had farming experience, so his idealism is not that of an unpractical theorist. He wants to develop a more spiritual outlook, a greater strength of character, and a deeper understanding of Nature than is now apparent in our overgrown urbanised populations (Advertiser, 1940b, p.10).

The first advertisement in the Australian press for *Look to the Land* stated:

Lord Northbourne suggests that present commercial and industrial tendencies particularly in their effects on farming cannot be allowed to continue to spread disease and disorder, nor to reduce world fertility to starvation point. Price 9/9 (Rigby Ltd., 1941, p.10).

*Look to the Land* featured as book of the week in *The News* where it was recommended as “a book for everyone”:

Lord Northbourne is a practical farmer, there is not much of the social or big business men about him. He is a large land owner and makes use of every yard of it in mixed farming and market gardens, working as hard as any employee, and, judging by his forthright character, as exemplified in this book, is a man after our own hearts and worth listening to.

He shows that man is dependent on the soil for his life and well being, and warns us all that we are not making proper use of our heritage. He tells you all about it in plain, everyday language, and makes his plaint so interesting and understandable that even the scribe who writes this covered the contents twice over.

... Starting off with the nutritional needs of plants, the importance of humus, he goes on to that dread subject, with which we in Australia can sympathise and understand - erosion.

These chapters on erosion are truly frightening, and are not the least overdrawn or exaggerated ...The Missouri basin has lost an average of seven inches of top soil in 24
years, which sounds pretty dreadful when learned professors have estimated the mean rate of soil formation as one inch in 10,000 years.

According to the author, much the same is true of many other countries. He makes the flat announcement that "Australia is going faster than America," but has only been under ‘civilised’ influence for one-third of the time of the United States. He gives his reason, overstocking and unsound cultural methods.

Well, I leave it to those who are in a better position to know as to whether Lord Northbourne is right or not, but, judging from what has been written and illustrated in books, papers, and magazines, I take it that this noble farmer's arguments will be fairly solid hurdles to cover.

Lord Northbourne discusses the farmer, and says he has a reputation for individualism and independence. "These are sound qualities, but they are not appreciated in modern, large-scale business," he says, adding, "But that is a debased form of organisation."

... He holds that the farmer is not incompatible with the highest form of social life, and gives it value, for he improves the quality of the smallest units, from which any such organisation must grow.

In reading Lord Northbourne, I feel sure that he has had a thorough education in every phase of life, and he said one thing that was driven into my nut, when a young art student ...

That is:-"If we want to succeed in the great task before us we must adopt a humbler attitude towards the elementary things of life than that which is implied in our frequent boasting about our so-called 'Conquest of Nature.' We have put ourselves on a pinnacle in the pride of an imagined conquest. It is just as sensible as if a man should try to cut off his own head, so as to isolate his superior faculties."

A book for everyone, be he parson, docker, clerk, or farmer, and especially the suburban gardener (Palette, 1941, p.2).

The Sydney Morning Herald's review of Look to the Land:

Lord Northbourne is himself a farmer, but instead of being a strictly practical advocacy of sane agriculture, as one might expect, his book turns out to be an almost mystical Interpretation of the relation of man to earth and a plea for recognition of more than material considerations In farming. Somewhat after the style of Meredith, he shows how love binds all creatures and the earth together and that any disturbance of this union for gain creates a profound unsettlement In the life of man and results in the impoverishment of the soil. ... He believes man is paying for his disturbance of the normal order through greed and his general remedy is a return to the land particularly the small farm and a loving cultivation of it. Social life could well begin again from this basis, he considers the land must be studied not exploited.

His book is full of Interesting matter - discussions of economics, health, chemical farming, international relations - and it may provide valuable suggestions In a new order after the war (SMH, 1940, p.10).

The West Australian reported positive sales results:

Published over a year ago by Dent's, Lord Northbourne's book 'Look to the Land' is selling increasing numbers every week. (Price 7/6) (West Australian, 1941, p.7).

The book was reviewed in Perth's Western Mail:

Lord Northbourne is a landowner in Kent and Northumberland who runs a mixed farm and market gardens. His recently-published book, "Look to the Land" is one that should be read by all thinking men for in it he sounds an alarm which the world should heed, in man's exploitation of the soil; in his reckless wastage of his heritage, fie traces the root cause of most of the physical, social, political, and economic ills from which the world is suffering. I started to review the book as a whole but found that the first chapter contained so much food for thought that I have contented myself with presenting in a condensed form, a few of the author's pronouncements concerning soil erosion contained therein ...
Lord Northbourne, author of 'Look to the Land,' modestly describes his book as an attempt by a layman, writing for laymen, to set forth how much more there is in agriculture than the mere production of cheap and abundant food.

The problems confronting agriculture throughout the world are not merely farmers’ problems, he points out, for the soil is the foundation of the physical life of man, whether he be a farmer or a city dweller. It is the background of every man's life for he is dependent upon the soil for his nutrition.

The Soil is an Entity … soil is a complex mixture of many ingredients living and non-living; a whole world in itself and a living entity … Increases of production, the author points out, must not be taken as increases in fertility. Actually an increase in production is usually secured by “cashing in” on existing fertility, and, as it is used up we encounter the disastrous results which have been described …

The temptation to exploit the fertility of the soil for immediate personal gain is no new thing, but during recent years man has enormously extended his physical powers by the use of mechanical devices so that one man can now do what used to be the work of hundreds and can do it faster. With the speeding up of cultural operations there has been a speeding up of erosion …

Man sets about his desert making in various ways. He alters the texture of the soil by using up humus and failing to replace it - by failing to feed the soil with organic matter; livestock are the great converters of otherwise unwanted organic matter to a form in which it can be used by plants. Stockless farming, under-stocking, burning straw, etc., are all cases of failure to observe the 'rule of return' which is the essence of farming. Only by faithfully returning to the soil in due course everything that has come from it can fertility be made permanent and the earth be made to yield a genuine increase.

Large-scale monoculture (the growing of one crop only) upsets the balance of factors in the soil in many ways. There is no give and take between crops. Disease spreads easily. Nature always provides a mixture of plants, and of animals; only so can living matter be kept constantly in circulation without wastage …The injudicious felling of timber may lead to much more than denudation of the hills on which the timber grows. Forests act as sponges, and level out the rate at which water leaves the hills. Thus injudicious deforestation leads to erosion on the hills, and to alternations of flood and drought in the valleys, ending in erosion or harmful sifting of the valleys themselves …

Debt and Destruction. "The rapid extension of exhaustive farming throughout the world is linked with the roughly simultaneous extension of a peculiar economic system which has led to a vast accumulation of financial debt. Such debt both internal and international has grown to a point at which repayment is practically impossible and the mere payment of interest is severely oppressive …

Under present conditions the only thing that pays is quick profit making whilst the going is good. By ignorant or unscrupulous exploitation and exhaustion of fertility- vast profits have been made (by financiers rather than by farmers) in the name of cheap food. The pace is forced for the sound farmer wherever he lives.

As is usual nowadays, it will be left to future generations to pay for our mistakes, but they may not have the wherewithal. Money alone is notoriously useless in a desert.

"Look to the Land," by Lord Northbourne. Published by J. M. Dent and Sons Ltd. Price 9/6 (MARTINGLE, 1941, pp.56-7).

Nemo (1944) reviewed Look to the Land in the Murray Pioneer, a South Australian rural newspaper. In the preamble he stated that:

Mr. W. Macgillivray (Member [of Parliament] for Chaffey), has kindly sent along a book for me to read which is so full of 'meat' that I don't know where to start to give it a full review. It is called "Look to the Land" by Lord Northbourne and deals with every aspect of agriculture in England, in the political, economic and scientific aspect, but covers a wide range of other countries as well” (p.8).
Northbourne’s book continued to attract mentions in the Australian press during the life of the AOFGS with nine mentions in that period, all favourable or neutral (Table 3).

Table 3. Northbourne mentions in the Australian press during the life of the Australian Organic Farming and Gardening Society (AOFGS).

<table>
<thead>
<tr>
<th>Date</th>
<th>Title</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 January 1945</td>
<td>Soil Fertility (Martingale, 1945)</td>
<td>Western Mail, WA</td>
</tr>
<tr>
<td>17 January 1945</td>
<td>Letters to the Editor: Soil Erosion (Daft, 1945)</td>
<td>The Mercury, TAS</td>
</tr>
<tr>
<td>7 July 1945</td>
<td>The Future Of Our Farm Industries (Scrutator, 1945)</td>
<td>Northern Star, NSW</td>
</tr>
<tr>
<td>13 July 1945</td>
<td>Books For Farmers (Alberts Bookshop, 1945)</td>
<td>Western Mail, WA</td>
</tr>
<tr>
<td>22 March 1946</td>
<td>Agricultural Bureau. Y.P Conference (Kadina &amp; Wallaroo Times, 1946)</td>
<td>The Kadina and Wallaroo Times, SA</td>
</tr>
<tr>
<td>4 July 1946</td>
<td>The Economics of Primary Production (Till, 1946)</td>
<td>Murray Pioneer, SA</td>
</tr>
<tr>
<td>20 June 1950</td>
<td>World Soil Erosion (Mannock, 1950)</td>
<td>Camperdown Chronicle, VIC</td>
</tr>
<tr>
<td>18 August 1951</td>
<td>Preece’s Farming (Preece, 1951)</td>
<td>The Advertiser, SA</td>
</tr>
</tbody>
</table>

No archive of the AOFGS was located. Colonel Harold White was prominent in the AOFGS, and was most likely a founder. He was the second most prolific author (after the editor, V H Kelly) of articles in the Organic Farming Digest, contributing 20 articles (of a total of 378 published articles) over the 29 issues of the Digest. White was an enthusiastic advocate of organic farming of the AOFGS, presenting lectures, doing radio interviews (e.g. White, 1954), writing letters to the editor, authoring a pamphlet (White, 1959) and co-authoring a book (White & Hicks, 1953). Of the participants in the AOFGS only White’s very incomplete papers were located by the author and some of his library remains in the possession of his family. The remnants of White’s library and papers revealed no copy of Northbourne’s Look to the Land, no copy of Ehrenfried Pfeiffer’s Bio-Dynamic Farming and Gardening, no issues of Rodale’s periodical Organic Farming and Gardening, no books of Rudolf Steiner, and no material of the Experimental Circle of Anthroposophical Farmers and Gardeners (ECAFG). White’s surviving papers, as inspected by the author, throw little or no light on the genesis of the AOFGS; a case of absence of evidence rather than evidence of absence.

The ECAFG was active in Australia from 1928 with its members practicing Anthroposophical and biodynamic farming, precursors to organic farming (Paull, 2013, 2014a, 2014b). On the evidence as it stands at present, the genesis and activities of the ECAFG and the AOFGS appear to have proceeded independently of each other.

Discussion and conclusion
The AOFGS adopted the term ‘organic farming’ as the defining raison d’être of the Society. The present research reveals that the book in which the term ‘organic farming’
first appeared, Northbourne’s *Look to the Land*, was available in Australia shortly after being published in London. It was advertised for sale in the four years prior to the founding of the AOFGS, as well as after. The book was favourably reviewed in the Australian press as a “Book of the Week” and it was recommended as a “book for everyone” which was “full of Interesting matter”.

The evidence available indicates that the AOFGS took up the term ‘organic farming’ directly from Northbourne’s book. *Look to the Land* was reissued in Britain in 1942 bearing the “War Economy Standard” logo and 1946. The book continued to be advertised in the Australian press suggesting that these editions made their way to Australia despite the shipping challenges of the time.

Rodale adopted Northbourne’s ‘organic farming’ term for his US periodical *Organic Farming and Gardening* (1942). There were no mentions of Rodale nor of *Organic Farming and Gardening* in the Australian press prior to the founding of the AOFGS. The evidence suggests that Rodale played no role in the genesis of the AOFGS. Historically, books and periodicals have generally entered the Australian market via British distributors, rather than American, and the apparent absence of Rodale’s periodical in Australia at this time is no great surprise and confirms this market distortion of the time.

Pfeiffer and his book *Bio-Dynamic Farming and Gardening* received scant attention in the Australian press prior to the founding of the AOFGS with just two mentions, and the book was neither reviewed nor advertised in the Australian press. The evidence suggests that it likely played little or no role in influencing the genesis of the AOFGS.

The present study leaves open the question of how the founders of the AOFGS settled on ‘Farmers and Gardeners’ in the title of their new society. The coupling of these terms - farmers and gardeners - generates a phrase that is generally absent in the agricultural publications and associations of the time (as well as now). The phrase ‘Farmers and Gardeners’ has nevertheless been used within the dissident agriculture movements from at least 1924. At his seminal Agriculture Course at Koberwitz, Rudolf Steiner (1924) established the Experimental Circle of Anthroposophical Farmers and Gardeners (ECAFG) (Paull, 2011a). When Pfeiffer (1938) presented the work of Steiner and the ECAFG to the world, he carried forward the phrase ‘Farmers and Gardeners’ in titling his book as *Bio-Dynamic Farming and Gardening*. Four years later, when Rodale (1942) adopted Northbourne’s term ‘organic farming’, and at a time when he was taking guidance from Pfeiffer, he titled his periodical *Organic Farming and Gardening*.

A standout feature of the tally of press mentions was that prior to the founding of the AOFGS there was not a single Organic Farming mention, while, in contrast, during the life of the AOFGS there were 353 Organic Farming mentions in the Australian press (Table 1, Figure 5). This is despite the wide coverage and availability of *Look to the Land*.

In the absence of the testimony of the founders of the AOFGS (which is lacking) and/or the emergence of the archives and records of the AOFGS (which remains a possibility), conclusions must remain tentative. That said, the conclusion to be drawn is that the founders of the AOFGS took up the term ‘organic farming’ from Northbourne’s book, and it is, after all, the core meme of the book and its foundational idea.
AOFGS archives, minutes, and/or records may at some future point come to light. Australia has the advantage over many other countries in that there has been no destruction of documents due to bombing (for example, as occurred in Britain in WWII), no war-time seizures of documents as booty or intelligence (for example, as apparently occurred with Anthroposophical Society documents in Nazi Germany and during WWII). Added to this, Australian homes are larger than those of most countries and this is a cause for optimism in recovering ‘lost’ documents which may still be ‘tucked away’ in spare rooms or sheds.

The archives of two Australian organics organisations have been secured. Records of the Living Soil Association of Tasmania (LSAT) are deposited in the State Library of Tasmania (Paull, 2009a) and the records of the Soil Association of South Australia (SASA) have more recently been deposited by the SASA archivist, Dr Sandra Grimes, into the State Library of South Australia (SLSA) (Paull, 2009b).

At the demise of the AOFGS, the Digest reported: “The Society has always operated under a financial handicap, and for this reason the Digest fell short in some respects. However the principles of organic farming have been sufficiently publicised for the work to continue … there is solace in the fact that it has performed a service in publicising organic farming principles in Australia” (The Executive Officers, 1954, p.1).

The successful advocacy of organics by the AOFGS is clearly evidenced by the 353 mentions of Organic Farming in the Australian press during the course of the life of the AOFGS (1944-1952) and is contrasted by the zero mentions of Organic Farming prior to the founding of the AOFGS (Table 5). The rise and fall of the Australian press mentions of Organic Farming (Figure 5) is a proxy index of the organics advocacy of the AOFGS and offers a proxy snapshot of the rise and fall of the AOFGS, Australia’s first organics association.

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Book review
Good Food for all: Developing Knowledge Relationships between China and Australia

Sandra Grimes PhD

Characterised by varying degrees of ambition, goodwill and risk, this book evolved from a more hard-nosed sounding forum entitled ‘Knowledge exchange of quality food production and distribution between China and Australia’. Held in Wuhan, China, in November 2013, the forum was hosted by Huazhong Agricultural University in partnership with Swinburne University of Technology (SUT).

Significantly, the book editors, Associate Professor Bruno Mascitelli and Professor Barry O’Mahony along with Dr Jue Chen, all from SUT, were the successful recipients of an award from the Australian Government through the Australia China Council, with the latter sponsoring the 2-day forum.

The editors, their co-workers and co-contributors are to be congratulated on this fast track publication which “emanated” from the forum “to provide some scholarly treatment of the event” from “invited experts and scholars” (p.vii). All the more congratulations given the diplomatic pathways that the editors presumably had to steer to complete the project with respect to cultural, pragmatic and institutional sensitivities for both Australia and China. While not necessarily made explicit, some sense of the path to project closure is evident to this reader threading through the “diverse” contributions (of interest is the Forum Program listed in the Appendix).

The preface by renowned chef and culinary ambassador, Tony Bilson, is indicative of the diversity among the Australian contributors. The preface advances the optimistic perspective that exchanging knowledge while exchanging food needs to be underpinned by cultural exchange, albeit driven by mutually profitable trade. “The sheer size of the market demands partnerships between Government, industry, academia and the arts” and “will demand a greater cultural sensitivity from Australians” (p.xii).

While the overall result is not unequivocal, the volume could well be useful as a reader for food and related studies, also for critical discussion in other areas such as international relations and socio-economic disciplines. It is of interest for a broader readership wanting to become both informed and challenged by easily accessible presentations (for the most part), ranging across issues of food production systems with special reference to knowledge exchange and export within the wider rubric of food security. In both countries, it may assist the citizens’ right to know and could well raise questions about the distinction between knowledge and the spin that can be confounded with knowledge.
The compare and contrast exercise between China and Australia, while underpinned by some serendipity, is structured by the growing trade between two nations for whom geographical distance is probably the least of their differences. All in all, this reader came out better informed about basics of agricultural trade and export of food with information and discussion, sometimes surprising, sometimes fascinating, bestowed from a variety of socio-historical and economic perspectives (for a more theoretical discussion with a public health emphasis see the account by Jo En Yap et al. in Chapter 4).

On matters of presentation, it would help the busy reader to have more summary profiles of essential basics relevant to the export activities both countries tabulated along the lines of the table in Chapter 3 which compares organic food & agriculture with the wider international picture (p.53). On matters of substance, where does climate change enter the picture and what of genetic modification (see below)?

In the chapter “Opportunities and Challenges for organic food and agriculture: China and Australia” organic food is described as “food grown without the use of synthetic pesticides and fertilisers, without genetically modified organisms (GMOs), nanotechnology or irradiation” (p. 50). This is accordingly indexed under GMO along with one other citation (p.160). Perhaps a more extended treatment of GMO’s in agriculture was left to the Chinese speakers (presumably due to publish their own version of the Forum composed, we are told, of 10 speakers from each ‘side’).

Earlier in Chapter 2, the Australian agricultural sector was credited with “a strong research & development (R&D) base ranking it among the best in the world” (p.41). It is claimed that this helps Australia combat the challenges of climate variability and poor soils to maintain “its leading position of producing food on the driest continent rife with low quality soils around the world” (p.41) with Australia able to export over half of its total annual agri-food production.

Against this general scenario of Australian agriculture, how does the organic sector rate? To measure progress and identify trends for organic agriculture, John Paull cautions that “the organic data sets for both Australia and China leave much to be desired” (p.61). So in order to present a comparative profile on the Australian organic sector, the indefatigable researcher draws on data supplied by international sources (FAO 2014 and IFOAM in partnership with the Switzerland Research Institute of Organic Agriculture profiles of international data in The World of Organic Agriculture: Statistics and Emerging Trends vols. 2011-2014).

Thus, Paull is able to present a credible profile of Australian organic agriculture in comparison with China, and it makes for a most interesting discussion. So, as if not to be over-shadowed by the glowing portrayal of the Australian agricultural sector earlier presented, Paull makes the case for both Australia and China as “global organic leaders” in export. Many readers of both the book and this Journal will be intrigued by this account. The case that is made therein is the best that can be made given the available data which he admits to his credit leaves much to be desired. Why so?

If Australian agricultural R&D ranks among the best in the world, why is it necessary to turn to internationally compiled data to profile the organic sector? Any answer is a longer story than can be told here. One historical pointer from Paull’s account is Lord Northbourne’s 1940 prediction, strongly suggestive of a division between organic and
other agriculture, namely, that supporters of the “organics idea” would be “fighting a rearguard action for many decades, perhaps for centuries” (p.51). For the most part, the organic sector in Australia has produced its own research & development largely by vigorous grass-roots efforts by ‘their own’ organisations of organic practitioners (typically under-funded and often subsidised by volunteers). At the national level, those mentioned herein include the National Association of Sustainable Agriculture in Australia and the former Biological Farmers of Australia now Organic Australia Ltd. (Perhaps to wit, see the co-authored report the Australian Organic Market Report produced in 2012 by the BFA, cited by Paull).

Against this background, I take issue with Paull’s comment that in Australia “there is no push from the organic sector….to inform the public or proselytise on behalf of the organics sector” (p.74). However, I agree with his comment that “there is no push …from the government to inform the public or proselytise on behalf of the organic sector” (p.74).

If confirmed in the future, the very success Paull predicts for Australian organic export activity will have come about on the backs of organic practitioners and their certifying and other organisations. All this with little benefit or funding from the academic and agricultural R & D infrastructure which has tended to favour their conventional cousins (family or corporate).

Circa 2008, the website of the Primary Industries Research Department of South Australia as listed by the State Library of SA contained no reference to organic farming that I could locate, suggesting a tardiness to publicly recognise the significance or achievements of organic farming. Of these and like matters, the public and consumers have a need to know, because one direct consequence is that the ‘organic idea’ has been little conveyed to the public by the largess of the relevant public purse. Instead volunteer organisations such as the (then) Soil Association of South Australia (Inc.) conducted information programs for both practitioners and the public.

Things can change quickly and Paull’s discussion is well worth attention as food for thought as to how change might happen. As hinted by Paull, sudden growth and change in the organic sector may entail pitfalls for the very ideals and ethics that have, to date, underpinned organic farming as the basis, presumably, for much of its appeal to consumers. This despite the half admiring comment by one insider in the Primary Production bureaucracy that I recall that “conventional farmers have a lot to gain from denigrating organics” (circa 2003). I would welcome further consideration and knowledge exchange between Paull and perhaps others in this volume in conversation with an audience of organic practitioners and their representative organisations within Australia.

Much more could be said about this book in other contexts. One article to pinpoint, which like Paull’s looks back as well as forward, is Rita Parker’s attention to matters dire relating to food security (climate change here rating mention). Parker highlights the spectre of armed conflict and national security as a significant dynamic in the analysis of food security, touching on the modern evolution of international concepts and infrastructure (UN & G20) used to address world hunger.

Congratulations Swinburne et al., this small volume carries a punch above its weight and is the perfect size for the Sydney–Shanghai flight. For contemplation therein why not ponder John Dalrymple’s case study highlighting the innovations and achievements wrought by immigration in the local food supply and processing sector in North
Melbourne. Then while in China, check out his prediction that a similar driver for innovation is occurring there in step with increasing urban migration. While there, you can, still following Dalrymple, demonstrate your expertise of benchmarking in evaluating the quality and diversity of the local food sector, with special reference to small and medium enterprises in providing organic, ethnic, and fusion cuisine. Nice work.