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Importance of Organic Farming and Status of Crop Research: Review

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Abstract

This paper reviewed the importance of organic farming with the objective to produce healthy and environmentally friendly food by closing the nutrient cycle and low external inputs like fertilizer application, prohibits use of herbicides and pesticides. Organic farming promotes on biodiversity, maintain soil fertility and agronomic practices in their ecological farming system. Organic farmers need a robust variety that adapted to organic and low input conditions. Breeding for the organic sector requires the desired traits such as stable yield, good quality, seed health, better root system as well ability to interact with beneficial soil micro-organisms, and suppress weeds. Still further strengthening is required on organic farming with integration of scientific research and improvement of the networking between all stakeholders like organic producers and policy makers at the regional and international level, because organic farming contribute to food security and the goal of sustainability in agriculture. Moreover, organic farming and its breeding techniques should be supported by biotechnological tools to enhance breeding efficiency.

Keywords: Organic Farming; Sustainability; Traits; Robust Variety

Introduction

Organic agriculture is described as a natural farming system. It is an integration of crop and livestock production system that strive for sustainability. Since 1990s, it more emerging and growing in globally; organic agricultural land is slowly increased in Europe as well the highest per capital consummation in this continent while steady in Africa [1]. Africa also producing agricultural product but destine for export. For example, Ethiopia is producing organic coffee and export to world. The other key objective of organic farming is for sustainability in agriculture in terms of ecological sustainability; the health of soil, bio-diversity, stability of eco-system, sustain profitability and socio-economic sustainability interims of increase productivity, food and nutritional security.

Importance of Organic Farming

Organic agriculture is increasing in developed countries and still steady in other regions with the objective to produce healthy and environmentally friendly food by closing the nutrient cycle and low external inputs like fertilizer application while avoiding the use of pesticides and herbicides [2]. It meets the goal of sustainable agriculture, because it produces healthy food while conserving soil ferality and maintain biodiversity in ecosystem [3]. Organic farming is promoting biological fertilizers that derived from farm yard manure, vermicompost, crop residue, green manure and nitrogen fixing crops and application of mechanical cultivation. For example, organic innovative farmers in India could be produced biological fertilizer from locally available resources such as FYM or compost and adding crop residues under field conditions (Figure 1)

Figure 1: Preparation of organic farm field by farmer at Dharamitra region, India. (Source: photo taken by Belay Garoma, 2015)

Intensive agricultural systems disturb natural habitats living organism and their heterogeneity, which results in less biodiversity, whereas organic and low-input farming could minimize this negative impact so as to maintain biodiversity of species at their ecosystem. [4] reported that 30 years practice data from organic farming showed increased species diversity richness about 30% with varying organism group than conventional. Similarly, the diversity at farm scale is highly heterogenous [5]. Moreover, the basis of sound in organic agriculture is care for building-up soil fertility that attribute for water holding capacity, ion exchange, reduce soil erosion and diverse soil biota. [6,7] demonstrated that organic and low-input farming practices after 4 years led to increase in the organic carbon, soluble phosphorus, ion exchange and other nutrients.

Purchasing of synthetic fertilizer, insecticides and herbicide is likely unaffordable for some subsistence farmers and marginal region in developing countries. For example, some sub-Saharan Africa farmers applied fertilizer below of recommendation rate and very few of them were not applying. Thus, small scale farmers and or who live at marginal areas in Africa should use local available materials such as FYM or compost, crop rotation, adding crop residues under field conditions and or cycled available materials that adapted to local conditions onward contribute to increase crop yield and sustainability in the ecology. It recalled that newsletter reported about shortage of chemical and synthetic fertilizer inputs in Cuba in the early 1990s that crippled agricultural inputs and impact on food security. Subsequently, some Cuba farmers took an action through means of participatory research on multi-disciplinary and integrated approach to enhances genetic diversity that aim to contribute food security.

Limitation of Organic Farming

Organic farming has a lot of advantage in terms of sustainable agriculture. However, it has also some limitation such as low yield when compare to conventional, small land holding, it is likely risky and affected by pest and disease, limited access organic inputs such organic seed and biofertilizers. These gaps can be reduced through research and innovation further implemented that play a great role to improve farming methods in their ecology, to develop a robust variety with enhanced nutrition and embrace marketing system.

Plant Breeding Under Organic Agriculture: In case of Wheat

Origin and Biology of Wheat

Wheat is believed to originate from South-Western Asia [8] and it feeds about 40% of the world [9] and alone provides 20% of the calories and protein for the world population.

Wheat is a predominately self-pollinating crop and up to 4% natural cross pollination occurs. The species of Triticum are grouped into three ploidy classes, these are: diploid (2n= 2x= 14), tetraploid (2n=4x=28) and hexaploid (2n=6x=42). Genetically, bread wheat (*Triticum aestivum. L*) is an allohexaploid with AABBDD genomes and possesses 21 pair of chromosomes, i.e each of A, B, and D, has a haploid set of seven chromosomes, while durum wheat (*Triticum durum L)*, is a tetraploid with AABB genomes and possesses 14 pair of chromosomes [8].

Evolutionary Plant Breeding

Darwin proposed the theory of natural selection for the processes of evolution. This theory recognized that the evolutionary change is based upon interaction between environment and population which containing individual representing heritable variation for onward progeny [10]. This breeding is based on a mass selection technique for crop improvement used by farmers over 10,000 years ago [11]. This technique also suggested to broaden the gene pool of germplasm and continued subjection of mass progeny to competitive natural selection in the area of expected use. Further explanation, evolving crop populations have the capability of adapting to the conditions under which they are grown. In evolutionary plant breeding, landraces and or genetic diversity or composite cross population are subjected to select under natural conditions.

Breeding for Organic and Low Input Conditions: The Concept of Composite Cross Population Development

Organic plant breeding is striving to develop population varieties that are bred and selected under organic condition and low input concept. Organic variety trials started in Austria in 1995, which led to the establishment of pure organic value for cultivation and use (VCU) for winter wheat and spring barely in 2001 and 2002, respectively [12]. Similarly, French agricultural research institute (INRA) started organic winter wheat breeding program in 2003 and tested cultivars under organic and low input condition showed a good performance of some cultivars selected under both condition [26]. Others cereals breeding programs are also conducted in Germany (www.-darzau.de) at Keyserlink institute and in UK (www.efrc.com) at Elm farm research center to develop composite cross populations.

Exploitation and broadening genetic variability in the gene pool population is one strategy of breeding for organic agriculture. Genetically heterogeneous populations, landraces, modern populations and variety mixture enable to buffer the fluctuation of environment stress. The great genetic variation within varieties can contribute to stabilize the yield and defense against stress environment under organic farming system. Multiline varieties and variety mixture can also provide a functional diversity that limits pathogen and pest expansion in crops under organic farming. This approach is to reduce the risk of resistance breakdown due to wider range of mechanism barriers in mixture, allelic variant and induced resistance [13]. However, composite cross population is consisting of broaden genetic diversity and recycled over generation that enable to buffering against biotic and abiotic stresses. This likely indicated that composite crossed population expected to more resilience or robust than variety mixture. Robust varieties are required under organic and low input conditions because these varieties contribute to resilience in these heterogeneous conditions [6,14]. In addition, these robust varieties developed from broadened genetic diversity enable to buffer against heterogonous environments.

Robust varieties for example, composite crossed populations that developed from diverse set of parent origin through possible crossed combination and recombined as well recycled over generation [10,15]. Similarly, [10] reported that composite cross population within diversity can improve the resilience of the variety population under organic farming condition to suppress the spread of yellow rust disease compared to the pure line meanwhile similar grain yield observed as pure line during evaluated cropping season. Likewise, [16] suggested that locally based breeding program is a good opportunity to achieve a sustainable increase of agricultural production under low input condition. Conventional low input trials can be regarded as an indirect selection environment for organic agriculture [17]. But, the relative efficiency of indirect selection at high input levels did not appear more efficient than direct selection at low input [18,19]. For instance, thirty five winter wheat genotypes tested under organic and conventional systems showed that high significant variation was observed in the genotypes x farming system interaction [11]. Also, the highest yielding winter wheat genotypes in the high input conventional system were not the highest yielding genotypes in organic systems because most traits are highly correlated between organic agriculture and low inputs. The other possible reason is that organic plant breeding program is step of selection, propagation and maintenance are carried out under organic conditions [6]. Two breeding schemes were proposed for organic winter wheat breeding [12], Figure2). First scheme, including crossing and pedigree selection under low-input conditions and later testing trials under organic conditions. The second approach includes the crossing and bulk reproduction of populations with individual ear selection under organic conditions followed by ear- to-row selection in a low input nursery. Yield trials are conducted parallel under low input and organic agriculture for further selection in these conditions.

Desirable Traits Under Organic Agriculture

The main goal of wheat breeding is to develop high yielding variety, biotic resistance, abiotic tolerance and good baking quality. In addition, relevant traits are predominately important under organic farming. These traits are tillering capacity, leaf area index, ground cover, early vigor and nutrient uptake efficiency [12]. Moreover, traits such as better root systems, weed suppression ability and others are required under organic and low input conditions. [20] reported that selection of suitable variety should be strong correlation between root hair length for efficient phosphate and water uptake, root associating with mycorrhizae fungi, high number of tillering capacities, early season N uptake followed by internal translocation of N at grain filling, and resistance to seed borne diseases under organic conditions. Similarly, trait such as high bacteria community on rhizosphere promote N-uptake efficiency and enable to protect the root against soil-borne pathogens [25]. Competitive ability to suppress weeds is an important trait preference under organic farming systems that to limit the use of herbicides and harrowing costs. Morphological traits such as tillering capacity, canopy height, ground cover and early crop vigorous are associated with wheat competitiveness tolerance to weeds [22]. Early establishment, more intercept light and height are features that should be used to select for varieties under organic systems [23]. Early season plant vigor trait can be efficiently utilized resources in terms of photosynthetic active radiation, accumulation of biomass and tillering improves competitive ability [24]. Similarly, initial root and shoot growth rate are the most important morphological traits under organic farming [25], because root growth rate is competition for nutrients, water and space as well as allelopathy to suppress weeds. Therefore, these desirable and correlated traits should be considered for organic breeding while selection among potential variety and their stable yield should be considered.

Strengthening of Organic Farming and Prospective Research

Organic farming and Organic plant breeding should further strengthen because it contribute to enhancing biodiversity (at farm, crop, species), healthy food, maintain soil fertility and mitigation of climate change. Further breeding efficiency and its technique is required under organic condition with supported biotechnological tools.

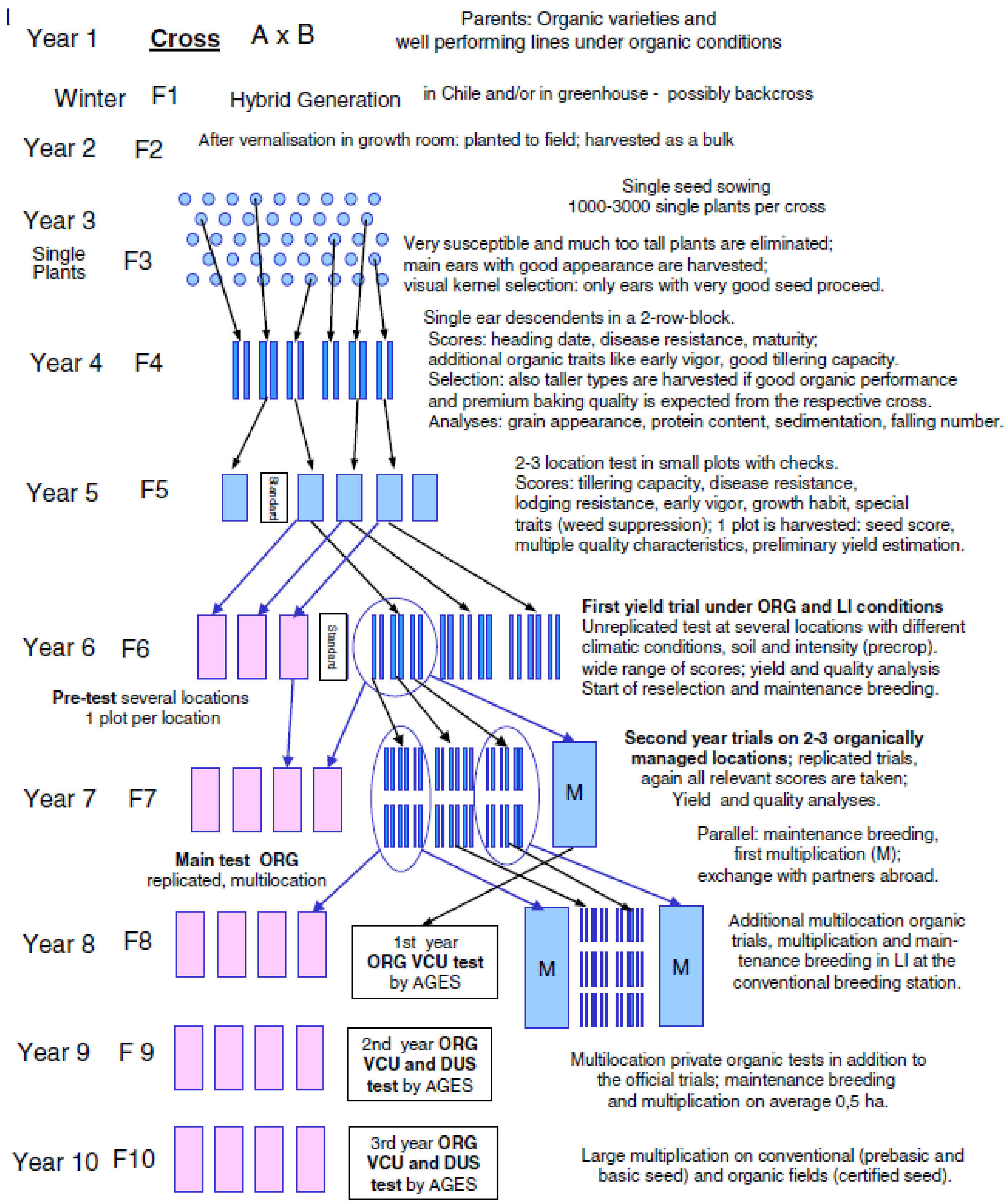

Figure 2: Breeding scheme for organic winter wheat as mainly performed by Saatzucht Donau (modified after [12]);

OA= Organic Agriculture, VCU= Value of Cultivation and Use, DUS= Distinctness, Uniform and Stability, AGES=National Austria cultivar catalogue, LI= Low input

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