APPLYING CONSERVATION AGRICULTURE FOR VEGETABLE PRODUCTION

by

Izhar, L., and Reyes, M., R

ABSTRACT

Conservation Agriculture (CA) is an effort to get sustainable farming, environmentally friendliness and increase production. CA is very necessary at this time to address the problems such as degraded land, erosion, declining production, global warming threat, pests and diseases pervasiveness, also for human survival in the future. Various countries and research institutes have started develop the CA concept throughout the world. There are many nomenclatures surrounding conservation agriculture and differ to each other lightly, so it requires a deep study site-specific and highly sustainability approach. Application and efforts of CA has been made for Horticulture especially vegetables crop in various places. Nevertheless, it needs on-farm assessment in order to move forward CA concept rapidly, specific location application and economically viable, socially accepted and technically easy.

Key words: Conservation Agriculture (CA), horticulture, vegetables

INTRODUCTION

Twentieth-century population growth pushed agriculture onto highly vulnerable land in many countries. The rapid population growth in some countries resulted in increased demand for agriculture and horticulture commodities. While the global warming resulting in unpredictable climate, pests and diseases increases, arising unfertile land, and agricultural land conversion to other areas make in declining its production.

Cultivation land in most of the agricultural areas is still using a conventional way in accordance to the development of “Green Revolution”. In fact, more land degradation occurs due to highly intensive land preparation, use of excessive fertilizers and pesticides, arising of pests/diseases and uncertain climate condition. Hence, it is necessary to overcome by creating Conservation Agriculture. CA is an application of modern agricultural technologies to improve production while concurrently protecting and enhancing the land resources on which production depends. Application of CA promotes the concept of optimizing yields and profits while ensuring provision of local and global environmental benefits and services (Giller et al. 2009).

On the other hand, land use developments for horticultural crops in Asia is growing largely in recent decades. This should be given special attention because of intensive land use causes environmental damage, erosion, and excessive use of chemicals dangerous to human life. Efforts need to be done immediately to prevent further damage by CA application (Rerkasem, 2005).

In some developed countries and few developing countries have adopted conservation agriculture cultivation patterns are mostly applied to cropland. While the majority of new
HORTICULTURAL LAND which Country is implementing CA, tends to increase the number. This paper study Conservation Agriculture for Horticulture especially vegetable crop.

CONSERVATION AGRICULTURE CONCEPT

Conservation Agriculture has been trumpeted as the solution for reducing soil degradation and increasing agricultural productivity around the world. CA is gaining acceptance in many parts of the world as an alternative to both conventional agriculture and to organic agriculture. Conservation agriculture (CA) is based on optimizing yields and profits, to achieve a balance of agricultural, economic and environmental benefits. It advocates that the combined social and economic benefits gained from combining production and protecting the environment, including reduced input and labor costs, are greater than those from production alone. With CA, farming communities become providers of more healthy living environments for the wider community through reduced use of fossil fuels, pesticides, and other pollutants, and through conservation of environmental integrity and services (Dumanski et al. 2006).

Conservation agriculture promises to revolutionize farming practices around the world. The theory of no-till farming first emerged in 1943. It wasn’t until herbicides became readily available in the late 1950s and early 1960s that the era of no-till agriculture or conservation agriculture, as it came to be called in 2001, began (World Congress of Conservation Agriculture 2001). Conservation agriculture (CA) represents the most dramatic change in soil management in modern agriculture (Ling-ling et al. 2011).

Conservation agriculture is the integration of ecological management with modern, scientific, agricultural production. Conservation agriculture employs all modern technologies that enhance the quality and ecological integrity of the soil, but the application of these is tempered with traditional knowledge of soil husbandry gained from generations of successful farmers. This holistic embrace of knowledge, as well as the capacity of farmers to apply this knowledge and innovate and adjust to evolving conditions, ensures the sustainability of those who practice CA. A major strength of CA is the step-like implementation by farmers of complementary, synergetic soil husbandry practices that build to a robust, cheaper, more productive and environmentally friendly farming system. These systems are more sustainable than conventional agriculture because of the focus of producing with healthy soils (Mulvaney et al. 2012)

Although the practice of CA on a large scale emerged out of Brazil and Argentina, similar developments were occurring in many other areas of the world, notably North America in zero tillage, and Africa and Asia with technologies such as agro-forestry. CA is being successfully implemented, primarily in the United States, Canada, Brazil, Argentina, Australia, Paraguay and on
the Indo Gangetic Plains, on about 95.8 million hectares, however of that area, only about one half million hectares were on small farms in 2002. In Southeast Asia, although conservation agriculture has not established a foothold, there are some promising sustainable agriculture and/or conservation agriculture activities in the region (Derpsch, 2008).

Harrington and Erenstein (2005), highlighted “the specific components of a CA system (establishment methods, farm implement selection, crops in the rotation, soil fertility management, crop residues and mulch management, germplasm selection, etc. tend to be environment-specific. Local investments in adaptive research are typically needed to tailor conservation agriculture principles to local conditions. This process of tailoring is most efficient when an innovation system emerges and begins to acquire a self-sustaining dynamic (Ekboir, 2002).

CA involves minimal soil disturbance, continuous retention of residue mulch on the soil surface and a diverse and rational use of crop rotations (Hobbs, 2007). CA also involves optimum integration of seed or seedling establishment methods, farm implement selection, choice of crops in rotation, germplasm suitability, and fodder management, demand for produce, profitability, nutrient management, farmer preferences and skills, local government policies, credit availability, production inputs, labor, and gender (FAO, 2013).

Conservation agriculture, including agro-forestry, specialty crops, and permanent cropping systems, promotes food sufficiency, poverty reduction, and value added production through improved crop and animal production, and production in relation to market opportunities. Reduced tillage leads to lessened human inputs, in both time and effort (Erenstein, et al 2008).

Conservation agriculture is best achieved through community driven development processes whereby local communities and farmer associations identify and implement the best options for CA in their location. Local, regional and national farmer associations, working through community workshops, farmer-to-farmer training, applied research and extension services, but with technical backstopping from conservation professionals, are the main players in the promotion of CA.

CA provides direct benefits to environmental issues of global importance. These include land degradation, air quality, climate change, biodiversity and water quality. Conservation agriculture relates directly to the United Nations Framework Convention on Climate Change, the International Convention on Biodiversity, the United Nations Convention to Combat Desertification and FAO Save ang grow paradigm.
The Principles of Conservation Agriculture

Conservation agriculture emphasizes that the soil is a living body, essential to sustain quality of life on the planet. In particular, it recognizes the importance of the upper 0-20 cm of soil as the most active zone, but also the zone most vulnerable to erosion and degradation. It is also the zone where human activities of land management have the most immediate, and potentially the greatest impact.

The principles of CA and the activities to be supported are described as follows: Maintaining permanent soil cover and promoting minimal mechanical disturbance of soil through zero tillage systems, to ensure sufficient living and/or residual biomass to enhance soil and water conservation and control soil erosion; Promoting a healthy, living soil through crop rotations, cover crops, and the use of integrated pest management technologies; Promoting application of fertilizers, pesticides, herbicides, and fungicides in balance with crop requirements; Promoting precision placement of inputs to reduce costs, optimize efficiency of operations, and prevent environmental damage; Promoting legume fallows (including herbaceous and tree fallows where suitable), composting and the use of manures and other organic soil amendments; Promoting agro-forestry for fiber, fruit and medicinal purposes.

Based on World Congress of Conservation Agriculture (2001), Kassam et al. (2009), and FAO (2013) the fundamental principles of CA were then formalized:

1. Minimal soil disturbance
2. Permanent vegetative cover
3. Crop rotations (Diversification of crop species grown in sequences and/or associations)

Figure 1. Principles of Conservation Agriculture (Edralin et al. 2012)
Potential benefits of CA include reduced soil erosion and water run-off, increased rainfall use efficiency (Thierfelder and Wall, 2009), early planting, increased soil quality and biological activity (Wells et al. 2000; Thierfelder and Wall, 2010), and savings in on-farm labour.

Tabel 1. A comparison of the principles and practices that underlie conservation agriculture compared to conventional agriculture (Ling-ling et al. 2011)

<table>
<thead>
<tr>
<th>Objective</th>
<th>Conservation agriculture</th>
<th>Conventional agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promote soil and water conservation</td>
<td>Soil surface covered during fallow:</td>
<td>Soil surface bare during fallow</td>
</tr>
<tr>
<td></td>
<td>Stubble retention:</td>
<td>Stubble removed, gathered, burnt or turned under</td>
</tr>
<tr>
<td></td>
<td>(i) reduces soil water evaporation</td>
<td>Tillage is at core of seed bed preparation</td>
</tr>
<tr>
<td></td>
<td>(ii) increases soil water holding capacity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(iii) increases soil organic carbon</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(iv) reduces run drop impact</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(v) reduces wind speed at soil surface</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sowing without tilling:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(vi) weed control with herbicides or suppressed by cover crop</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(vii) protection of soil structure against compaction</td>
<td></td>
</tr>
<tr>
<td>Increase crop productivity</td>
<td>More efficient water use</td>
<td>Add more fertilizer</td>
</tr>
<tr>
<td></td>
<td>More efficient nutrient loss in runoff</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Higher soil water storage</td>
<td></td>
</tr>
<tr>
<td>Increased profitability</td>
<td>Better nutrient cycling</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reduce costs of inputs such as fuel and fertilizer</td>
<td>Increase area under cultivation</td>
</tr>
<tr>
<td>Improve long term sustainability</td>
<td>Prevent soil compaction and soil structure declined</td>
<td>Use more aggressive pest control</td>
</tr>
<tr>
<td></td>
<td>Develop self-sustaining system</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Remove unnecessary chemical pollutants from the crop environment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Most practices are unsustainable in the long term dependent on high inputs of energy (fuel) and chemicals (pesticides, weedicides, and fertilizers)</td>
<td></td>
</tr>
</tbody>
</table>

CONSERVATION AGRICULTURE FOR VEGETABLE PRODUCTION

Minimum Soil Disturbance (no-till farming, zero tillage, direct drilling, soil conservation tillage)

The First World Congress of Conservation Agriculture was held in 2001, and the term “Conservation Agriculture” for no-till farming practices was coined. The frame of reference also changed from targeting mechanized commercial farming operations to smallholder farms in developing countries (World Congress of Conservation Agriculture 2001).

Zero tillage is a ‘cornerstone’ of CA, and can be practiced in both large and small farming systems. With zero till (also termed no-tillage and direct drilling) the only tillage operations are low-disturbance seeding techniques for application of seeds and fertilizers directly into the stubble of the previous crop. Gradually, organic matter of the surface layers of zero tilled land increases, due to reduced erosion, increased yields resulting in more crop residue added to the soil surface, and decomposition of soil organic matter (Harrington and Erenstein, 2005).

In Switzerland, 521 ton eroded soil, 26% of total erosion in the 10-year period took place on potato fields. It is difficult to employ soil conserving tillage practices with sufficient soil cover in the production of potatoes. It is, therefore, not surprising that most erosion (99%) occurred on the conventionally tilled fields. Consequently, it’s importance to introduce soil conserving tillage (Zero tillage) methods which can reduce soil loss (Prasuhn, 2012).
Most of the agricultural benefits of zero tillage relate to increased organic matter in the soil. This results from the combination of eliminating soil disturbance in conventional tillage, increased biomass from improved crop yields, greater diversity of types of organic matter from increased rotation and cover crops, reduced erosion and differences in the assimilation of soil organic matter from reduced surface soil temperatures and increased biodiversity (Doran and Perkin 1994).

In years of average or above average rainfall, the improved soil conditions ensure crop yields comparable to those with conventional tillage, but often with considerably less fertilizer and other inputs. In dry years, the improved soil moisture levels, aggregation and organic matter status of the zero till soils often ensure yield where conventionally tilled soils do not. Profit margins with zero tillage are normally better than under conventional tillage systems, and this enhances the sustainability and future continuity of the CA farming systems (Overstreet et al. 2010).

In addition to reducing erosion, CA practice helps retain water, raises soil carbon content, and reduces the energy needed for crop cultivation. Instead of plowing land, disking or harrowing it to prepare the seedbed, and then using a mechanical cultivator to control weeds, farmers simply drill seeds directly through crop residues into undisturbed soil (with special machines), controlling weeds with herbicides. The only soil disturbance is the narrow slit in the soil surface where the seeds are inserted, leaving the remainder of the soil undisturbed, covered by crop residues and thus resistant to both water and wind erosion. Small farmers can no-till seed their crops using a stick or a manual hand planter (Nguyen et al. 2007).

Zero tillage is effective in mitigating many of the negative on-farm and off-site effects of tillage, principally erosion, organic matter loss, reduced biodiversity and reduced runoff. These conditions are replaced with permanent soil cover, improvements in soil structure, improved organic matter status, improved water use efficiency, and improved soil biology and nutrient cycling (Freeman et al. 2013).

Zero tillage, including controlled traffic (where all in-field traffic traverses only specified wheel or foot tracks), is highly compatible to precision treatment of field conditions. Procedures include differential fertilizer applications according to nutrient requirements, spot spraying for weed control, controlled traffic in association with zero till, etc. As a consequence, wetlands, water bodies, habitats, and stream courses in agricultural areas can be better protected. In high input systems, precision treatment is becoming popular because of the improved efficiencies of operation and reduced input costs. At the same time, these principles have been used for many centuries in low input systems to optimize local nutrient, soil moisture, and sunshine conditions, as well as natural plant symbiosis. About 47% of the 95 million ha of zero tillage is practiced in South America, 39 % in North America, 9% in Australian, and 3.9% in Europe, Asia and Africa (Dumanski et al. 2006).
Zero tillage is conducive to promotion of the environmental integrity of the soil systems, and to maintenance of environmental services. Stability of the soil organic matter under zero tillage, due to enhanced soil aggregation and reduced erosion, enhances sequestration of carbon and contributes to mitigation of climate change. Soil carbon sinks are increased by increased biomass due to increased yields, as well as by reducing organic carbon losses from soil erosion. Fuel use and tractor hours are reduced up to 75%, with further reductions in greenhouse gas emissions. Other environmental benefits include reduced siltation, eutrophication and pesticide contamination of rivers and dams. The system is also valuable to mitigate the environmental effects of droughts by ensuring some biological production, surface cover, and erosion control even under severe conditions, due to the greatly improved soil aggregation, biodiversity and organic matter status, and subsequent improved water infiltration and water storage in the soil (Horowitz et al., 2010).

Maintaining proper soil pH is one of the most important crop production consideration in conservation tillage and has significant impacts on nutrient availability and toxicity. Special care needs to be directed to maintaining pH to the optimal level prior to initiating a continuous conservation tillage system. Lime has relatively low water solubility and leaches slowly through the soil profile. Therefore, lime should be applied based on soil testing recommendations and incorporated prior to initiating a long-term conservation tillage plan. Eventually, fertilizer, organic matter decomposition, and rain will acidify the soil surface, but sub-soil will continue to be at optimal (pH=6.0 to 7.0) levels. Continued liming based on soil test recommendations will maintain the proper pH (Freeman et al. 2013).

Conservation tillage in potato (Solanum tuberosum L.) systems, in cool-humid climatic regions, can benefit soil physical and biological properties. Conservation compared to conventional tillage, increased soil organic C, large water-stable macro-aggregates, and soil particulate C and N in the potato year only. After the potato phase, rotation crops were associated with the further restoration of all soil C and N fractions and soil structural stability indices; and also increases in soil microbial biomass C and microbial activity indices, and soil Collembola abundance (Carter et al. 2009).

No-Tillage stimulates soil life, accelerating residue decomposition and release of soluble nitrogen (N) and other crop nutrients and burning up organic matter in the process. Clean cultivation with prolonged bare-soil periods will increase the risk of erosion and crusting, depress soil biological activity and open niches for weed growth (Swenson and Moore 2009).
Figure 2. The roller-crimper (left) has been developed specifically for no-till management of high biomass cover crops. The flail mower (right) is a versatile tool, in that it can be used to generate even, finely chopped mulch, or can be operated with the PTO off to function as a roller (Schonbeck and Morse 2007).

Continues Mulching (Cover Crops)

Cover crops play a key role in organic vegetable production because they protect and feed the soil, improve tilth, promote nutrient availability and balance, reduce weed pressure, and provide habitat for beneficial insects. Organic exudates from living cover crop roots sustain beneficial root-zone bacteria and fungi during off-seasons in annual vegetable rotations. Organic mulch is developed on the soil surface, and this is eventually converted to stable soil organic matter because of reduced biological oxidation compared to conventionally tilled soils (Schonbeck and Morse 2007).

Cover crops can improve a soil’s physical structure and fertility. As cover crops row, they become reservoirs for important plant nutrients such as nitrogen, phosphorus and potassium, as well as micro-nutrients. Cover crops also help prevent soil erosion, reduce weed problems (Altieri et al. 2011), and provide a habitat for beneficial insects (Higgins et al, 2012).

Avoiding soil erosion is to never allow the soil to be bare and unprotected, but to ensure that the soil surface is always covered with growing plants or the dead mulch from these same plants. To achieve this in modern agriculture, all types of tillage and soil loosening should be avoided. The no-tillage technology has shown to be one of the most efficient methods of protecting the soil from being eroded by wind and water (Goddard et al. 2008).

With time, the soil gradually becomes physically and chemically stratified with a mulch of accumulated plant litter at the soil surface, rich in organic carbon and nutrients. The mulch layer creates a stable microbial ecology and environment for biological activity, and insulates the soil from temperature extremes and rapid desiccation. The microbial and macro faunal (earthworms) populations become more like those of natural soils. Their activity greatly enhances the assimilation
and transfer of surface organic mulches into deeper soil layers and in the process creating physically robust channels to enhance water penetration and dispersion into the soil (Thierfelder et al. 2013)). Different number of Earthworm counts between CA and conventional agricultural system shown in Figure 3.

Figure 3. Earthworm (*Lumbricus terrestris*) counts (per 0.25 m2) for spring and fall.

Earthworm populations were measured to determine effects of agricultural management decisions. Treatments were tillage (plow or strip till), input (synthetic or organic fertilizers and pesticides) and vegetable rotation (continuous or rotation). Strip tillage with organic fertilizers and crop rotation systems as closely related to CA was acquired the highest number of individual earthworm. Agricultural conservation practices result in greater abundance of nematodes and earthworms. Conversely, the long-term combinations of deleterious agricultural management decisions (e.g. intensive tillage and fumigation) create increasingly negative environmental conditions for soil organisms when used in combination (Overstreet et al. 2010).

All conservation practices that maintain an important cover during the rainy season (improved fallow with legumes, planted fodder and to a lesser extent open grass, agro-ecological practices and vegetated strips) have a more conspicuous impact in reducing runoff than sediment yield (Valentin et al. 2008). The application of fertilizer, manure, and compost-based fertility practices in an organic vegetable cropping system, without cover crop application still give a negative affect for soil erosion. However, improvements in some bulk density and porosity indicated that benefits of longer term (Evanylo et al. 2008; Higgins et al. 2012).
Table 2. Effects of cover crop type, straw mulching and applied nitrogen on garlic (cv. Musik) survival, yield and quality. 2003-2004 seasons (Bratsch et al. 2009)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cover Crop</th>
<th>Bulb Loss (%)</th>
<th>Total Yield (gr/plot)</th>
<th>Mrkt. Yield (gr/plot)</th>
<th>Mrkt. Bulbs (%)</th>
<th>Bulb Weight (gr)</th>
<th>Bulb Diameter (cm)</th>
<th>Clove Count (#/bulb)</th>
<th>Internal Clove Decay (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorghum</td>
<td>Sudangrass</td>
<td>44.3a</td>
<td>697a</td>
<td>512b</td>
<td>65b</td>
<td>51.2a</td>
<td>4.8a</td>
<td>6.2a</td>
<td>4.9a</td>
</tr>
<tr>
<td>Lablab</td>
<td></td>
<td>32.4ab</td>
<td>958a</td>
<td>859a</td>
<td>88a</td>
<td>58.0a</td>
<td>5.0a</td>
<td>6.8a</td>
<td>1.9ab</td>
</tr>
<tr>
<td>Sunhemp</td>
<td></td>
<td>31.2b</td>
<td>871a</td>
<td>777ab</td>
<td>89a</td>
<td>52.8a</td>
<td>4.8a</td>
<td>6.5a</td>
<td>0.9b</td>
</tr>
</tbody>
</table>

The levels of biomass residue are presented in Table 2, with Sunhemp, lablab and Sorghum Sudangrass providing there were no significant differ for total yield, bulb weight, bulb diameter on garlic. Bulb loss following planting in all three cover crop treatments. Bulb loss was over 44% after Sudangrass caused low in total yield, marketable yield and marketable bulb, while in the other two treatments, the losses was lower. The straw mulch application was significantly increased total and marketable yield, the percent of marketable bulbs, and increased bulb weight, diameter and clove counts per bulb. There was also a trend for greater bulb loss when plots were not mulched, though mulching had no effect on clove decay percentages. Located in the mountain region, it appears that mulching is beneficial for winter protection of cloves, even when significant residue exists from cover crops (Bratsch et al, 2009).

Dintan et al, 2006 reported that using conventional agriculture in cabbage, yield was reducing significantly to 40 % compared to CA. Altieri et al. (2011) stated that cumulative tomato yields were estimated by totaling commercial fruit weight obtained in eight consecutive harvests. The vetch + fodder radish and the black oat exhibited the highest cumulative yields with values of 82.6, 78.2, and 76.1 Mg ha⁻¹, respectively. Without cover crop exhibited yields 74.3 Mg ha⁻¹. Further studies are necessary to determine the location and specific models using CA to fit the best cover crop (mulching). Figure 4 show the influence of cover crop on vegetables:
Zucchini (Cucurbita pepo L.), total yield, above ground crop residues biomass and weed biomass (Canali et al. 2013)

Canali et al. (2013) conducted research by applying treatments as: control (no cover crop), green manure (green manured barley) and roller crimper (flattened barley mulch Obtained by ILRC technique) in organically managed systems, vegetable cropping systems in Mediterranean, a two-year field experiment in Central Italy, transplanted zucchini growing in 2010 and 2011. Roller crimper is machine tools to make it easier to apply cover crop (mulch). So ones of CA principles “using cover crop” on a large scale can be easily performed and proved to be better.

Whereas in another experiment that lasted just as long in treatment between the experimental plots with cover and without cover crop on various vegetable crops addressing trends are not significantly different results. Accordance with kosep CA where at the beginning of the application of the concept of trend crop yields will decline and rise again after 2-3 years of continuous application of CA. As Edralin et al. (2012), assessed the difference in vegetable crops using cover crop and non-crop cover. It indicated that there were not differed significan in vegetable yield except Okra. Use of cover crop as one of the CA application can usually be done at the beginning of lowering the yield (FAO 2013), but in this study showed good results and can do further research to better known for the long-term results.

Cover crop management effect on soil temperature were also reported by many authors in different pedological and climatic conditions and often identified as potential cause of poor planting and yield reduction (Altieri et al. 2011; Luna et al. 2012). The reduction of average daily soil
temperature determined neither lower above ground biomass nor yield reduction of zucchini and could indicate that in Mediterranean environment, conversely than the continental climates, reduction of summer soil temperature due to the presence of the mulch do not affect crop productivity (Altieri et al. 2011). However, the heat requirement by zucchini is considered relatively low and this finding should be verified in the case of higher heat demanding species, like melon (*Curcumis melo* L.) or water melon (*Citrullus lanatus* M.). Different cover crop treatments offer soil temperature were shown in Figure 5.

![Figure 5](image.jpg)

**Figure 5.** Mean daily temperature (°C) of the soil at 0.10 m depth of the different cover crop treatments during April–July 2010 (A). Mean daily temperature (°C) of the soil at 0.10 m depth of the different cover crop treatments during April–July 2011 (B) (Canali et al. 2013).

As far as soil moisture is concerned, the results obtained could depend by the presence of the flattened cover crop mulch that, in the roller crimper treatment, strongly reduced soil evaporation. The intermediate values observed by the green manure treatment were probably due to the presence of the cover crop residues which, even if subjected to mineralization during the zucchini cropping cycle, partially remained into the soil as well as on the soil surface, affecting soil evaporation. Furthermore, the higher presence of applicable weeds could have determined a different evaporation–transpiration, thus influencing soil water content. It is a promising technique to reduce water consumption and increase water use efficiency in the organically managed vegetable cropping systems (Schonbeck and Morse 2007). Different cover crop treatments offer soil water content were shown in Figure 6.
Cover crop which is growing well and can be applied properly on vegetable crops was *Arachis pintoi*. Mainly, farmer and researcher use *A. pintoi* as living ground cover in vegetable production, fruit orchard, plantation or legume-grass associated pasture (Kartika et al. 2009). According to Firth et al. (2002), there are several attributes, for plant in order to suit ideal ground cover such as present ground cover in low and relatively high light intensity, ability to cover soil quickly, persistence, low sward height, and have sufficient herbage mass for effective erosion control. *A. pintoi* hame almost all the attributes to be ideal ground cover. *A. pintoi* very good to reduce erosion and run off (Sugahara et al. 2001), produces dense soil cover (Neef et al. 2004), high dry matter production (Gallegos 2003; Espindola et al. 2005; Oelbermann et al. 2006), recover degraded areas (Doanh and Tuan 2004), tolerant to shade (Addison 2003), high nutritive value and low fiber content, persistence, low sward height (Firth et al. 2002), faster nutrient cycling (De Oliveira et al. 2003) and grow well in low fertility soil with minimal fertilizer, minimal irrigation and no pesticide (Bryan et al. 2001).

Several soil quality improvement has been reported, integrating *A. pintoi* as living mulches in pasture, orchard or plantation showing good results: *A. pintoi* improved soil physical properties, such as soil density, soil structure, soil moisture and porosity (Maswar et al. 2005). Associated *A. pintoi* as living ground cover with grass or under the tree, help the soil to be more productive because *A. pintoi* function as a blanket for the soil, the herbage mass cover the soil and prevent it to loose to much water from evaporation, also the root biomass improve the porosity, density and structure of the soil. *A. pintoi* improved soil chemical properties, like soil N, P, K and Ca (Oliveira et al. 2002; Duda et al. 2003; Huang et al. 2004). *A. pintoi* perform dense soil cover which can reduce erosion and leaching of some soil chemical properties and fixing Nitrogen from atmosphere thereby it can help improve nitrogen availability of the soil.
A. pintoi improved soil living properties, like greater micro fauna and source of organic matter (Badejo et al. 2002; Lanes et al. 2003; Canellas et al. 2004). Dense soil cover performed by A. pintoi help the soil to maintain the moisture of the soil, became suitable place for microfauna to live, also, A. pintoi role as organic matter source, the food for soil microfauna which degraded organic matter into inorganic properties. Some cover crops can be applied in vegetable crop production systems (Table 3).

Table 3. Recommended cover crops and green manures for the home vegetable garden (Higgins et al. 2012)

<table>
<thead>
<tr>
<th>Cover Crop</th>
<th>Sowing Time</th>
<th>Seeding Rate Per 1000 sq. ft. (16' x 10' Garden)</th>
<th>Does This Plant Fix Nitrogen?</th>
<th>Growth Rate</th>
<th>Primary Uses/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buckwheat</td>
<td>Spring, Summer</td>
<td>2 lb</td>
<td>No</td>
<td>Fast</td>
<td>Is easily worked into the soil. Attracts pollinators and beneficial insects. Re-seeds prolifically. DO NOT allow to go to seed.</td>
</tr>
<tr>
<td>Clover (Sweet)</td>
<td>Spring, Summer</td>
<td>1½ lb</td>
<td>Yes</td>
<td>Medium</td>
<td>Grows better in high pH soils than other clovers.</td>
</tr>
<tr>
<td>Oats</td>
<td>Late Summer, Early Fall</td>
<td>4 lb</td>
<td>No</td>
<td>Medium</td>
<td>Likes well drained soils. Does over the winter. Makes a good chance in areas to be worked early the following spring.</td>
</tr>
<tr>
<td>Peas (Field)</td>
<td>Spring, Early Fall</td>
<td>6 lb</td>
<td>Yes</td>
<td>Fast</td>
<td>Can outcompete many weeds.</td>
</tr>
<tr>
<td>Radish (Ohseed)</td>
<td>Fall</td>
<td>1 lb</td>
<td>No</td>
<td>Fast</td>
<td>Is easily worked into the soil.</td>
</tr>
<tr>
<td>Rye (Winter)</td>
<td>Fall</td>
<td>4 lb</td>
<td>No</td>
<td>Fast</td>
<td>Easy to grow. Good fast. Can be planted late in the season.</td>
</tr>
<tr>
<td>Ryegrass (Annual)</td>
<td>Late Summer, Early Fall</td>
<td>1 lb</td>
<td>No</td>
<td>Fast</td>
<td>Easy to grow.</td>
</tr>
<tr>
<td>Wheat (Winter)</td>
<td>Late Summer, Fall</td>
<td>2 lb</td>
<td>No</td>
<td>Fast</td>
<td>Needs fertile soil. Does not like low pH soils.</td>
</tr>
</tbody>
</table>
There are several alternative cover crop that can be used in vegetable production systems. It’s important to select the suitability and fitness between the main crops (vegetables) and the cover crop with both no competition that results in lower production of major crops. Further study to see specific location diverse, it still need to do suitability assessment to carry the capacity of cover crop supporting on the main crop. Image of cropping tool in accordance with the CA principles and used in the vegetables production along with images cover crop on vegetable crops can be seen in Figure 7 and Figure 8.

Figure 7. The No-Till Planting Aid and cover crop residues helped the vegetable by conserving moisture during a hot, dry season (Schonbeck and Morse 2007).

Figure 8. The triticale cover crop (left) has accumulated about 2.3 tons/acre biomass and does not completely cover the ground. Spring weeds will likely grow through its residues before a no-till vegetable can get established. No ground is visible through the vigorous biculture of triticale + Austrian winter peas (right), which has reached 4.8 tons/acre, and will provide an effective, weed-suppressive mulch (Schonbeck and Morse 2007).
Diverse Species

Crops grown with the concept of CA is to maintain the existing biodiversity around the circumstances. Environment that is mimicked areas of primary forest that containing different species of plants. Planting multiple cropping is one way that can be done to maintain the diversity of various species / varieties of plants application (Thierfelder et al. 2012). Some part of multiple cropping is application of planting systems with intercropping, alley-cropping, agroforestry and other.

Multiple cropping not only maintaining diversity of the species but also giving some benefits such as intercropping for microclimate manipulation to aid in better crop space organization, pests and disease reduction, including counteracting measures; wind damage reduction by intercropping, and surface modification for other protective and productive purposes (Ramesh 2010). Multiple cropping can bring the best social, economic and ecological benefits, increase product yield and farmers’ income and promote sustainable development of vegetable production.

Crop rotations to improve crop yields, reduce soil erosion and input requirements, and improve resource use and farm income. Inter-crop practices to reduce soil erosion and increase soil organic matter. Mixed production systems to increase resource use efficiency and make the inclusion of pastures in the rotation more attractive. Pastures will reduce soil erosion and N requirements, and increase soil organic matter (Dogliottiet et al. 2004).

Intercropping is commonly used in tropical parts of the world and by indigenous peoples throughout the world. Many findings suggest that intercropping encourages biodiversity or abundance of natural enemies, such as spiders or parasitoids, increases the crop quality, reduces soil erosion and improves nitrogen fixation. Therefore, many ecologists and entomologists advocate intercropping in integrated pest management systems for suppression of insect pests (hongjiao et al. 2010).

Another technique that can be used to maintain the diversity of species is crop rotation with various species and use different plants which must have a mutually symbiotic. This technique has a maximum frequency of groups of related crops and minimum period in years between crops of the same group (Dogliottiet et al. 2004).

Dansi et al. (2008) stated that more than 187 leafy vegetable species belonging to 141 genera and 52 families were recorded in Benin Republic. Those various species is regularly planted by applying multiple cropping and annual rotation between species. Examples of crop disperse species by applying multiple crop rotation system is shown in Table 4. The importance point is the crops need to be selected properly in order to avoid competition for nutrients and disease emergence.
Table 4. Crop rotation sequence and seeding/planting rates (Overstreet et al. 2010).

<table>
<thead>
<tr>
<th>Growing season</th>
<th>Rotation</th>
<th>Summer crop</th>
<th>In-row (between row) plant spacing (cm)</th>
<th>Fall crop</th>
<th>In-row (between row) plant spacing (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>Sweet corn</td>
<td>15.2 (91)</td>
<td>Cabbage</td>
<td>35 (100)</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>Cucumber</td>
<td>36 (152)</td>
<td>Cabbage</td>
<td>35 (100)</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>Tomatoes</td>
<td>46 (152)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>Sweet corn</td>
<td>15.2 (91)</td>
<td>Cabbage</td>
<td>35 (100)</td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>Cucumber</td>
<td>36 (152)</td>
<td>Cabbage</td>
<td>35 (100)</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>Tomatoes</td>
<td>46 (152)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>Peppers</td>
<td>46 (152)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>Yellow squash</td>
<td>46 (152)</td>
<td>Broccoli</td>
<td>35 (100)</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>Tomatoes</td>
<td>46 (152)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>Peppers</td>
<td>46 (152)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Another application which is closely related to CA systems is Agroforestry cropping models. Agroforestry is a dynamic, ecologically based, natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for all land users at all levels (World Agroforestry Centre, 2013).

The vegetable-agroforestry system (VAF) is a viable farming entity that integrates vegetables in a tree-based system or vice versa. It offers multiple benefits, including provision of micronutrients to the diet of rural communities and enhancement of on-farm biodiversity and environmental sustainability (Catacutan and Duque-Piñon, 2007; Catacutan et al. 2012).

Vegetable production systems is usually carried out in the mountainous areas, and only a small part that apply conservation systems (Sidle et al. 2006). Cultivation area is closely related to land typology, slope, and the selection of the best suitable vegetable crops. In terms of conservation,
vegetable forestry system is proved better than monoculture which intensively cultivate the soil and decreased fertility (Susila et al. 2012).

Farming practices in some Vietnam Upland areas still are unsustainable land uses that form a vicious circle of shorter crop cycles, no fallow and no protective soil cover during the onset of the rainy season, leading to soil erosion, declining yields and unstable livelihoods. Water scarcity further aggravates the difficulty of sustaining crop productivity and incomes. Starting in 2011, Agroforestry for Smallholders’ Livelihoods in Northwest Vietnam, seeks to improve the performance of smallholders’ farming systems through agroforestry. The goal is to establish more diverse and sustainable production systems and better income from tree products (Hoang et al. 2013). Whereas, vegetable Agroforestry system have been applied more than fifteen year ago on the most upland areas in Indonesia especially in coffee plantation (Iijima et al, 2003).

Manurung et al. (2007) stated, there is opportunity to expand vegetable production in the understory of agroforestry system, but farmers have limited experience with such practices. Some advantages can be taken by smallholder farmers by intensifying agroforestry systems for vegetables cultivation as following: 1) restoration of degraded lands, 2) reduction of insect or disease damage, 3) market risk may be reduced by growing a variety of products, 4) produce facilitative interactions, 5) improving individual-timber tree growth rate and stem quality, and 6) increasing carbon and nutrient sequestration. Intensifying without adding cost of production is the main purpose of smallholder farmers. Vegetable production under agroforestry systems shade is a viable option for smallholder farmers, however more intensive species-specific and site-specific management is required.

Figure 10. Vegetable under cinnamon trees in Jambi, Indonesia
Some vegetables showed a good performance on growth (height and diameter) and production in the mixed fruit-timber-bananas-annual crop systems and the mixed fruit-timber systems compared to the full sunlight (no shading) conditions. The vegetables included were amaranth (Amaranthus sp.), kangkong (Ipomoea aquatica Forsskal), egg plant (Solanum melongena L.), chili (Capsicum annuum L.), tomato (Lycopersicon esculentum Miller), long bean (Vigna unguiculata (L.) Walp.), and katuk (Sauropus androgynus (L.) Merrill). In understory of the mixed fruit-timber-bananas-annual crop systems (under medium light level), the production of those vegetables over the no shade control (from 107.33% to 278.2%). Furthermore, those seven vegetables were able to produce at least about 42.82% of the full sunlight plot production under low light level (Manurung et al. 2007).

Adoption and implementation of sustainable biodiversity conservation are essential for sustaining protected areas. But development of effective strategies to achieve them is problematic. This is often because of limited knowledge about the impact of biodiversity conservation policies on livelihood of indigenous people (Ezebilo 2010).

Further, some analysis suggests that given the diversity of institutional, socio-economic and agro-ecological contexts, a geographically differentiated approach to CA dissemination. Immediate priorities should include a shift in research paradigms (e.g. towards more participatory approaches with farmers), development of commercially available reduced and no-till seeders suitable for smaller-scale farm enterprises, and advocacy so that decision makers understand how different policies may encourage or discourage innovations that lead towards more sustainable agricultural intensification (Kienzler et al. 2012).

Many strategies are still to be explored in overcoming this challenge in order to adapt CA at the field, farm and community level. We conclude that the benefits of CA can accrue on different soil types and across different systems, but that scaling up and out requires time and the whole community to be targeted, rather than individual farmers. Site-specific research is needed to address, understand and overcome these biophysical and socio-economic constraints at all levels (Thierfelder et al. 2013).

**CLOSING REMARK**

The principles of CA include maintaining permanent soil cover, promoting a healthy, living soil, promoting balanced application and precision placement of fertilizers, pesticides, and other crop inputs, promoting legume fallows, composting, and organic soil amendments, and promoting agroforestry to enhance on-farm biodiversity and alternate sources of income. CA provides direct benefits to environmental issues of global importance, including control and
mitigation of land degradation, mitigation of climate change, improved air quality, enhanced biodiversity including agrobiodiversity, and improved water quality.

Basically the concept of CA for horticulture has already applied, but not fully adopts the principle of CA as a whole. It needs agronomic, ecological, economical and social approach to further implement CA concept as a one prefect system and give a good impact to the sustainability of life. In addition to the component selection and cultivation of CA should always be kept adjusted to the specific conditions.

ACKNOWLEDGEMENT

We thank to Indonesian Agriculture for Research and Development Agency (IAARD), to North Carolina Agriculture & Technical State University, and to all whom involved with this review article.

REFERENCES


