Development of Conservation Agriculture in Viet Nam

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ABSTRACT

Keywords: Conservation agriculture, no-soil systems, soil erosion, crop residue, permanent soil cover, environmental pollution

Conservation agriculture (CA) aims to achieve sustainable and profitable agriculture and subsequently at improved livelihoods of farmers through the application of the three CA principles: minimal soil disturbance, permanent soil cover, and crop rotations.

CA holds tremendous potential for all sizes of farms and agro-ecological systems, but its adoption is perhaps most urgently required by smallholder farmers, especially those facing acute labour shortages. It is a way to combine profitable agricultural production with environmental concerns and sustainability and has been proven to work in a variety of agro-ecological zones and farming systems.

CA has been successfully implemented in North and South America, Africa, and Australia for many years and has brought benefits to their economy and environment.

Viet Nam is known as an agricultural country, with 75.8 per cent of its manpower involved in agriculture, forestry, and fisheries. Agricultural production is mainly manual, small-scale, and low-capacity. Yields of crops and animals are only 60-70 per cent compared with other countries in the region.

Conventional agriculture is mainly accepted in crop production with intensive and increasing crops. Development of CA is slow and unremarkable.

1. INTRODUCTION

1.1 Background of Viet Nam

Viet Nam is situated in South East Asia in the Indo-Chinese Peninsula.

Its natural area is 330,990 square kilometres, in which 7,348.5 thousand hectares or 22.2 per cent of the natural area is arable.

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Viet Nam lies in the region of monsoon, tropical weather with a high temperature of 7500^{o}C/year; rainfall volume of 1800-2000mm/year and is not evenly distributed among the months of the year. Versatile and various climates of the regions create a variety of vegetation and domestic animals, originating from the temperate area, sub-tropical, and tropical areas. Drought is experienced during the dry season and floods and storms during the rainy season.

In 33,099,093 ha of natural land, there are 7,348,449 ha of agricultural land. In the country's long-term plan, arable land of 5,523,899 ha would be utilized as meadowland for animal husbandry (1,247,161 ha); water surface for agriculture (304,274 ha and 273,115 ha).

Land used for forestry is 9,641,142 ha (29.13 per cent of natural land) of which, planted forest covers 779,438 ha and natural forest covers 8,841,704 ha. Specialized land of 1,117,697 ha, or 3.3 per cent is natural land area; inhabited land covers 773,960 ha or 23 per cent of natural land area; virgin land covers 14,217,845 ha or 42.95 per cent of natural land area.

Viet Nam is known as an agricultural country, with 75.8 per cent of its manpower involved in agriculture, forestry, and fisheries. This sector contributed approximately 23.0 per cent to the national gross domestic product (GDP) in 2002 and 21.8 per cent in 2003. The output value structure of agriculture, forestry, and fisheries in 2002 was 76.90 per cent, 4.33 per cent, and 18.77 per cent, respectively.

Viet Nam's economy is classified as one of the under-developed countries in the world. Average GDP in 2005 was only US$654 /person. Production and social infrastructures are still poor and backward.

Agricultural production is mainly manual; small-scale and of low capacity. The yields of crops and animals are only 60-70 per cent compared to other countries in the region. Market for exporting agricultural products is not stable. Prices of exports of agricultural products only equal 60–70 per cent of average export prices of other countries in the region. Deforestation rates are fast, covering 29 per cent of the whole nation.

At present, there are 10 million hectares of bare hills and empty lands which are eroded and washed, badly affecting the ecological environment.

The rate of population development is still high with an average of 2.2 per cent per year. In rural areas, this ratio is higher and is a big hindrance in economic development. Population density is 214 person/km^2.

1.2 Situation of Conservation Agriculture in the World and Viet Nam

Conventional agriculture is generally harmful to the environment. It includes practices such as burning of crop residues, deep soil inversion by tilling to control weeds, and seedbed preparation. These techniques considerably increase soil deformation by compaction, erosion and river contamination with sediments, fertilizers and pesticides. In addition, conventional agriculture techniques increase the emission of CO_2 into the atmosphere, contributing to global warming and reducing the sustainability of agriculture by lowering soil organic matter and fertility, along with further negative environmental effects (e.g., a decrease in biodiversity). In conventional agriculture, tillage operations require considerably higher inputs in machinery investment and maintenance, fossil combustibles, and labour.

CA refers to several practices which permit the management of soil for agrarian uses, altering its composition, structure and natural biodiversity as little as possible and protecting it from degradation processes (e.g., soil erosion and compaction). Generally, CA includes any practice which reduces changes or eliminates soil tillage and avoids residues burning to maintain enough surface residues throughout the year. The soil is protected from rainfall erosion and water runoff; soil aggregates are stabilized; organic matter and the fertility level naturally increase; and less surface soil compaction occurs. Further, the contamination of surface water and the emissions of CO_2 to the atmosphere are reduced, and biodiversity increases.

CA is gaining acceptance in many parts of the world as an alternative to both conventional agriculture and to organic agriculture. 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 for zero tillage, Africa and Asia with technologies such as agro forestry. CA techniques can be adapted to very different climatic and soil conditions, as well as agrarian systems.

No-tillage is now being adopted in more than 95 million ha worldwide and the technology is gaining increasing interest among farmers. The countries with the biggest area under no-tillage are the USA, followed by Brazil, Argentina, Canada, Australia and Paraguay. These are the six countries where adoption is above 1 million ha. Adoption rates are increasing faster in South America than in other parts of the world. Also, the quality of no-tillage is better in terms of permanently not tilling the soil and permanent soil cover. Adoption rates continue to be very low in Europe, Africa and most parts of Asia. Approximately 47 per cent of the no-tillage technology is practiced in South America; 39 per cent is practiced in the United States and Canada; 9 per cent in Australia and about 3.9 per cent in the rest of the world, including Europe, Africa and Asia.

Despite good and long lasting research in this part of the world, the development of CA brings a great benefit to production and environmental protection.

In Viet Nam, the development of CA is slow and unremarkable. CA is mainly accepted in production with intensive cropping systems and increasing crops.

2. OPPORTUNITIES AND CHALLENGES OF DEVELOPMENT CONSERVATION AGRICULTURE IN VIET NAM

2.1 Opportunities

Sustainable development has become viewpoints of the Party and directions and policies of the Government and was affirmed in the Resolution of the 9th National Communist Party Congress as: “Fast, effective and sustainable development, economic growth in parallel with the implementation of social progress and equality and environment protection” and "Socio-economic development along with environmental improvement, ensuring harmony between artificial and natural environment, and preserving biodiversity".

The overall and long-term objective of the agricultural and rural sector is to build up an agriculture and forestry production that is large-scale, organic, modern, efficient, sustainable, and that which has high productivity, high quality, and clear environment based on the application of advanced science and technology achievements so that they are able to meet the domestic and export demands. Government concentrates its efforts to develop an organic, sustainable agriculture industry. Therefore, development of sustainable agriculture has to be closely linked to CA techniques.

CA has successfully been developed in many countries in the world, and experiences could be learned from them.

The great number of qualified technicians, engineers, and research institutions have experienced the successful development of agricultural techniques in Viet Nam for many years.

Many advanced techniques and technologies are extensively applied in CA.

Support has been received from international organizations and governments for the development of CA techniques.

The advanced achievements and experiences in the promotion of CA in the world provide enormous information, research materials and facilities to the research and applications in Viet Nam.

2.2 Challenges

Vietnamese agricultural production is still poor and backward, manual, small-scale, low capacity and with yields of crops and animals at only 60-70 per cent compared to other countries in the region.

Conventional agriculture has been closely attached to the farmers for a very long time. It is mainly accepted in the production of intensive crops. Development of CA is slow and unremarkable.

The most important limitation in all areas where CA is practiced is the initial lack of knowledge. To be widely adopted, farmers have to clearly understand the economic, agronomic and environmental benefits of CA. This lack of knowledge and understanding among farmers is due to the following: (1) Lack of transfer of technology. Research has demonstrated that these techniques can be applied and well as their benefits, but these results have not been showed to farmers and technicians. (2) Lack of technology. The adaptation of machinery and techniques used in one country need to be disseminated in other countries. (3) Lack of institutional support. Institutions have not concentrated to assist farmers to practice CA.

3. ASSESSMENT OF DEVELOPMENT ON CONSERVATION AGRICULTURE

3.1 Soil Resources

Soil is a limited natural resource on which agrarian activities (agriculture, livestock, and forestry) are carried out. It is interconnected with other natural resources, which are also essential for human life, such as the air, water, fauna, and flora. Soil acts as the most important intermediate and regulating factor in many agricultural processes and, by extension, the environmental effects of agriculture.

If soil is well-managed, the effects of agriculture on the environment will be acceptable. If soil is badly managed, agriculture will deteriorate other resources needed by humans (water, fauna, flora, and atmosphere).

Most of the operations or practices related to traditional or conventional agriculture is anchored on soil tillage, i.e., inversion tillage using mouldboard plough or disk harrow, or vertical tillage using chisel, "spiked" harrow and other tools.

Tillage drastically alters the original structure of the soil, breaking up its natural aggregates and burying the residues of the previous crop. The bare soil becomes unprotected and exposed to the action of wind and rain. Under these circumstances, water and soil erosion and sediment runoff are likely to occur.

Soils are important reservoirs of active carbon (C) and play a major role in the global C cycle.

Soil erosion is a major environmental threat to the sustainability and productive capacity of conventional agriculture worldwide. During the last 40 years, nearly one-third of the world’s arable land has been lost to erosion and continues to be lost at a rate of more than 10 million hectares per year. Crop yields in eroded soils are lower than those in protected soils because erosion reduces soil fertility and water availability. For example, in some locations, crop yields on severely eroded soils were 9-34 per cent lower than those on slightly eroded soil. Water resources also decreased due to erosion. For example, in light textured soils, which exhibit high water infiltration rates, applying conventional cultivation results in very fine and smooth seedbed surfaces. Such are very susceptible to crusting by rain impact. Consequently, infiltration rates decrease, runoff occurs for long periods and water is lost to groundwater recharge.

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 differences in the assimilation and decomposition of soil organic matter. Gradually, 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. 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. The 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.

Most of the 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 and decomposition of soil organic matter from reduced surface soil temperatures and increased biodiversity. 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. 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.

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. 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 higher levels of 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 per cent with further reductions in greenhouse gas emissions. Other environmental benefits include reduced 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.

In Viet Nam, zero tillage and minimum tillage have initially been accepted for crops on the wetland and dry land at low levels.

Zero tillage

Zero tillage has been applied for soybean. Soybean is directly seeded by machinery into the rice field just after harvesting a summer rice crop and covered by rice straw without tillage. With extra soybean crops in the two rice crops in the rice-growing provinces of the Red River Delta in recent years, farmers obtain more income and increase on rice soil fertility. As the effective cultivation mode applied, CA in the region of greater rice production has been quickly and actively adopted.

The Agricultural Extension General Department supports farmers to develop more soybean areas and seeding machines. In 2006, in the Hatay province, 40 per cent of the area grown to two rice crops raised soybean as winter crop with zero tillage.

Figure 1. Soybeans are sowed directly to the rice field without tillage, just after rice harvest.

Minimum tillage

Wet soil for rice crops are tilled using rotary cultivator or tilling cages attached to small two-wheeled tillers with 12 hp engine (BS-12), instead of mould board ploughs mounted to big four-wheeled tractors with 50 or 80 hp engine (MTZ-52/82). The number of times the tiller is run into the rice field is reduced. Thus, cost for tilling also decreases to 60 per cent and soil quality is improved. Trafficability on the wet soil is improved.

Soil preparation for sugarcane is tilled by the no-conversion subsoiler instead of mouldboard plough attached to the four-wheeled tractor with 50 or 80 hp engine (MTZ-52 / 82). The number of times the tractor runs in the rice field is also reduced. So cost for tilling also decreases to 40 per cent and soil quality is improved,

Soil preparation for crops on the dry land such as soybean, peanut, coffee, tea, vegetable, etc., is done using a rotary cultivator instead of the mouldboard plough attached to a small two-wheeled tiller with 12 hp engine (BS-12) or four-wheeled tractor with 30 or 50 hp engine. The number of times the tractor runs into the field is also reduced. Thus, cost for tilling also decreases by 50 per cent and soil quality is improved.

3.2 Crops Residues

Crop residues are kept on the soil surface to maintain or enhance soil chemical, physical and biological properties and prevent land degradation.

In many areas of the world, crops and livestock compete for the same resources, and require proper management to meet conservation agriculture objectives. Synergistic integration of crops and livestock offers numerous advantages.

In Viet Nam, returning crop residues to soil significantly improves soil physical-chemical properties. Crop residues are traditionally removed from the field to serve multiple purposes in the household. Today, crop residues of rice, sugarcane, soybean, peanut, are available on the field for soil protection.

3.3 Cover Crops

A permanent soil cover is important to:

(1) Protect the soil against the deleterious effects of exposure to rain and sun; to provide the micro and macro organisms in the soil with a constant supply of "food"; and alter the microclimate in the soil for optimal growth and development of soil organisms, including plant roots.

(2) Improve infiltration and retention of soil moisture resulting in less severe, less prolonged crop water stress and increased availability of plant nutrients.

(3) Increase formation of humus which is the habitat for diverse soil life; creates channels for air and water, biological tillage and substrate for biological activity through the recycling of organic matter and plant nutrients.

(4) Consequentially reduce runoff and erosion.

(5) Create better conditions for the development of roots and seedling.

In Viet Nam, azolla (water-fern) on the surface of rice fields in the Red River Delta and Mekong River Delta is a good soil cover crop and supplies the rice field green manure. About 10-15 tons of green manure is needed for one hectare.

Some of the bean-family weeds are effectively grown as soil cover crops in fruit farms, coffee farms, etc.

Permanent soil cover with a mulch of PVC film for peanut production results in an increase of 30 per cent output in some peanut areas in the North provinces.

Figure 2. Peanuts are covered on the soil-surface by nylon film.

3.4 Crop Rotation

The rotation of crops is not only necessary to offer a diverse "diet" to the soil micro-organisms, but as they root at different soil depths, they are capable of exploring different soil layers for nutrients. Nutrients that have been leached to deeper layers and that are no longer available for the commercial crop can be "recycled" by the crops in rotation. This way, the rotation crops function as biological pumps. Furthermore, a diversity of crops in rotation leads to a diverse soil flora and fauna, as the roots excrete different organic substances that attract different types of bacteria and fungi, which in turn, play an important role in the transformation of these substances into plant available nutrients. Crop rotation also has an important phytosanitary function as it prevents the carry over of crop-specific pests and diseases from one crop to the next via crop residues.

The effects of crop rotation include: (1) Higher diversity in plant production and thus in human and livestock nutrition; (2) Reduction and reduced risk of pest and weed infestations; (3) Greater distribution of channels or bio pores created by diverse roots (various forms, sizes and depths); (4) Better distribution of water and nutrients through the soil profile; (5) Exploration for nutrients and water of diverse strata of the soil profile by roots of many different plant species resulting in a greater use of the available nutrients and water; (6) Increased nitrogen fixation through certain plant-soil biota symbionts and improved balance of N/P/K from both organic and mineral sources; and (7) Increased humus formation.

Crop rotation is an essential element in the success story of no-tillage expansion. Only those farmers that have understood the importance of these practices are obtaining the highest economic benefits from this system. When practiced in monoculture or even in double cropping, i.e., when the same crop or crops are repeated on the same land each year, no-tillage is an imperfect and incomplete system, in which diseases, weeds and pests tend to increase and profits tend to decrease.

In Viet Nam, there are a lot of effective systems of crop rotation, of intercrop depending on crops' condition such as: rice–soybean/maize/vegetable/potato - rice, rice – fish, soybean – maize, intercrop of sugarcane with peanut/soybean, green been / maize with sweet potato, maize with soybean.

Figure 3. Peanuts are intercropped with sugarcane.

3.5 Fertilizer Application

Nitrogen fertilizer is mainly used for rice, sugarcane, vegetables and other crops in Viet Nam. Recent research results in Viet Nam showed that there is a large potassium imbalance for paddy. For example, since one ton of paddy exploits from the soil about 20 kg K_2O, it requires 200 kg K_2O per ha for a rice annual yield of 10 tons. The nutrient depletion is also indicated not only for other major elements (N, P, K, S, and Mg) but also for micro-elements (Mo, Bo). Further, more imbalance (depletion or eutrophication) and not friendly fertilization alters the chemical and physical-chemical characteristics of the soil and destroys the microorganisms' lives. The management of the soils requires integrated practices that can increase fertility, and the nutrient and water holding capacity. Biological management of the soils can be an effective way to increase soil quality through management of biomass.

The use of large amounts of fertilizers, pesticides and irrigation help to offset the deleterious effects of erosion but in themselves have the potential for soil degradation, create pollution and health problems, destroy natural habitats, and contribute to high energy consumption and unsustainable agricultural systems.

In Viet Nam, microorganism fertilizers are widely applied for crop such as rice, sugarcane, peanut, coffee, tea. The resulting produce is of good quality.

Figure 4. Plant for manufacturing microorganism fertilizers.

3.6 Weeds

Herbicides are used for controlling cover crop and weed development. A comprehensive publication is needed that describes all the products available in the market with all their chemical and toxicological characteristics, amount to be used per hectare as well as a listing of the weeds that can be efficiently controlled by each specific product. This is very necessary information without which not only farmers, but also technicians, extensionists and scientists would have a hard time to make no-tillage work.

3.7 Forests

The 1998 Decision 661 allocated funds for the 5 Mha Reforestation Programme. Loans and ODA-funded projects contributed to the objectives of programmes 327 and 661. The National 5 Mha Reforestation Programme aims to establish five million hectares of forests from 1998 to 2010 to restore the country’s forest cover back to 43 per cent, the same percentage that was under forest in 1943. The objective of the programme is to reverse environmental degradation. At the same time, the project aims to boost the productivity of the national forestry sector. A total of 2 Mha of degraded lands are to be converted to industrial wood plantations, 1 Mha to cash crops and 2 Mha to conservation forest. About 1 Mha is to be grown through natural regeneration.

Biodiversity is reduced in conventional agriculture since bare soil for a long period of time does not provide food and shelter for wildlife at critical times. In contrast, high-residue crop production systems have been shown repeatedly to be attractive and valuable for helping several forms of wildlife to thrive in agricultural areas (birds, small mammals, reptiles and soil invertebrates especially predators of key pests).

In forestry, many new technical advances have been applied, especially the techniques of quick selection and creation of new varieties, and fast multiplication by cutting and cell culture techniques. As a result, the productivity and quality of forest plantations have received extensive improvements.

3.8 Water Resources

Soil water content is often a very important limiting factor in agricultural productivity. It has been reported by many authors that conservation techniques increase the water content in the soil profile in comparison with conventional techniques. The straw over the soil decreases soil water evaporation, while each tillage operation increases it.

Water quality is seriously impaired by conventional agriculture. Soil sediments from eroded agricultural land are by far the most important contaminant of surface water. Due to CA systems greatly reducing soil erosion (> 90 per cent for direct sowing/ no-till, > 60 per cent for non-inversion tillage), the adoption of these systems significantly improve surface water quality by reducing sediments.

Further, these systems also result in a reduction of about 70 per cent in herbicide runoff, > 85 per cent in oxidized nitrogen, > 65 per cent in soluble phosphate, and about 69 per cent less water runoff than moldboard plough, all of which are a real boon to improving water quality.

In Viet Nam, the system of water, irrigation, and drainage have basically met the demands on agricultural development in the lowland areas, but still those for dry lands and sloping areas are lacking.

4. SOLUTION FOR CONSERVATION AGRICULTURE

4.1 Conservation of Soil and Water

Soil and water conservation are important in relation to the following:

(1) Use of appropriate/improved seeds for high yields as well as high residue production and good root development;

(2) Use of various cover crops, especially multi-purpose crops like nitrogen-fixing, soil-porosity-restoring, pest repellent, etc.;

(3) Optimization of crop rotations in spatial, timing and economic terms;

(4) Transferring step-by-step monocrops to crop rotation;

(5) Design and implementation of crop rotations according to the various objectives such as food and fodder production (grain, leaf, stalks); residue production; pest and weed control; nutrient uptake and biological subsurface mixing/cultivation, etc.; and

(6) Establishment of system of water irrigation and drainage, dams, water reservoirs, etc., needed to be supplied to the crops.

4.2 Development of Biotechnology

Development of biotechnology in agriculture improves capacity and quality of crop products; promotes wide application of bio-technology and preservation of gene pools of local plant.

Biotechnology is applied as advanced techniques and technologies in agriculture.

The use of appropriate/improved seeds for high yields as well as high residue production of above-ground and below-ground parts should be considered, given the soil and climatic conditions.

The establishment of microorganism fertilizer plants supply the needed fertilizers to crops; develop the production of organic and biological fertilizers; as well as those with slow dissolubility for the development of CA.

The use of organic pesticides protects the environment.

4.3 Biodiversity

There is a need to strengthen the conservation of biodiversity in agriculture and protect the environment.

Biodiversity is reduced in conventional agriculture since bare soil for a long period of time does not provide food and shelter for wildlife at critical times. In contrast, high-residue crop production systems have been shown repeatedly to be attractive and valuable for helping several forms of wildlife to thrive in agricultural areas (birds, small mammals, reptiles and soil invertebrates especially predators of key pests).

4.4 Machinery

There is a need to develop and improve equipment and machines suitable to CA techniques,

For small- and medium-sized mechanized farms, it is recommended that farmers buy a no-tillage machine suitable for wide row crops (i.e., soybeans, maize, sorghum, sunflower) and for narrow row crops (wheat, oats, rye and green manure cover crops in general). Failure in buying a multipurpose machine puts farmers who do not have enough capital to purchase two specialized machines, in a situation where they cannot plant narrow row crops. Thus, they are not able to seed small grains or green manure cover crops and do adequate crop rotations.

4.5 Enhance Awareness on Conservation Agriculture

The most important limitation in all areas where CA is practiced is the initial lack of knowledge**.**

To be widely adopted, any new technology needs to have benefits and advantages that attract a broad group of farmers who understand the differences between what they are doing and what they need. In the case of CA, these benefits are:

(1) Economic benefits. These benefits include time savings and thus reduction in labour requirements. Reduction of costs, e.g. fuel, machinery operating costs and maintenance, as well as a reduced labour cost is also expected. Higher efficiency resulting from more output at lower input as well is expected.

The positive impact of CA on the distribution of labour during the production cycle and, even more important, the reduction in labour requirement are the main reasons for farmers in Latin America to adopt CA, especially for farmers who fully rely on family labour.

(2) Agronomic benefits. Adopting CA leads to improvement of soil productivity; increase of organic matter, and in-soil water conservation. All these result in improvement of soil structure.

The constant addition of crop residues leads to an increase in the organic matter content of the soil. In the beginning, this is limited to the top layer of the soil, but with time will extend to deeper soil layers. Organic matter plays an important role in the soil- fertilizer use efficiency, water holding capacity, soil aggregation, rooting environment and nutrient retention, all depend on organic matter.

Environmental benefits. The reduction in soil erosion, improvement of water quality, improvement of air quality, biodiversity increase, carbon sequestration are environmental benefits of CA.

Residues on the soil surface reduce the splash-effect of the raindrops, and once the energy of the raindrops has dissipated, the drops proceed to the soil without any harmful effect. This results in higher infiltration and reduced runoff, leading to less erosion. The residues also form a physical barrier that reduces the speed of water and wind over the surface. Reduction of wind speed reduces evaporation of soil moisture.

However, it should be pointed out that if farming practices are to consistently change from conventional agriculture towards CA, farmers need to be convinced that a new way of farming (conservation) is needed, which is quite different from the traditional/ conventional one that they have used for decades. For instance, new techniques for weed management and direct sowing need to be learned and farm equipment has to be adapted and/ or reorganized to correctly implement conservation techniques. Therefore, a tremendous effort at the administrative and technology transfer level is needed.

4.6 Supports from Government

There is a need to strengthen investments from Government for developing CA. Government needs to support farmers' adoption of CA in the form of financial resources for buying equipment as well as for agricultural research and extension. International cooperation requires that policies need to expand the cooperation and exploitation of international collaboration and investment for developing CA in Viet Nam.

5. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

CA aims to achieve sustainable and profitable agriculture and subsequently at improved livelihoods of farmers through the application of three CA principles: minimal soil disturbance, permanent soil cover, and crop rotations. CA holds tremendous potential for all sizes of farms and agro-ecological systems, but its adoption is perhaps most urgently required by smallholder farmers, especially those facing acute labour shortages. It is a way to combine profitable agricultural production with environmental concerns and sustainability and has been proven to work in a variety of agro-ecological zones and farming systems.

CA has been successfully implemented in North and South America, Africa, and Australia for many years and brings benefits to the economy and environment.

Viet Nam, as an agricultural country is still poor. Conventional agriculture is still mainly accepted in production in intensive cropping systems. Development of CA is slow and unremarkable. However, a number of achievements have been initially gained in the development of CA due to the strong investments on it and farmers' interest in the technology.

Recommendations

Rice is an essential crop and grows in the wetlands in Viet Nam and some countries in Asia. However, at present, there is no document mentioning the practice of CA in rice areas, especially no-tillage culture for rice.

CA will result in economic benefits at the later stages.

During the initial stage of CA adoption, some people are concerned that the technology will involve risks which would decrease product output. It is then difficult for them to accept CA. They need the active support from international organizations.

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