Actual state and perspectives of multipurpose cover crop research:Combination of mulch-purpose cover crops with zero-tillage farming

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ABSTRACT

Zero-tillage practices, designed to reduce soil erosion, have become increasingly popular in both North and South America. The development of numerous effective herbicides has contributed to the increasing prevalence of this practice. However, resource-poor farmers in developing countries who can not afford the cost of herbicides are unable to use these techniques.

An experiment in zero-tillage farming using sorghum as the main crop and mucuna bean (*Mucuna pruriens*) as the cover crop was conducted in 2003 on Ishigaki Island, Japan. Mucuna bean is a green manure used in Africa, South America and Okinawa. Adoption of both cover cropping and zero tillage practices resulted in decreased water run-off and soil erosion, as well as decreased weed dry matter, while sorghum yield increased. This indicates that a combination of zero tillage and use of cover crops has major potential as a farming system.

This idea is similar to what is called "Conservation Agriculture (CA)" which, as generally recommended by the FAO, consists of direct sowing into the soil with minimum disturbance and with maximum soil surface cover that comprises residues of previous crops. The FAO has initiated extension projects for CA in African countries, although more scientific research is still needed. In Asia and the Pacific islands, however, FAO research and extension activities are modest, and feasibility studies await appropriate introduction. The JIRCAS Okinawa Sub-tropical station is ideally positioned to act as a base for setting up an extensive international research network on this topic.

Introduction

The United States initiated zero-tillage farming research to limit soil erosion in cultivated land in the 1940s and, as a result, 19,000,000 ha are currently under zero tillage, accounting for 16% of total cultivated land (Table 1). This technique was thereafter transferred to South America. At present, zero tillage is practiced on 21% of cultivated land in Brazil and 52% in Paraguay. Crop weeding, usually controlled by herbicides, is one of the most important problems tackled by zero-tillage farming. Development of various effective herbicides has contributed to the expansion of this farming system.

Green manuring has been used to improve soil fertility since the distant past. In addition, the utility of mulch is now focused on control of soil erosion, weeds, nematodes, etc. Nowadays, green manure cover crops and mulch-purpose cover crops are under extensive research worldwide. Several states in the USA have built a list of recommended cover crop species and published manuals on their use. In Africa, the International Institute for Tropical Agriculture (IITA) has also set up a database (called Lexsys) of high-

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potential cover crops in Africa.

These two farming practices have been gradually combined, and the effective introduction of cover crops or general crops in zero-tillage farming systems has been the subject of several research studies (crop rotation) designed to reduce the use of herbicide and other agro-chemicals (integrated pest control). Zero-tillage farming without the use of herbicides, however, remains impractical, probably limiting its adoption as a farming practice by resource-poor farmers in Asia and Africa (Kyuma K. *et al*, 2001).

Table. 1. Land surface area covered by zero-tillage farming in different countriesfertilizer and from livestock excretions in one year

Country	Zero-tillage area (million ha)	Percentage of total cultivated area
USA	19	16
Brazil	11	21
Argentina	7	32
Canada	4	18 (?)
Australia	1	6 (?)
Paraguay	0.8	52

Source: FAO, 2000

Experiments on Ishigaki Island

In this context, an experiment on zero-tillage farming using sorghum as the main crop and mucuna bean (*Mucuna pruriens*) as cover crop was conducted in 2003 on Ishigaki Island, Japan. Mucuna bean is a kind of green manure used in Africa, South America and Okinawa.

The treatments are shown in Table 2. The results of combined cover cropping and zero tillage effects are summarized as follows (unpublished).

Table. 2. Experimental design of the zero-tillage trial on Ishigaki Island

0 F	1/2 F	1/2 F	1 F	1 F	0 F	Fertilizer application [1]
Zero-tillage (Z)	Zero-tillage (Z)	Tillage (T)	Zero-tillage (Z)	Tillage (T)	Tillage (T)	Soil treatment[2]
Mucuna fallow (m)			Natural fallow (n)			Previous crop

1) The amounts of fertilizers applied as 1 F were 100 kgN, 100 kgP_2O_4, and 100 kgK_2O / ha, respectively.

2) Soil treatment was conducted just before sorghum sowing.

3) Each treatment is expressed as combination of each treatment abbreviation (e.g., Mucuna fallow and Zero tillage and half fertilizer application: mZ-1/2F).

1) Effects on soil loss and water runoff: During the cropping period (March to September), the total soil loss was 42.7 ton/ha for nT treatment (average nT-0F and nT-1F). The mZ treatment decreased total soil loss by more than 95% compared to nT treatment. mT and nZ treatments showed soil losses ranging near those of the two above treatments. Mucuna cropping and the use of its mulch increased water infiltration of the soil and considerably decreased water runoff, the chief cause of soil erosion.

2) Effect on sorghum growth and yield: Sorghum grew quickly at the initial stage after mucuna cropping, either by incorporation or as a mulch. Panicle yield was the highest for mT-1/2F and mZ-1/2F. Moreover, the head yield for mZ-0F was almost the same as that of nT-1F, indicating the very marked effect of mucuna as green manure.

3) Effect on weed growth: The dry matter of weeds 6 weeks after sowing was significantly lower for mZ-1/2F and mZ-0F treatments than for the mT-1/2F and fT-1F plots. Our results indicate that a combination of zero tillage and mucuna fallow can control vigorous weed growth without application of herbicides. In fact, weeding was practically unnecessary in this treatment.

The above results suggest that a combination of zero tillage and mucuna cover crop would be a highly suitable farming system for resource-poor farmers in terms of soil erosion and water runoff, soil fertility improvement and weed control. Dissemination of this cropping system would be enhanced if another economically viable crop was available instead of mucuna. In the past, research on cover crops and zero-tillage farming has been studied separately. Zero tillage-based rotation studies need to be set up. Not only rotation but also other cropping parameters, such as weeding, agricultural machinery, and varieties are required to encourage the dissemination of zero-tillage farming.

Future perspectives

This idea is similar to "Conservation Agriculture (CA)" which, as recommended by the FAO, consists of direct sowing in the soil with minimum disturbance and with the maximum soil surface covered by residues of previous crops. The FAO has initiated extension projects for CA in African countries, although more scientific research is still needed. The FAO is trying to play the following roles (Dr. Lamourdia Thiombiano, L., FAO, oral communication):

1. Encouraging programs to generate knowledge to guide the utilization of CA;
2. Facilitating the collection and sharing of information related to CA;
3. Utilizing FAO programmes to support the adoption and local adaptation of CA;
4. Identifying field initiatives, securing funds, and providing technical support where expansion of CA is sought by member countries.

In Asia and the Pacific Islands, however, FAO research and extension activities are modest and no feasibility studies have yet been initiated (Dr. Y. Niino, oral communication).

There are still numerous topics to be studied concerning cover crops or CA.

1. Comprehensive evaluation of CA on soil erosion, soil fertility improvement, water run-off and weed control.
2. Collection and validation of chief cover crops in different agro-ecological zones
3. Studies of the conversion process from conventional agriculture to CA.
4. Techniques for restoring and developing degraded land using cover crops.

The JIRCAS Okinawa subtropical station has sufficient competency and capacity to lead research on this issue, and is thus ideally placed to create an extensive international research network for developing countries. For this purpose, information exchange is a starting point for introduction of this farming system. A manual on conservation agriculture and cover crops adapted to Asia and the Pacific Islands may be of foremost importance in the near future. These studies have the potential to contribute directly, as developmental research, to resource-poor farmers in developing countries.

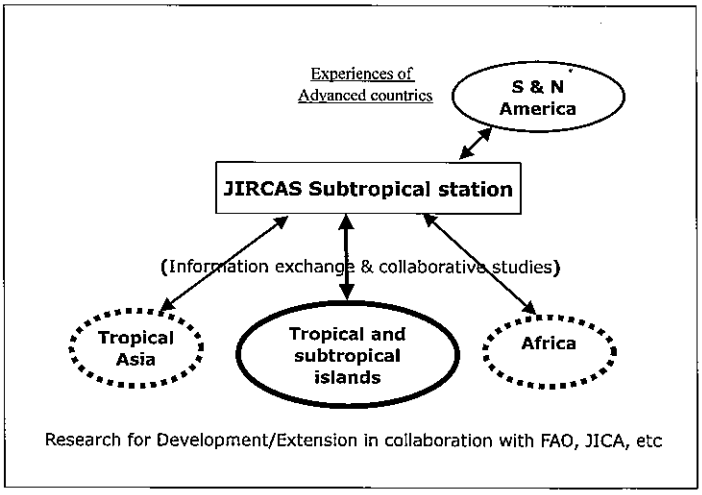

Fig. 1. Basis of Conservation Agricultural ResearchAs

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