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No-tillage Crop Production in the Tropics

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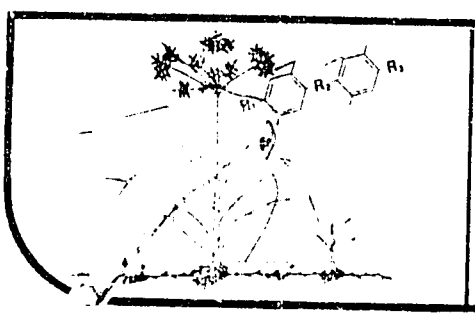

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TECHNOLOGY TRANSFER IN NO-TILLAGE CROP PRODUCTION IN THIRD WORLD AGRICULTURE

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INTRODUCTION

Heavy tillage of soil is quite recent in the long history of agriculture. The earliest systems of crop production were essentially no-tillage (Phillips, et al., 1980) and, in many less developed countries, minimum tillage is widely practiced today.

Tillage was introduced into farming systems for weed control, seedbed preparation, and for some supposed value of loosening the soil. Many experiments in the United States, starting in the 1880's and continuing to the present, have shown that the main value of cultivation of the soil after planting is for weed control (Sturtevant, 1884; Thompson, 1927; Robinson, 1964). More recent work on complete no-tillage including no land preparation has shown that crop yields can be achieved that are at least equal to those from conventional tillage, and that there are many advantages for this system (Allen, et al., 1975; Unger and McCalla, 1975; Shenk and Locatelli, 1980; Gingrich, et al., 1981; Lal, 1981).

The large number of herbicides available now makes possible the practice of no-tillage on many crops in extensive areas of the world. Notably, no-tillage is increasing rapidly in the countries considered to have a high

level of agricultural technology. But what is the situation in less developed countries? To quote Shenk and Locatelli (1980): "Ironically, pressure to increase productivity or economic efficiency is resulting in widespread acceptance of reduced tillage systems in countries with highly developed agricultural technology, while in many countries with less developed technology, where reduced tillage has been practiced for centuries, the adoption of highly mechanized technology is frequently being advocated."

It should become clear that, with help from herbicides, small farmers in the tropics can have the most advanced crop production systems paralleling those practiced by large farmers in developed countries. Minimum changes are needed and at relatively small cash cost. Certainly, the introduction of expensive tillage equipment and large tractors is a big step backward.

Before discussing the systems and technology involved, the possible advantages and disadvantages of no-tillage should be stated:

Possible Advantages of No-tillage

(1) can be used on hilly, rocky, rough land where animal or tractor tillage is difficult or impossible;

(2) reduces the fuel, animal and human energy required in crop production (Allen, et al., 1980; Nalewaja, 1980).

(3) requires smaller, less expensive equipment (Phillips, et al., 1980);

(4) greatly reduces both water and wind erosion of the soil (Mannering, 1979; Lal, 1981);

(5) conserves soil moisture (Lal, 1981; Gingrich, et al., 1981);

(6) conserves soil organic matter (Lal, 1981);

(7) may improve soil structure (Johnston and Sullivan, 1949; Lal, 1981);

(8) leaves mulch on the soil surface which reduces weed germination, avoids stimulating germination of weeds seeds through burning, and does not bring new weed seeds to the surface;

(9) lowers soil temperature and reduces daily fluctuations which favor the growth of many crops in hot climates (Lal, 1981);

(10) saves time and moisture in critical planting periods by reducing "turn around time" between harvest of one crop and planting of the next one (Allen, et al., 1975; Gingrich, et al., 1981);

(11) allows for optimum spacing between plants to obtain maximum yields (Bleasdale, 1963);

(12) eliminates injury to crop plant roots caused by between-row mechanical tillage and hand weeding (William and Warren, 1975; Hamdoun and El Tegani, 1977);

(13) reduces incidence of certain soil-borne diseases due to lack of spreading by equipment and injury to plants which favors infection (Green, 1980[1/]; Norris, 1981);

(14) may reduce certain insect problems (Edwards, 1979; Shenk and Saunders, 1981).

Possible Disadvantages of No-tillage

(1) may increase some insect, disease, and other pest problems (Unger, et al, 1977; Edwards, 1979; Unger and McCalla, 1979);

(2) can cause perennial weed population increase unless the system used effectively controls them (Triplett and Lytle, 1972);

(3) may cause more water to be lost by runoff if little or no surface mulch is present (Robinson, 1964).

REQUIREMENTS FOR A NO-TILLAGE SYSTEM

The systems used in no-tillage will vary greatly with the crop, climate, soil, topography, and economic situation. However, there are certain general requirements which include: 1) weed control without stirring the soil; 2) a surface mulch of crop residues and/or added mulch; 3) a system for planting through the mulch with a minimum of soil disturbance; 4) appropriate fertilizer program; and, 5) control of insects, diseases, and other pests. Harvesting and storage of the crop usually do not vary greatly from present methods found with conventional tillage systems.

A. Weed control

More than any other aspect, effective weed control, practiced with little or no soil disturbance, is the key to a modern no-tillage system. Prior to planting, existing vegetation must be killed. This can be accomplished entirely with herbicides, or by slashing with a machete or similar

1/ R.J. Green. 1980. Personal communication.

tool, followed by a herbicide treatment. Mulch on the surface contributes significantly toward controlling weeds. Those not controlled by the mulch can be killed by directed applications of herbicides, either between the crop plants or, for tall weeds, above the crop. Products that are especially valuable for small farmers using no-tillage systems are contact herbicides such as paraquat and translocated herbicides such as glyphosate. These two materials essentially have no soil activity; thus, calibration of application equipment is not critical. Many new selective, translocated, postemergence grass herbicides are being developed and these should be of great value in no-tillage.

Preemergence residual herbicides, widely used on large farms for no-tillage, are not as well adapted for small farms in developing countries. The need to calibrate accurately to avoid crop injury is a real problem. For flooded rice in Japan, this application problem largely has been overcome by using granular formulations. Unfortunately, these formulations are not available in most less developed countries. Another solution involves the government or private contractors applying preemergence herbicides as a paid service to the farmers, a method being used with success for irrigated cotton in the Sudan. To be used by small farmers, residual herbicides should provide a sufficient safety margin to the crop being treated and avoid danger to subsequent crops in the rotation.

Equipment required for herbicide application can be simple and low cost. Backpack sprayers are widely used by small farmers throughout the world. For directed sprays between crop rows, these can be improved by the addition of a shield around the nozzle. Granular applicators also are inexpensive and easy to operate.

There have been exciting recent developments in application equipment. The types most adaptable to small, as well as large, farms are the so-called "wiper applicators." A concentrated herbicide solution is wiped on the weeds with either hand-held or tractor-mounted equipment. The applicators can be simple, even home-made. For example, a bamboo pole wrapped with burlap and kept moist with the herbicide can be carried just above the crop to contact tall weeds. Narrow width applicators can be used between crop plants.

Herbicides that have been applied successfully with wiper equipment include glyphosate and 2,4-D. These are translocated materials, so only part

of the plant needs to be contacted to kill all of it. Other translocated herbicides, such as the new experimental selective grass killers, should be effective when applied with wipers. This method of application has distinct advantages over spraying: equipment cost is very low, spray drift is eliminated, the quantity of herbicide used is reduced since none is wasted on bare soil, and the amount of water required is small.

B. Mulch

A surface mulch is an essential component for a viable no-tillage system. Often crop and weed residues provide sufficient material. If not, surplus materials, such as rice straw, may be applied. The mulch serves to protect the soil from wind and water erosion, reduce water loss during heavy rains, reduce evaporation from the soil surface, and suppress weeds. While mulch is essential to the system, it also can create problems during crop planting.

C. Planting

On highly mechanized farms in temperate regions, special planters have been designed to cut through the mulch to place seeds in the soil. On small farms in the tropics, tools already in use, such as a sharp stick, small hoe, or jab planter, effectively plant through most mulches.

D. Fertilizer

The fertilizer most appropriate to use fits the specific crop, climate, soil, and economic situation. Nitrogen requirement under no-tillage may increase somewhat. Application to the surface is usually satisfactory since the roots in this zone are not destroyed by cultivation.

E. Pests Other Than Weeds

Some pest problems may increase, some may decrease, and others remain unchanged when comparing no-tillage to other tillage systems. However, pests must be controlled for maximum production regardless of the tillage system. The difference is that the farmer needs to be alert to changes in the pest problems. The methods of control, equipment and materials will be similar to those used in conventional systems. Resistant cultivars and appropriate pesticides will be the most common control methods.

CONCLUSIONS

A no-tillage crop production system obviously requires several changes from conventional tillage. Fortunately, many small farms in less developed countries already practice minimum tillage. With the help of modern herbicides and the latest application equipment, the advantages of no-tillage systems used in developed countries can be realized. Cash outlays can be low; only small changes need to be made in present production practices. No-tillage appears to be essential for the maintenance of soil structure and productivity in many tropical soils. Research and demonstration trials should be encouraged. The long-term gains from widespread conversion to no-tillage could be greater than from any other innovation in third world agricultural production.

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