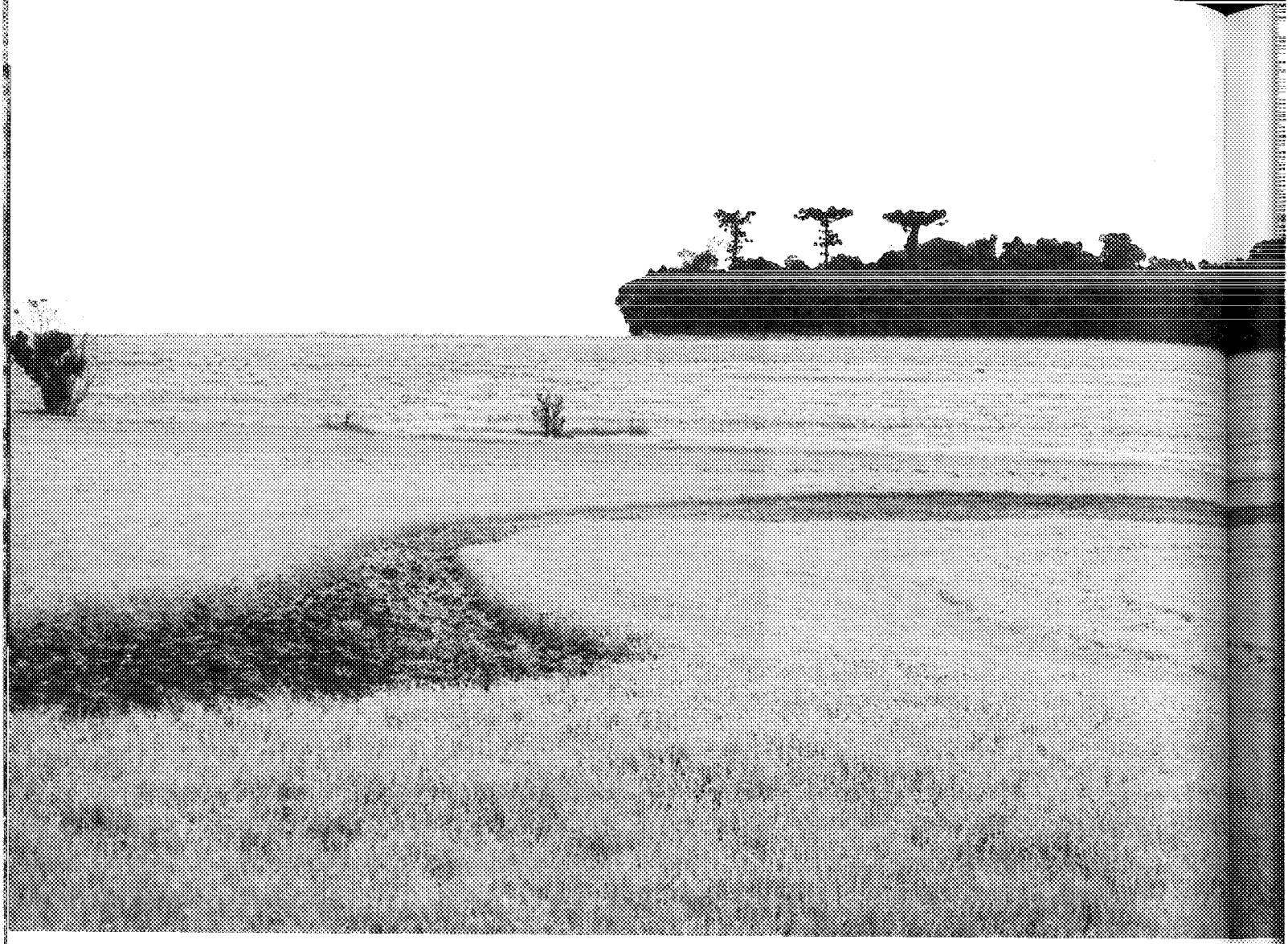

Gently sloping terrace in the Victor Graeff Watershed within the COTRIJAL cooperative near the city of Victor Graeff, Rio Grande do Sul (the Brazilian pines in the background once covered the landscape)

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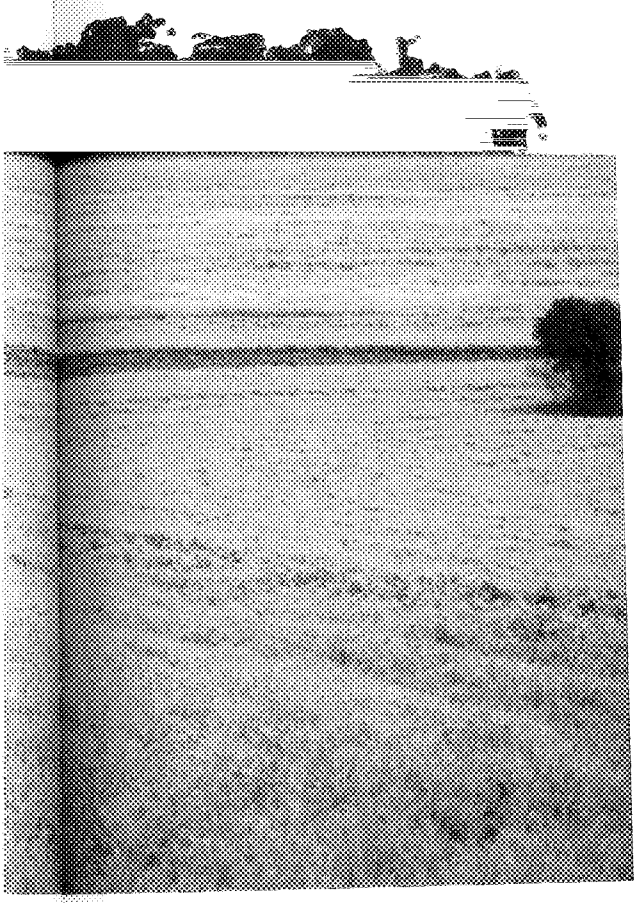
Conservation farming in southern Brazil: Using cover crops to decrease erosion and increase infiltration

Warren J. Busscher, D. Wayne Reeves, Rainoldo A. Kochhann, Philip J. Bauer, Gregory L. Mullins, William M. Clapham, W. Doral Kemper, and Paulo R. Galerani

In August of 1995, six researchers from the United States were invited to observe conservation farming systems in the mountains and rolling hills of Rio Grande do Sul, in the southernmost state in Brazil, and to its north in the state of Paraná. Southern Brazil has gained a reputation for its successes in conservation agriculture. The goal of the trip was to exchange information with agricultural research scientists and to get a first-hand look at the application of the research and technology on the farms. The group spent two weeks on visits to two federal research centers, a private research lab, and several farms and co-ops. They also attended the First International Seminar on the Direct Planting System in the town of Passo Fundo in Rio Grande do Sul.

The trip was hosted by EMBRAPA (Empre-



No-till edible black bean growing in Southern Paraná. Beans are part of a two-year, five-crop rotation

sa Brasileria de Pesquisa Agropecuária), the Brazilian Agricultural Research Corporation linked to the Ministry of Agriculture, Food Supply, and Land Reform. EMBRAPA is a federal research service akin to the Agricultural Research Service (ARS) of the U.S. Department of Agriculture. The journal *Plantio Direto* also hosted the visit. *Plantio Direto* is published byAldeia Norte Editora.

Rio Grande do Sul

The group first visited Passo Fundo, Rio Grande do Sul, an area where local researchers and farmers alike use conservation tillage and consider it a necessity in preserving and improving their farm land.

Rio Grande do Sul receives an evenly distributed annual precipitation of 63 inches (1600 mm). During the growing season, the rain is used to grow crops. Residue from previous crops and crop canopies protect soil from erosion. During the winter season, however, the rains can cause severe erosion on unprotected ground. Local farmers and researchers decided to take advantage of the winter rainfall by using it to grow cover crops. August in the Southern Hemisphere is seasonally like February in the Northern Hemisphere—a time when many fields are plowed and left bare. In the Passo Fundo area, most fields that grew summer soybeans were covered with wheat, black oat, and forage radish. Experimental and demonstration fields were also planted to winter crops of triticale and legumes such as hairy vetch.

Also while in Passo Fundo, the group visited the Centro Nacional de Pesquisa de Trigo (National Wheat Research Center). Here, 59 scientists work in genetics, crop protection, post harvest quality and protection, crop diversification, soil recovery and improvement, agricultural machinery, cropping systems, sustainability, and technology transfer. Attitudes in research labs and on farms in this area were positive toward no-tillage and conservation-tillage systems and for using cover crops.

The Victor Graeff Watershed project. Two examples of the striking success of conservation techniques in Rio Grande do Sul were METAS and the Victor Graeff Watershed. METAS was a collaborative project between EMBRAPA and agrichemical companies, agricultural machinery companies, seed companies, the extension service, and farmer cooperatives. The purpose of METAS was to promote no-tillage agriculture. METAS started in 1993 when 110,000 acres (45,000 ha) of the 2.4 million agricultural acres (1 million ha) in the state were in no-tillage systems. To date there are 1.5 million acres (600,000 ha) in no-tillage systems, four times their original goal. They attribute the success to training, demonstration plots, and technical assistance through research and extension.

One reason for the success of METAS is the Victor Graeff Watershed, which was a successful example of no-till farming on a watershed basis. Estudo Básico da Microbacia de Victor

Soybean no-till planted into wheat stubble in near Ponta Grossa, Paraná

Graeff was a pilot project to prevent erosion and clean up the pollution of the Jacui River and consequently the basin of the Guaiba River. Previously, clean tillage and burning residues led to gullies up to 100 feet (30 m) wide and 40 feet (12 m) deep. The whole community of Victor Graeff, including urban and rural residents with guidance from research and extension staff, cooperated to eliminate erosion. The mayor of Victor Graeff, also a farmer in the watershed, championed the project. The Bank of Brazil provided short-term loans to farmers; the community and co-op lent bulldozers, plows, and trucks to build terraces and close gullies; and the municipality donated labor. Together they eliminated ditches; rebuilt eroded roads; and increased infiltration with terraces, with chiseling of compacted layers, and with cover crops such as black oat. Terraces were essentially berms as tall as eight feet (2.5 m) that prevent water from flowing too far downhill. Landowners cooperated by allowing terraces and roads to cross their property lines, making erosion control more effective. Farmers planted fast-growing eucalyptus trees to help stabilize soils and provide fuel and lumber. Traditional row crop farms diversified into dairy, poultry, swine, forest, mate (a popular tea), and fisheries. The watershed had a three percent increase in cultivated land and a 25 percent increase in forestry because of eliminated gullies, ditches, and roads. They had cleaner water to drink, less flooding, and a more stable road system. In the six years between 1986 and 1992, watershed yields increased from 25 to 45 bushels per acre (1.7 to 3.0 Mg/ha) for soybean; 25 to 31 bushels per acre (1.7 to 2.1 Mg/ha) for wheat; and 47 to 70 bushels per acre (2.9 to 4.4 Mg/ha) for corn.

What caused all the erosion? EMBRAPA research showed that the severe erosion in the Victor Graeff Watershed was caused by the clearing of forests and clean tilling agricultural fields, which dropped infiltration rates from 5.3 inches per hour (135 mm/hr) to 0.008 inches per hour (0.2 mm/hr). No-till management with winter cover increased infiltration to 0.3 inches per hour (7.5 mm/hr) after four years and 1.2 inches per hour (31 mm/hr) after seven years. Organic matter in the surface soil increased from 2.5 percent to five percent and erosion decreased from 5.8 tons per acre (13 Mg/ha) to less than 0.5 tons per acre (1 Mg/ha).

Southern Paraná

Travelling 300 miles to the northeast, the U.S. scientists next stopped in Castro, Paraná. Researchers and farmers were just as enthusiastic about no tillage in southern Paraná as they had been in Rio Grande do Sul. Here, the same conservation techniques were credited with saving thousands of farms from losing their soils to erosion.

A monument to no-till farming is in the foreground; white lupin being rolled to maintain soil surface protection in the background

The ABC Foundation. In Castro, the group visited the ABC Foundation, a private research laboratory. The mission of the foundation is to help combat erosion and solve other farm-related problems. The Foundation has nine research agronomists, 27 extension agents, and 18 technicians. It was established by the Batavo Group, a conglomerate of three cooperatives: Arapoti, Batavo, and Castrolanda. The group represents more than 1,600 producers, makes more than 300 products, and has an annual gross income of US$400 million.

In the 1970s and 1980s, co-ops expanded rapidly in Brazil because of low interest rates, expanding international markets, and good prices for farm products. Soybean was a major crop for the ABC farmers. Within five years, yields began to decline because of erosion caused by clean tillage. In 1976, about the same time that EMBRAPA was formed, the Batavo Group formed the ABC Foundation. Each year a scientific council of farmers, researchers, and extension agents reviews research priorities.

The ABC Foundation, in cooperation with EMBRAPA and IAPAR (Instituto Agronomômico do Paraná—The Agronomic Institute of Paraná) provides training and research for the co-op. Foundation research currently includes new crop development, soil conservation, pasture development, soil fertility, weed control, economics, diversification, variety trials, and disease control. Among ABC's more recent developments is a rotation that produces five crops in two years: corn/dry bean/winter cover/soybean/winter cover.

Extension agents within ABC provide a link between the farmer and research, industry, and post-production processing. They work on a combination of salary and commission based on production. Extension agents are viewed as farm co-managers.

Northern Paraná

Travelling 125 miles northwest, the group of U.S. scientists came to northern Paraná. Soils in northern Paraná have not responded as readily to no tillage as have those to the south. Here, conventional no tillage leads to compaction and restricts root growth. Soil surfaces seal and reduce infiltration. Attempts to transfer techniques successful further south have given "no till" a bad name. Reduced tillage, occasional tillage, scarification (strip tillage), and perhaps some no till integrated into crop rotations have been used with limited success since 1990. The relative lack of success in regular no-till systems has been attributed to several factors, including the following: warmer climate and less evenly distributed rainfall; finer textured soils, poorer soil structure, and lower organic matter in the soil; and different management practices, such as the burning of cane fields just before harvest followed by rapid ratoon regrowth. EMBRAPA, in cooperation with farmers and state and private researchers, is working on new conserva-

Eight-foot high berm helps prevent erosion in the Victor Graeff Watershed within the COTRIJAL cooperative near the city of Victor Graeff, Rio Grande do Sul

tion systems for this area.

National Soybean Research Center. In Londrina, Paraná, the group visited EMBRAPA's National Soybean Research Center. This center has a staff of 23 PhDs, 35 MScs, and 230 field and lab technicians. Recently, they developed new soybean varieties to help open new agricultural areas in the Cerrado, a region of the States of Motto Grosso and Motto Grosso do Sul with land holdings as large as 245,000 acres (100,000 ha). Because these areas are currently developing, researchers expect new conservation techniques and new varieties to be accepted easier than in areas where existing behavior would have to change.

IAPAR. In northern Paraná, EMBRAPA cooperates with IAPAR and COCAMAR. IAPAR is a state agricultural research organization. Founded in 1972, it provides a technical basis for agriculture by adapting existing information to conditions within the state and by promoting rural development. IAPAR has three research centers and a seed production facility. They have a staff of 1,165 people; 165 are researchers. IAPAR performs research in irrigation, water quality, farm management, and renovation of eroded soils. They engineer low-draft machinery and catalog soil losses using geographic information systems.

COCAMAR, a co-op. Near Londrina is a large cooperative, COCAMAR, Cooperativa Cafeicultores e Agropecuarista de Maringá (the Coffee, Agricultural, and Livestock Production Cooperative of Maringá). COCAMAR has a 650-acre (262-ha) experimental farm where field days transfer technology to farmer members. It has a diverse product base of soybean, sugar cane, corn, wheat, cotton, coffee, manioc, oranges, canola, milk, and silk. COCAMAR has an annual gross income of US$251 million with exports of US$36 million. COCAMAR researchers see erosion as related to tillage with the disk. The co-op screens prospective members based partly on management practices but does not punish poor management of current members. The government assesses damages to a neighbor or to a stream and levies fines. Contours are expected to cross property boundaries, as seen in other areas. Surface residues are viewed as necessary to limit runoff and erosion. Non-inversion tillage is encouraged since it does not bury crop residue. The co-op has 75,000 acres (30,000 ha) in conservation tillage. Through education and demonstration, they hope to increase this to 245,000 acres (100,000 ha) by the year 2000.

Conclusions

Southern Brazil is a fascinating area where the farms and farmers are sophisticated and dedicated to conservation. The terrain varies from mountainous to rolling hills, and many farmers and agricultural researchers see some form of conservation tillage as a necessity. The U.S. scientists plan to cooperate with these successful Brazilian researchers and hope to learn from the adaptations that were made in areas where original forms of conservation tillage had not succeeded. The resolve of farmers, researchers, and extension agents in southern Brazil provides their communities with agricultural systems that are flourishing—both environmentally and economically.