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Alternatives to slash and burn agriculture in the Ichilo-Sara region of Bolivia.

Author

Barry Pound

Organisation

Natural Resources Institute
Chatham
UK

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DFID Natural Resources Systems Programme

NRSP, HTSPE, Thamesfield House
Boundary Way, Hemel Hempstead, HP2 7SR
United Kingdom

t: +44 (0) 1442 202447
f: +44 (0) 1442 219886
e: nrsp@htspe.com
w: www.nrsp.org.uk

FINAL TECHNICAL REPORT

ALTERNATIVES TO SLASH AND BURN AGRICULTURE IN THE ICHILO-SARA REGION OF BOLIVIA

R6I65CB

June 1996

Executive Summary

The project was initiated in February 1994 under the ODA Adaptive Research Initiative, as a collaboration between NRI and the Centro de Investigacion Agricola Tropical (CIAT, Bolivia). The purpose of the project was to adapt and validate technologies and participative research methodologies that enable the evolution of sustainable farming systems.

Following TeamUp project development activities a planning workshop was held in Bolivia between NRI, CIAT and Governmental and Non-Governmental Institutions from the project area. An outcome of this was an Adaptive Research Network to co-ordinate adaptive research in the project area. Over 150 on-farm technology evaluation plots were established, and a researcher managed experiment initiated. Procedures for supervision and data collection were established. Participatory workshops, field days, study tours and trainings were held with farmers, field technicians and researchers. NRI consultancies were conducted in farming systems, weed science, data handling and socio-economics. Several of these were conducted in collaboration with an ODA-supported Crop Protection Programme project.

The project was due to run until April 1996, but was superseded by a project under the NRSP F/A I from August 1995. Therefore most activities and outputs are of a start-up/preliminary nature, which will be consolidated in the follow-up project. However the 18 month project period was productive in establishing procedures and a large number of field activities. Specific outputs are:

A. Methodology Development

a) The use of participatory workshops between farmers and technicians for the planning and evaluation of technology validation trials was found to be effective.
b) The collaboration of NGOs and grass roots farmers bodies in technology development with research institutes was found to increase the number and geographical spread of trials.

B. Technology Development

a) Preliminary results indicate that cover crops such as *Canavalia ensiformis* and *Mucuna* sp are effective in providing a rapid ground cover and controlling weeds in perennial crops. However a great deal more work is needed to determine the best cover crop species and their management for particular circumstances.
b) Preliminary results suggest that cover crops sown simultaneously with, or a month after, dryland rice compete with the rice to reduce rice grain yields. Further work is needed to quantify the effects on weeds, fertility and longer term stability of cover crop/rice systems.
c) Preliminary results indicate that intercropping of perennial crops with annual and/or semi-perennial crops and cover crops can provide the basis for a stable cropping system with sequential cash and food outputs.

Contribution of Outputs to Project Goal:

Because of the short-term nature of the project, outputs have not contributed *directly* to the RNRRS project goal of increasing productivity and productive potential of F/A I production systems. However the groundwork has been done to establish a methodology and institutional conditions for contributing to the goal. Technical approaches have also been identified that will be followed up in the extension to this project.

Background

Agricultural production which is dependent on the clearing of forest land (usually logged natural forest or long-term forest fallow) is common to many countries of the humid tropics. This shifting (slash and burn or swidden) agriculture results in the reduction of forest cover as only a proportion of the cleared land is returned to forest. In Bolivia, and in other countries, rise in populations through immigration and natural increase from 1-5 people per sq.km. to 5-50 per sq.km over the last 40 years has resulted in rapid reduction of forested cover and the degradation of soil, water and bio-diversity resources. In order to conserve forest resources and to provide farmers with long-term stability and economic well being it is necessary to develop farming systems that allow farmers to produce sufficient food and/or incomes from permanent holdings on a sustainable basis. This accords with the CIAT (Bolivia) strategic plan for 1990-95 which states as a main priority "the development of sustainable agricultural production systems which permit the definitive establishment of farmers on their land...." (CIAT, 1989).

An historical overview of colonisation in Santa Cruz has been compiled by Thiele (1990). Together with a recent socio-economic study by Davies (1993) these provide a good basis for understanding the social and cultural aspects of the problem. The overall dilemma of the colonist farmer in the forest fringe has been referred to as the "barbecho crisis", which translates as the "bush fallow crisis" (Thiele, 1993). In brief, newly arrived colonists clear land for crops and take between one and three harvests before returning the land to the first of several cycles of bush fallow (typically each shorter than the previous). This return to bush fallow is required to restore soil fertility and structure and to smother weeds. After some years the farmer has used all the high forest on his land and fallows become too short to maintain yields. This is the point of crisis. Many farmers sell their land and move to other forest land, thus expanding the agricultural frontier. If the land goes into grazing, this may continue to be productive for a number of years (depending on fertility and management), but normally loses fertility and is degraded by the ingress of invasive, unpalatable weeds.

The possibilities for escape from the "bush fallow crisis" have been a major focus for applied research by the British Tropical Agriculture Mission together with CIAT, as explained by Wilkins (1988) in a review paper, and in the large number of technical reports produced by the two organisations.

The basic problems are threefold. Firstly the **decline in soil fertility and soil structure**. The soils are inherently low in available phosphorus, and under heavy rainfall and high temperatures nitrogen is quickly lost by leaching and volatilisation. Nitrogen, sulphur and organic matter are also lost through burning. Micro-nutrients can quickly become limiting under acid conditions with poor organic matter buffering. The soils of tropical Bolivia have been extensively studied by Barber and Diaz (1994). A very recent study by the Santa Cruz development corporation (CORDECRUZ) and GTZ has led to a strategic plan for the use of soil (CORDECRUZ, 1994) on which much of the agricultural development planning for Santa Cruz will be based. Outside Bolivia the work of Jordan on tropical forest soils in Amazonia is of direct relevance (Jordan 1988).

The second technical factor limiting the continuous use of land for annual crops, tree crops or pasture is **weeds**. In the first growing season after bush clearance weeds are mostly easily-controlled, broad-leaved annuals. This changes progressively with time into a flora dominated by aggressive perennial grasses (Webb and Gonzales 1989). One technology that appears very promising for the simultaneous control of weeds and improvement of soil fertility in annual and perennial crops is the use of cover crops. CIMMYT and World Neighbours are active in research into a range of cover crop species such as *Mucuna, Canavalia* and *Arachis pintoi* (Buckles 1994). NRI is currently producing a database of cover crops (Kiff and Pound; in preparation). A recent publication on the Brazilian experience with cover crops (Caligari 1993) is particularly useful in identifying potential relevant species.

The third limiting factor condemning farmers to a life captured by the "bush fallow crisis" is the **lack of locally validated agricultural income generating technologies** that justify investment in the land, leading to settled agriculture. Some of the options (dual purpose cattle, hair sheep, small farmer mechanisation, fruit production) are examined in papers by Thiele (1990) and Wilkins (1988). Access to inputs (credit and genetic material) and markets are two limitations. Due to the difficulties of communication in the tropical lowlands it is difficult for farmers to reach experimental stations to see novel technologies in action. Even if they can, they are unsure if the technologies would work under their own conditions. This suggests the need for local on-farm testing of a range of options selected and assessed with the participation of farmers.

A fourth technical area to be addressed by the project is that of **Livestock Production within Farming Systems**. The proposed project will concentrate on the establishment and management of the feed resources (pasture, tree fodder and cut and carry grasses) produced on farm, and their integration into the farming systems. Work on this topic at CIAT/BTAM has gone through a number of phases (Paterson, 1994), starting with trying to establish herbaceous legumes in pasture (this proved difficult to manage); then protein or joint protein/energy banks (e.g. of Leucaena) were tried (but required too much labour where land is not a limiting factor). More recently the use of forage alleys and dispersed trees in pasture appear promising techniques for combining legumes with grasses (James Johnson, personal communication).

The present adaptive research project has started a verification plot programme (which would be expanded under the present proposal) to test the following:

- Cover crops for soil fertility maintenance and weed control in rice using *Calopogonium mucunoides*
- Cover crops (*Neonotonia wightii, Arachis pintoi, Canavalia ensiformis, Mucuna Spp, Pueraria phaseoloides, Desmodium ovalifolium*) in citrus, coffee, pineapple and macadamia
- Intercropping of annual and perennial crops
- Multi-locational testing of locally novel perennial crops (citrus, coconut, pineapple, macadamia, tamarind, mango and palm hearts)
- Renovation of pasture using smother crops
- Forage alleys (using *Flemingia, Gliricidia, Calliandra* or *Leucaena* as the hedgerow)
- Contour planting of a live barrier for soil erosion control (Vetiver, *Flemingia*, cut and carry grasses)
- Systems for the transition between bush fallow and perennial (fruit and/or timber) production without burning.

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Webb M and Gonzalez G (1989) Weed dynamics of crop yield according to cropping systems, weeding treatment and fertilizer use in the CRI, Yapacani 1986-1989. Working document No 77, Santa Cruz de la Sierra; CIAT.
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Identification of demand for Project
The project was identified following a visit by an NRI Deputy Director to CIAT (Bolivia) during which Bolivian interests were identified. This was followed up by a visit by three NRI staff who developed a project framework with CIAT staff using TeamUp methodology. The congruence of local demand for the project theme and ODA/NRI interests has been substantiated by the keenness of local GO and NGO institutions to join the project co-ordinated Adaptive Research Network.

Project purpose

The project purpose was *to adapt and validate technologies and participatory research methodologies that enable the evolution of sustainable farming systems*. The main development problems of the smallholder slash and burn farmers at the forest frontier are forest degradation, migration and lack of environmentally acceptable economic development options. Technical solutions to these problems sought by this project were to develop sustainable and economically viable farming systems with an emphasis on soil fertility and weed management, and the development of appropriate income-generating opportunities. In a complex and dynamic situation such as the project area the best chance for developing technologies that will be adopted by farmers is to work closely with them, sharing technical and local knowledge. This required the project to use, and develop, participatory technology evaluation methods suited to the circumstances of the project area.

Research Activities

Before trials were planned a number of preparatory activities were undertaken. These were:

A diagnostic survey of institutions involved in agricultural R&D in the project area, resulting in the publication: **Hoyos F** (1994). Experiencias y propuestas tecnologicas agricolas institucionales en las provincias Ichilo y Sarah. CIAT/NRI/PRODISA: Agosto 1994.

A participatory farmer/technician/researcher workshop to identify themes and methods of research, resulting in the publication of: **CIAT (1994)** Taller de Evaluacion de Parcelas de Validacion de Tecnologia; PRODISA/CIAT Julio de 1994.

A planning workshop between NRI, CIAT and local GO/NGO institutions resulting in the establishment of an Adaptive Research Network of GO and NGO institutions co-ordinated by CIAT and supported technically by NRI, and in the publication: **CIAT (1994)** Taller de Planificacion del Proyecto de Investigacion Adaptativa Ichilo-Sara (Sistemas Agropecuarias Sostenibles en los Margenes de Bosque). CIAT/PRODISA/NRI; Agosto de 1994.

Using experience from previous on-farm trials, and from CIAT commodity scientists a set of farming systems models was then developed following a number of principles (the need to maintain soil fertility, control weeds, minimise labour inputs, generate income and ensure good income flow, cover soil where possible, diversify production and gradually intensify production towards stable and sustainable farming systems). Altogether 37 farming systems models were designed, and these were discussed with farmers through local institutions.

As a result of these discussions 188 on-farm trials were initiated, of which 158 were successfully established. The majority of these trials were implemented by local institutions under the guidance of CIAT, and it was necessary to train the field staff in data collection and farmer interview and recording techniques.

A second farmer participatory technology evaluation workshop was held after the first season of the project. The proceeding were published as: **CIAT (1995)** Taller "Evaluacion de las Parcelas de Validacion de Tecnologia"; 11-12 de Abril de 1995m, and farmers field days and study tours were held with the objective of assisting farmers to observe the experience of others in on-farm and on-station trials, and to provide feedback to researchers.

A researcher-managed trial was initiated on the CIAT Regional Research Site at Quayta. The trial is entitled "Rice in Association with Different Cover Crops", and studies the positive and negative influences of growing different cover crops (*Calopogonium mucunoides*, *Vigna umbellata* and *Macroptylium axilare*) as an intercrop planted simultaneously with rice or at first weeding. Initial results indicate that planting the cover crop at the same time as the rice results in severe competition and rice yield loss. The Calopogonium appears to be the best of the three covers in

terms of speed of cover and persistence. Several management problems need to be addressed before this can be recommended to farmers, and it is expected that the follow-on project will continue the work.

The CIAT/PRODISA/NGO team implementing the project activities was supported by NRI consultancies in farming systems, weed science, data handling and socio-economics. Several of these were conducted in collaboration with an ODA-supported Crop Protection Programme project.

Outputs

The anticipated outputs of the project were:

1. Capacity of collaborating institutions in participatory research, and discipline specific expertise, enhanced
2. Technologies validated
3. Methodologies for research and diffusion refined

Output one (*Capacity of collaborating institutions in participatory research, and discipline specific expertise, enhanced)* was partially achieved through the NRI consultancies listed above. However the project was too short to radically change the attitudes of all researchers and field staff who had been used to a formal, top-down technology transfer model of research and development.

Output two (*Technologies validated)* was only partially achieved because of time constraints. It is expected that the follow-up project will build on the framework established by this project.

On-farm technology evaluation plots
188 plots were established, mostly in November 1994, of which 158 survived to the end of the project. The plots cover a wide range of component technologies, many of which are new to the farmers involved in the execution of the plots (cover crops, perennial crops and agroforestry species). Table One shows the expansion in the numbers of on-farm trials during the project period (1994-1995).

TABLE ONE: ON-FARM TECHNOLOGY EVALUATION PLOTS 1992/3 - 1994/5

Season	N° of Models	N° of Plots	N° of participating institutions
1992/1993	7	7	CIAT - PRODISA
1993/1994	14	40	CIAT - PRODISA
1994/1995	32	158	CIAT - PRODISA - PRODEPA - NGOs: (Agrosalud, Unapega, Cáritas, Cipca, Universidad NUR)

Table Two shows the institutions involved and the number of communities reached by the on-farm trials.

TABLE TWO: COMMUNITIES WITH ON-FARM RESEARCH PLOTS

INSTITUTION	N° OF PLOTS	PROVINCES	MUNICIPALITY	COMMUNITIES
CARITAS	21	Ichilo	Buena Vista	10
AGROSALUD	30	Ichilo	Yap.Buena Vista	17
CIPCA	13	Ichilo/Sara	S.Carlos/Sta Rosa	9
PRODEPA	17	Ichilo	BV/San Carlos	11
UNAPEGA	26	Ichilo	Yap.Buena Vista	18
UNIV.NUR	6	Ichilo	Buena Vista	3
CIAT	45	Ichilo/Sara	Yapacaní Buena Vista San Carlos Portachuelo	21
TOTAL	**158**			

Because the majority of plots were established in November 1994, and the project ended in August 1995, there are few results to report at this time. One clear indication however, was the large differences in speed of ground cover of different cover crops. This is shown in Table Three:

TABLE 3: DAYS TO REACH 25, 50, 75, 100% SOIL COVER FOR TWO COVER CROPS

Days to 25%	23	92
Days to 50%	31	99
Days to 75%	50	119
Days to 100%	72	148

Canavalia ensiformis ? Arachis pinto ?

The on-farm trials have only just started yielding useful data, and will be continued in the follow-up project; however it can already be stated that there is enthusiasm on the part of farmers for cover crops and for income generating perennials (citrus, macadamia and peach palm) and semi-perennials (pineapple and bananas). Preliminary results indicate that cover crops such as *Canavalia ensiformis* and *Mucuna* sp are effective in providing a rapid ground cover and controlling weeds in perennial crops. However a great deal more work is needed to determine the best cover crop species and their management for particular circumstances.

Researcher managed trials

The researcher managed trials have two objectives: a) to investigate under controlled conditions problems that arise from the on-farm plots; b) try out, at no risk to farmers, new technology introduced from outside the project area.

During the project life only one trial was established, although more are planned. The trial arose from a set of on-farm plots that tested the intercropping of a perennial legume cover crop (*Calopogonium mucunoides*) with rainfed rice, with the objective of extending the cropping period of rice from one or two seasons to several seasons before returning the land to bush fallow.. A workshop with farmers resulted in a number of suggestions from farmers for improvements to the system. These were incorporated as treatments in the trial design. Three cover crops were compared, with the covers planted either simultaneously with the rice or at the time of first weeding.

Table Four shows the effect of cover crop planting date on the extent of soil surface cover at 84 and 134 days.

Table 4. Mean % soil cover (at 84 and 134 days after sowing of rice) of cover crops established simultaneously with rice or 30 days after rice was sown

Date of estab. of cover crop	% cover (mean of 3 cover crops) At 84 days	At 134 days
Simultaneous sowing	80.71	93.84
Estab. at 1st weeding	34.35	81.33
S.E.	15.97	5.21

As shown in Table 5 although *Vigna umbellata* (Rice bean) had the best cover at 84 days, by the time of harvest, *Calopogonium* had the greatest percentage soil cover.

Table 5. Mean % soil cover at 84 and 134 days for the 3 covers

Species of cover crop	% cover At 84 days	At 134 days
Calopogonium muconoides	66.1	96.55
Macroptyilium axillare	31.2	77.34
Vigna umbellata	75.3	88.88
S.E.	5.58	10.97

There was a marked effect of all three cover crops on rice yield, with the effect being much stronger where the covers were planted simultaneously with the rice (Table 6).

Table 6. Yield of rice (gms./plot)

Cover crop species	Yield of rice (g/plot)
Calopogonium mucunoides	277.6
Macroptylium axilare	481.5
Vigna umbellata	201.9
Monocrop rice (control)	628.0
S.E.	84.03

The effect of planting date of the cover can be seen in Table 7.

Table 7. Yield of rice (g/plot) according to planting date of cover crops

Date of planting of cover crop	Rice yield (g/plot)
Simultaneous planting	298.6
Planting at 1st weeding	495.9
S.E.	57.7

The intercropping of cover crops with rainfed rice is a novel approach to the problem of the short cropping period in slash and burn systems that leads to a continuous need to chop down bush fallow or high forest. The concept needs considerable further work before a system acceptable to farmers is developed.

Output 3 (*Methodologies for research and diffusion refined*) has been addressed through the participatory techniques used by the project. These have not yet been formally assessed, and it is expected that this will form part of the follow-on project. Preliminary conclusions are that:

a) The use of participatory workshops between farmers and technicians for the planning and evaluation of technology validation trials was found to be effective.

b) The collaboration of NGOs and grass roots farmers bodies in technology development with research institutes was found to increase the number and geographical spread of trials.

Contribution of outputs

How outputs contribute to ODA development goals
Because of the short-term nature of the project, outputs have not contributed *directly* to the RNRRS project goal of increasing productivity and productive potential of F/A I production systems. However the groundwork has been done to establish a methodology and institutional conditions for contributing to the goal. Technical approaches have also been identified that will be followed up in the extension to this project.

Promotion pathways to target institutions and beneficiaries
The target institutions (CIAT and GO/NGOs in the project area) are integral to and fully involved in the project. Promotion is therefore mainly through project workshops, field days and through the distribution of publications such as those listed below. All visit reports are published in English and Spanish, and all in-country reports in Spanish.

Target beneficiaries are the smallholder farming households of the project area. Some 150 are involved in on-farm trials, while up to ten times that number attend seasonal field days. Because the local extension institutions (both GO and NGO) are part of the technology generation process, there is a direct link from research into dissemination. However it is recognised that in the follow-up project it will be necessary to monitor this process and learn from it.

Internal reports produced by the project are as follows:
CIAT (1994) Taller de Evaluacion de Parcelas de Validacion de Tecnologia; PRODISA/CIAT Julio de 1994.
CIAT (1994) Taller de Planificacion del Proyecto de Investigacion Adaptativa Ichilo-Sara (Sistemas Agropecuarias Sostenibles en los Margenes de Bosque). CIAT/PRODISA/NRI; Agosto de 1994.
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Follow-up indicated/planned

The project "Sustainable Agriculture in Forest Margins" (R6382) has followed on from this project, building on its foundation and re-orienting its focus towards strategic research. R6382 is due to run to April 1999.

B Pound

Barry Pound
[Farming Systems Agronomist, NRI]