Animal-Drawn Wheeled Toolcarriers:
Perfected yet Rejected

By: Paul Starkey

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Paul Starkey

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– management of all financial obligations to the partner-country.

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A cautionary tale of development

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Deutsches Zentrum für Entwicklungstechnologien – GATE
in: Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH

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The Author: Paul Starkey qualified in Natural Science at Oxford University and in Education at Cambridge University. He worked for some years in Malawi, before studying Tropical Agriculture Development at the University of Reading. He worked for seven years in Sierra Leone, where he initiated a national traction programme. At present he works as a consultant. His main professional interest is in the improved utilization of draft animal power and in stimulating closer international liaison in this field.

Cover: On-farm evaluation of Nikart in Mali, 1986.
Photo: Bart de Steenhuysen Piters.

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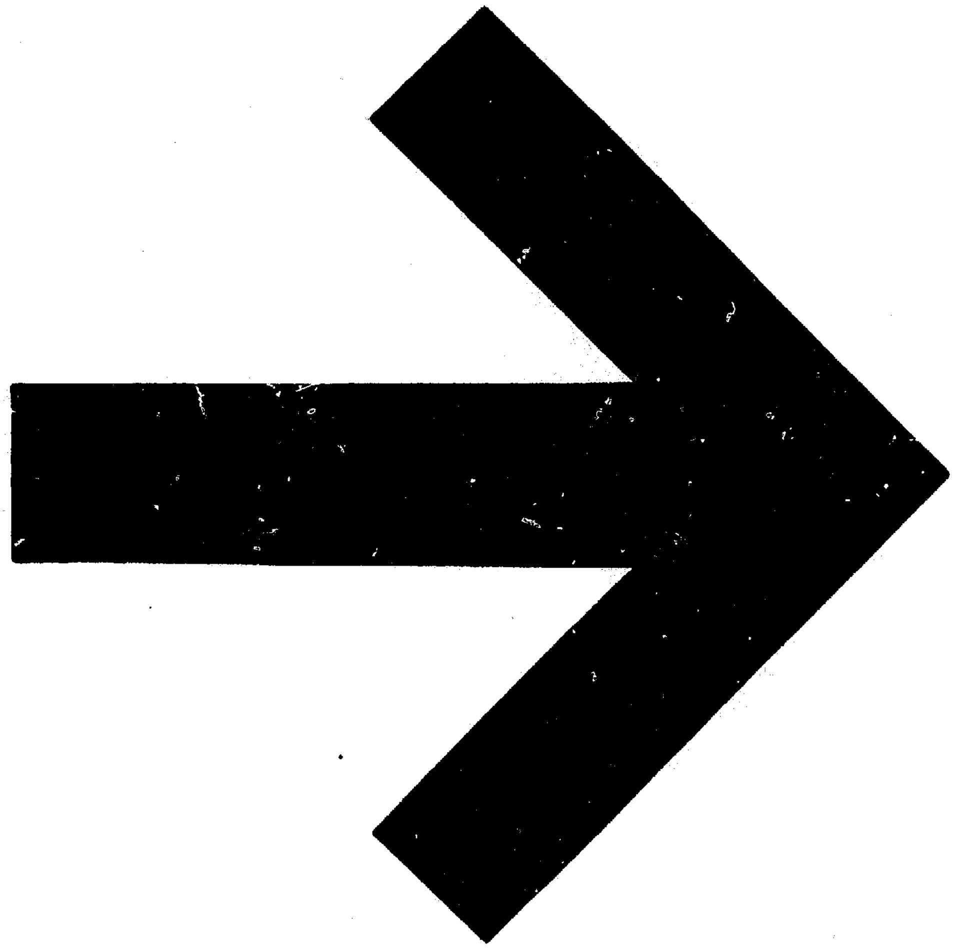

The author unravels the remarkable story of the animal-drawn wheeled toolcarrier. These implements have been universally hailed as „successful" and yet they have never been accepted by farmers. By carefully fitting together information from more than thirty different countries around the world, the author provides a detailed history of three decades of research, development and promotion.

Despite credit and subsidies the multipurpose implements that proved highly efficient in the ideal conditions of research stations have been conclusively rejected by farmers faced with reality. As institutions and aid agencies have been afraid to admit problems, reports have continued to be highly optimistic so that further organisations have gone on to sponsor wheeled toolcarrier projects.

What starts as a detailed analysis relating to animal traction broadens in scope to become a well-argued plea for more open discussion and more farmer involvement in research. The conclusion has implications for all involved in development: „negative lessons" should only be seen as „failures" if individuals and organizations ignore them.

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Preface

This book did not start as a formal research study or a publication proposal. Rather it developed from a promise made to a colleague who was contemplating ordering wheeled toolcarriers for evaluation in a West African country. The promise was to contact professional colleagues and, by means of a "networking" approach, to track down information relating to the successful use of wheeled toolcarriers by farmers. The idea was that it would save much time and money if that country learned about existing experience before it started its own work. At that stage it was naturally assumed there were successful experiences to find. So started eighteen months of correspondence and literature review in the search of successful use of wheeled toolcarriers by farmers. It slowly became apparent that everyone contacted thought that these implements were indeed successful – but somewhere else! Therefore it seemed worthwhile to put all the detective work together so that people could learn from the obvious lessons. Following discussions with Eduardo Busquets of the German Appropriate Technology Exchange (GATE), GATE agreed to sponsor the preparation of this text, and their support is gratefully acknowledged.

A great deal of the information for this book was gathered through personal correspondence and discussions and the author would like to thank the very many people who readily responded to requests for facts, impressions, illustrations and comments on sections of the draft text. These include Akhil Agarwal, Alphonse Akou, N.K. Awadhwal, Mike Ayre, Mats Bartling, R.K. Bansal, Stewart Barton, Hans Binswanger, David Gibbon, Michael Goe, David Horspool, Diana Hunt, David Kemp, Andrew Ker, Wells Kumwenda, Bill Kinsey, Harbans Lal, J.S. Macfarlane, Peter Munzinger, Fadel Ndiamé, Jean Nolle, M. von Oppen, John Peacock, Bart de Steenhuysen Piters, K.V. Ramanaiah, Franz Rauch, Eric Rempel, Marc Rodriguez, Gerald Robinson, Andrew Seager, Philip Serafini, Brian Sims, Alan Stokes, Gerald Thierstein, Gérard Le Thiec, David Tinker and Dramane Zerbo. Some of these colleagues went to great trouble to assist in this work by finding and forwarding pertinent information, documents and illustrations, and searching for, or specially taking, relevant photographs. The major manufacturers were also most helpful and valuable information was provided by CEMAG, Geest Overseas Mechanization, Mekins Agro Products, Mouzon S.A. and SISMAR.

Further information was gathered during various consultancy missions and the support of the sponsoring organizations in both authorizing and facilitating this exchange of experience is gratefully acknowledged. Many of the recent details relating to India were obtained during a visit to the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and particular thanks go to ICRISAT for providing many documents and illustrations. Experiences and opinions from several African countries were also obtained during consultancy assignments financed by the International Development Research Centre (IDRC) of Canada, and the Farming Systems Support Project (FSSP) of the University of Florida, and the support of these organizations is gratefully acknowledged. Special mention is also due to the Overseas Division of AFRC-Engineering (formerly NIAE) which has been helpful in providing photographs and commenting on the draft text.

Despite all the help received from many people, it seems inevitable that there will be some inaccuracies or errors in the text. For these the author has to be responsible himself and he apologizes in advance for any incorrect statements or impressions given. Should errors be noticed, the author would welcome factual corrections. He would also be happy to receive comments, observations and additional information on this topic. This would be particularly useful should any updated or translated edition be planned. Correspondence may be addressed to the author at the Centre for Agricultural Strategy, University of Reading, Earley Gate, Reading RG6 2AT, United Kingdom.

For those interested in the evolution of languages, it may be noted that, while standard English spellings have been used in this text, with each of two commonly used words draught/draft and plough/plow the simpler of the alternative spellings has been adopted. All four spellings have been used in the English language for several hundred years and there are both ancient and recent precedents for the shorter, simpler versions. Current North American standards arose from spellings in use in Britain two hundred years ago and there now seems little justification in English for maintaining the "ugh" spellings for these words. It would simplify terminology if international publications used one spelling, and so *plow* and *draft* have been adopted here.

Finally several colleagues warned that the subject of wheeled toolcarriers would be a difficult one to tackle, as those involved might be very sensitive to any implicit criticism of the various wheeled toolcarrier programmes. However, as should be apparent, there is absolutely no intention of censuring individuals, organizations or the toolcarrier concept itself. The objective has simply been to analyse experiences, good and bad, positive and negative, and to try to draw lessons from these. As noted in the conclusions, the question of "failure" will only arise if people do not make good use of "negative lessons". This is unlikely to be the case with wheeled toolcarrier technology as the majority of researchers and institutions involved with wheeled toolcarriers during the past thirty years have directly or indirectly assisted and contributed to this study. This has been most stimulating and it is hoped that this publication may be of value to its many contributors as well as others involved in planning and implementing development programmes.

Paul Starkey

April 1987, Reading, UK.

List of abbreviations used

ADT	Animal-Drawn Toolbar.
ADV	Animal-Drawn Vehicle.
AFRC	Agriculture and Food Research Council, U.K.
AICRPDA	All India Coordinated Research Project for Dryland Agriculture.
ATSOU	(Avant-train porte-outile universel), acronym for wheeled toolcarrier of Groupe Traction Animale, Comité d'Etudes et de Propositions, Savoje, Chanaz, France.
AVTRAC	(Avant-train traction animale), acronym for a wheeled toolcarrier design, France, 1964.
CADU	Chilalo Agricultural Development Unit, Addis Ababa, Ethiopia.
CECI	Centre Canadien d'Etudes et de Coopération Internationale, Montreal, Canada.
CEEMA	Centre d'Expérimentation et d'Enseignement du Machinisme Agricole, Samanko, Mali.
CEEMAT	Centre d'Etudes et d'Expérimentation du Machinisme Agricole Tropical, Antony, France.
CEMAG	Ceara Maquinas Agricolas S/A, Fortaleza, Brazil.
CGIAR	Consultative Group on International Agricultural Research, c/o The World Bank, Washington DC, USA.
CIAE	Central Institute for Agricultural Engineering, Bhopal, India.
CITA	Centro Investigaciones Tecnologica Agropecuaria, Nicaragua.
CPATSA	Centro de Pesquisa Agropecuaria do Tropico Semi-Arido, Petrolina, Brazil.
DLFRS	Dryland Farming Research Project, Gaborone, Botswana.
DMA	Division du Machinisme Agricole.
DRSPR	Division de Recherches sur les Systèmes de Production Rurale, Mali.
E	English language publication.
EEC	European Economic Community, Brussels, Belgium.
EFSAIP	Evaluation of Farming Systems and Agricultural Implements Project, Gaborone, Botswana.
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria, Brasilia, Brazil.
F	French language publication.
FAO	Food and Agriculture Organization of the United Nations, Rome, Italy.
G	German language publication.
GATE	German Appropriate Technology Exchange, GTZ, Eschborn, Federal Republic of Germany.
GOM	Geest Overseas Mechanisation Ltd., Boston, Lincolnshire, U.K.
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit, Eschborn, Federal Republic of Germany.
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics, Patancheru, India.
IDRC	International Development Research Centre, Ottawa, Canada.
IFAD	International Fund for Agricultural Development, Rome, Italy.
IICA	Inter-American Institute for Cooperation in Agriculture, San José, Costa Rica. (Local offices in Brasilia and Petrolina, Brazil).
ILCA	International Livestock Centre for Africa, Addis Ababa, Ethiopia.
INIA	Instituto Nacional de Investigaciones Agricolas, Veracruz, Mexico.

ITDG	Intermediate Technology Development Group, London, U.K.
kg	kilogram.
km	kilometre.
kN	kiloNewton (unit of force approximately equivalent to 100 kg)
MAMATA	Machinisme Agricole Moderne à Traction Animale (acronym used by Jean Nolle, France).
MFM	Multi-farming machine.
mm	millimetre.
M-N	Mouzon-Nolle, France.
MONAP	Mozambique Nordic Agriculture Programme, Maputo, Mozambique.
NGO	Non-governmental organization.
NIAE	National Institute of Agricultural Engineering, Silsoe, U.K. (now known as AFRC-Institute of Engineering Research).
OACV	Opération Arachide et Cultures Vivrières, Mali.
ODA (ODM)	Overseas Development Administration (or Ministry), London, U.K.
P	Portuguese language publication.
Pl	Polish language publication.
RH	Right hand.
S	Spanish language publication.
SATEC	Société d'Aide Technique et de Coopération, France.
SEMA	Secteur Expérimental de Modernisation Agricole. (Senegal).
SIDA	Swedish International Development Authority, Stockholm, Sweden.
SISCOMA	Société Industrielle Sénégalaise de Constructions Mécaniques et de Matériels Agricoles. (Predecessor of SISMAR at Pout, Senegal).
SISMAR	Société Industrielle Sahélienne de Mécaniques, de Matériels Agricoles et de Représentations. (Pout, Senegal).
TAMTU	Tanzania (or Tanganyika) Agricultural Machinery Testing Unit.
TNAU	Tamil Nadu Agricultural University, Coimbatore, India.
UDA	Unidad de Desarrollo y Adaptacion, Comayagua, Honduras.
UEA	University of East Anglia, Norwich,U.K.
USAID	United States Agency for International Development, Washington DC.
VITA	Volunteers in Technical Assistance, Mt Rainier, Maryland, USA.
WADA	Wum Area Development Authority, Wum, Cameroon.
WTC	Wheeled toolcarrier.

1. A Summary

Historically and geographically most animal-drawn implements have been devised for one major purpose. Wheeled toolcarriers are multipurpose implements that can be used for plowing, seeding, weeding and transport. Many have been designed as ride-on implements using a "bullock-tractor" analogy. Careful distinction should be made between these implements and the much lighter, cheaper and more successful "simple toolbars" without transport wheels.

Pioneering work was undertaken in Senegal in 1955 by the French agricultural engineer Jean Nolle who has since designed many wheeled toolcarriers including the Polyculteur and Tropicultor. The British National Institute of Agricultural Engineering (NIAE) produced a wheeled toolcarrier prototype in 1960 and several original designs were developed in India and Africa from 1960 to 1975.

As a result of British and French technical cooperation, early toolcarriers were tested in many countries in the world. They were actively promoted with credit and subsidies in Senegal, Uganda, The Gambia and Botswana. In all countries they were conclusively rejected by farmers as multipurpose implements and mainly became used as simple carts.

In 1974 the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) started a major programme of research involving the use of wheeled toolcarriers in a crop cultivation system based on broadbeds. This resulted in the development and refinement of two main wheeled toolcarriers, the Tropicultor and Nikart. The cropping system was very effective in the deep black soils of the research station and was promoted in several states in India. It did not prove successful at village level. Up to 1200 toolcarriers were distributed to farmers through credit and subsidies of up to 80%, but they were rejected as multipurpose implements, and most now lie abandoned or are used as carts.

Encouraging reports of the on-station successes of wheeled toolcarriers increased during the 1970s and early 1980s and stimulated much wider international interest in the technology. Significant numbers of wheeled toolcarriers were imported into Mozambique, Angola and Ethiopia and smaller quantities were tested in Cameroon, Lesotho, Malawi, Mali, Niger, Nigeria, Somalia, Zambia, Zimbabwe and elsewhere. Large scale production was started in Brazil and Mexico, with smaller numbers produced in Honduras and Nicaragua.

To date about 10 000 wheeled toolcarriers of over 45 different designs have been made. Of these, the number ever used by farmers as multipurpose implements for several years is negligible. The majority have been either abandoned or used as carts. Present prospects for these implements in Asia and Africa seem very poor. Recent initiatives in Latin America have not yet been fully evaluated, but already many of the reasons for the equipment being rejected in Africa and India have been cited as constraints in Latin America, and there is little reason for optimism.

Wheeled toolcarriers have been rejected because of their high cost, heavy weight, lack of manoeuvrability, inconvenience in operation, complication of adjustment and difficulty in changing between modes. By combining many operations into one machine they have increased risk and reduced flexibility compared with a range of single purpose implements. Their design has been a compromise between the many different requirements. In many cases for a similar (or lower) cost farmers can use single purpose plows, seeders, multipurpose cultivators and carts to achieve similar (or better) results with greater convenience and with less risk.

Farmer rejection has been apparent since the early 1960s, yet as recently as 1986 the majority of researchers, agriculturalists, planners and decision makers in national programmes, aid agencies and international centres were under the impression that wheeled toolcarriers were a highly successful technology. These impressions derive from encouraging and highly optimistic reports.

All wheeled toolcarriers developed have been proven competent and often highly effective under the optimal conditions of research stations. Most published reports derive from such experience and individuals and institutions have consistently selected the favourable information for dissemination. Published economic models have shown that the use of such implements is theoretically profitable, given many optimal assumptions relating to farm size and utilization patterns. In contrast there are virtually no publications available describing the actual problems experienced by farmers under conditions of environmental and economic reality.

The wheeled toolcarrier programmes have illustrated the dangers of research limited to research stations and domineering ("top-down") philosophies. They have also highlighted the problems of emphasizing technical efficiency rather than appropriateness, both to the needs of the farmers and to the realities of their environments. In future farmers should be involved (like consultants) at all stages of planning, implementing and evaluating programmes.

Most individuals and institutions are afraid of adverse public reaction if they report "failures". Attitudes must be changed so that disappointments are seen constructively as valuable "negative lessons". If the national programmes, the aid agencies and the international centres fail to accept this challenge, major opportunities for learning will be lost and more time and money will be wasted.

The wheeled toolcarrier story is remarkable, for the implements have been universally "successful" yet never adopted by farmers. If the lessons from this can lead to more realism in reporting, more appropriate programmes and more involvement of farmers, then the time and money spent may eventually be justified.

2. Introduction to Wheeled Toolcarriers

2.1 Geographical predominance of single purpose implements

The great majority of animal-drawn implements in use in the world today are designed for one operation. The most common implements are plows used for primary tillage. Thus in Africa there are about three million *maresha* ards in use in Ethiopia (ards or scratch plows are made by village artisans mainly of wood but generally with a simple steel share), and elsewhere in Africa about three million steel mouldboard plows are employed. In India, numbers of traditional wooden plows (ards) are put at 40 million, while there are seven million mouldboard plows in use. Comparable numbers would be in use in the rest of Asia, and in Latin America one might estimate there would be a total of five million plows in use, the majority of them of steel mouldboard designs. Although there were many millions of animal plows in use in Europe and North America earlier this century, numbers in present use are well under one million. Thus an approximate figure for the world total of animal-drawn plows would be 100 million. Other implements in use are far fewer than this.

Different designs of seedbed preparation equipment such as harrows and levellers would be second on the list, but these are not universally used as in many countries two or three passes of the plow, whether of the ard or mouldboard design are used for seedbed preparation and weed control. In most countries seed planting is performed by hand, and numbers of animal-drawn seeders would be about 0.2 million in Africa, 5 million in India and 10 million worldwide. Weeding is usually carried out using hand-held implements, and the use of animal-drawn weeding cultivators would be about 0.5 million in Africa, 2 million in India and 5 million worldwide. Some farmers will use an ard, mouldboard plow or ridger for inter-row weeding. Animal-drawn grain harvesting equipment was developed in Europe and North America in the second half of the last century, but such equipment is presently used in very few countries. The lifting of groundnuts is more common, although world use would probably be below one million. Animals are commonly used for transport, and there are about 0.2 million animal-drawn carts in use in Africa, 15 million in use in India and 35 million worldwide.

Thus geographically most animal-drawn implements in use in the world would be classified as single purpose tools, although they may have more than one function (e.g. the use of simple ard plows for primary/secondary tillage or tillage/weeding).

2.2 Animal-drawn equipment in Europe and America

At the peak of animal power in Europe and North America in the first half of the present century farmers used separate implements for plowing, harrowing, seeding, weeding, harvesting and transport. This is clearly illustrated in the nationally and internationally circulated equipment catalogues of the period. In these there were very few

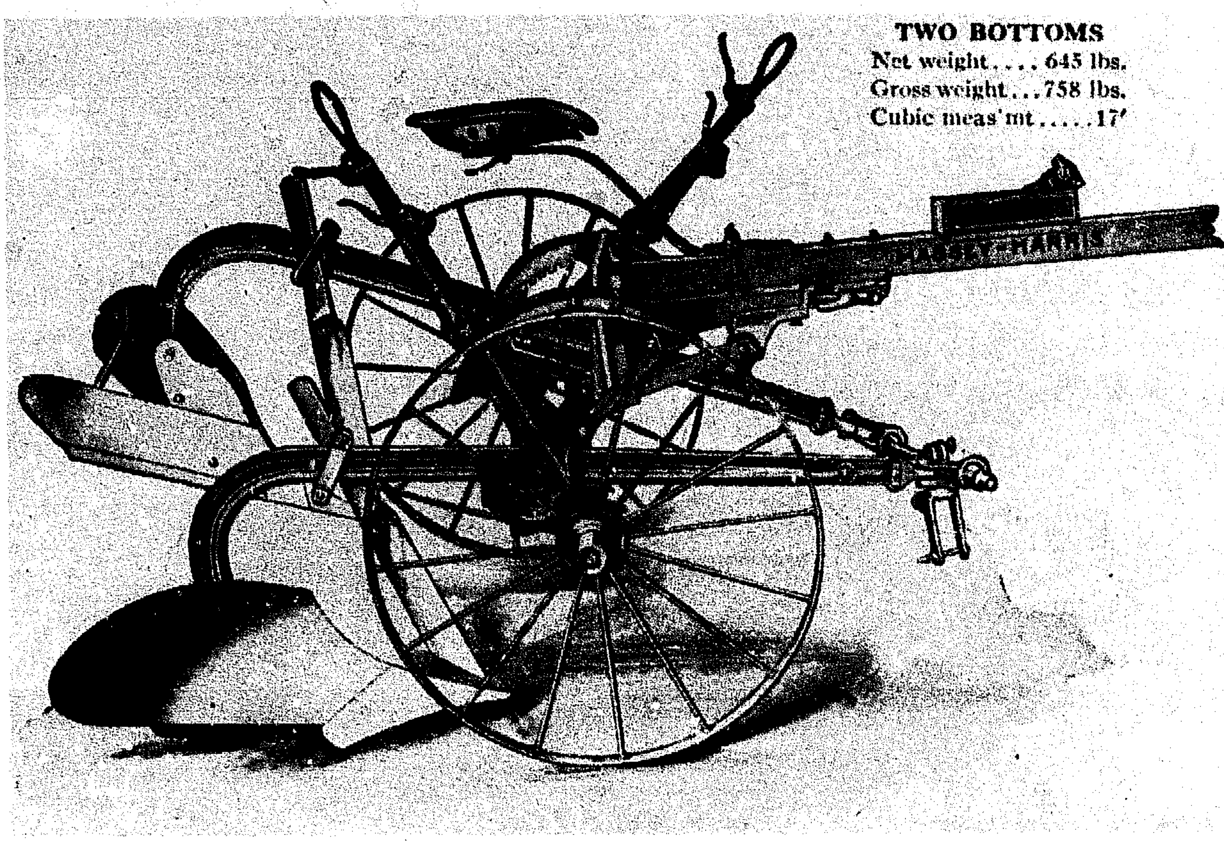


Fig. 2-1: Ride-on "Sulky" plow, Massey-Harris Catalogue, 1927. (Source: Institute of Agricultural History, Reading).

examples of multipurpose equipment, and the different manufacturers sold hundreds of thousands of single purpose implements at this time.

In the first half of this century there were several examples of wheeled weeding/cultivating implements to which could be fitted a selection of different tines. These had steel wheels and either straight axles or stub axles supporting a frame on which different combinations of tines could be mounted. Some of these were developed to allow several different secondary tillage operations. For example the British "Martins Patent Cultivator" of 1920 (fitted with an operator's seat) could be used as a three furrow ridger and the Canadian Massey Harris cultivator of 1927 could be used for inter-row weeding, full-width weeding and root-crop lifting. In Germany and Switzerland multipurpose animal-drawn implements known as "Vielfachgerät" spread to a limited extent between about 1910 and 1950 (H. Binswanger, personal communication, 1986). These steel-wheeled cultivators, such as the "Hassia Model 54" manufactured by Troster in Germany, were not ride-on implements, but were steerable from behind and could carry out a range of secondary cultivation operations including weeding, punching holes for potato planting and root-crop lifting. Seeder units could be fitted, but they were not used for primary cultivation (plowing) or for transport.

As the history of agricultural equipment is full of small scale initiatives, there may well have been earlier attempts to develop multipurpose implements for a wider range of activities. If such prototypes were developed they did not diffuse successfully for it is clear from historical records that the most common and successful animal-drawn implements have been designed for specific operations.

Fig. 2-2: Ride-on "Sulky" plow pulled by three horses in United States, from International Harvester Catalogue, 1920. (Photo: Institute of Agricultural History, Reading).

Historically plowmen have walked behind their plow guiding it. However in the latter part of the 19th century and in the first half of the present century there was a tendency in Europe and North America to design plowing, weeding and harvesting equipment that provided a seat for the operator above the working implement. For example "sulky" plows were ride-on single mouldboard plows. These were generally used with several large horses. They had two steel wheels, but unlike the straight axle multipurpose cultivators, the wheels were usually offset. These implements were easier to transport to the fields than conventional mouldboard plows, and the seat provided some operator comfort, but they required strong animals and were more expensive than conventional equipment.

With the development of tractors, ride-on farming operations became standard but farmers continued to use separate imple-

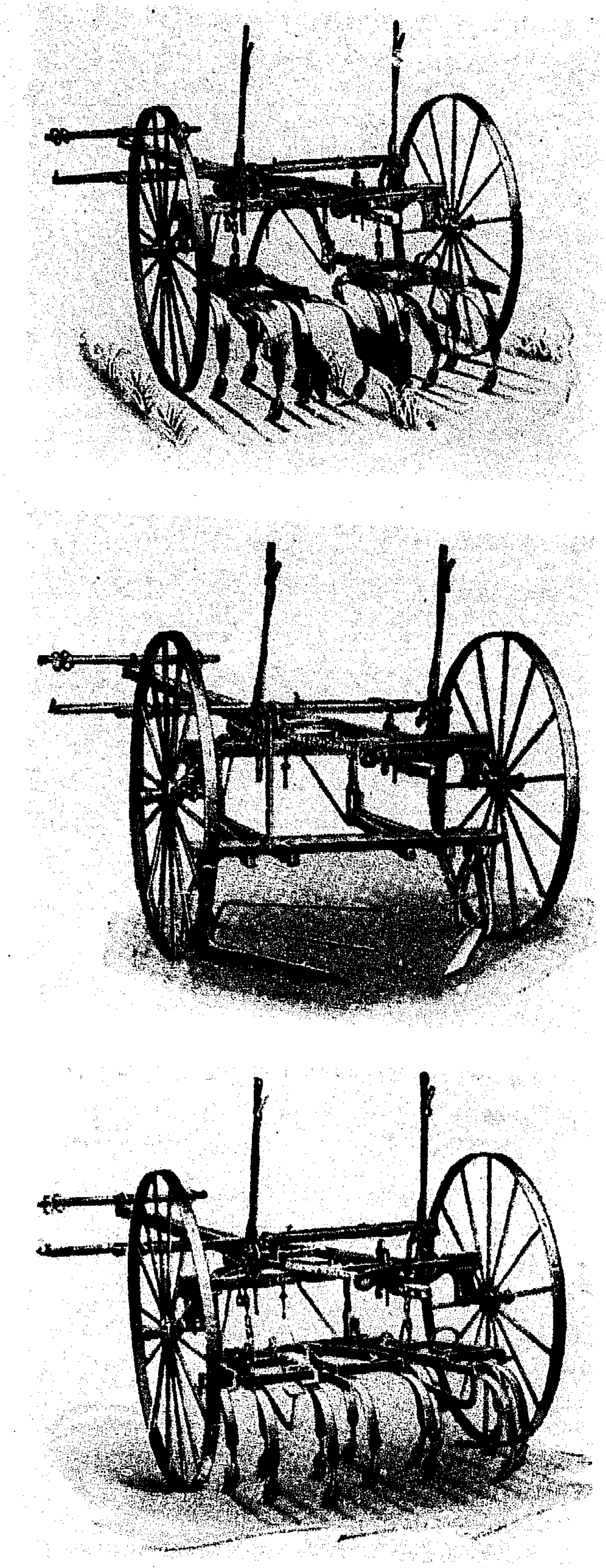
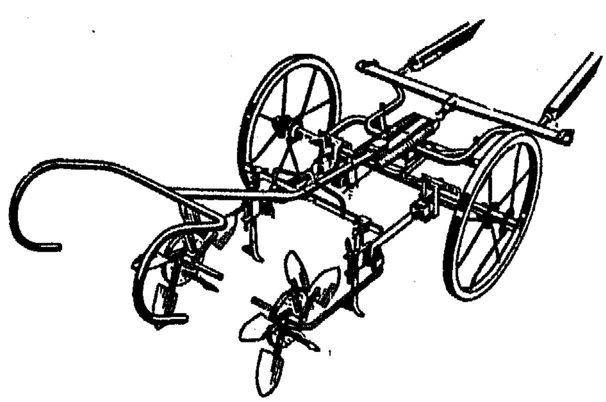


Fig. 2-3: Multipurpose animal-drawn wheeled cultivator in Massey-Harris Catalogue, 1927. a) Two-row weeder. b) Root lifter. c) Tine cultivator. (Source: Institute of Agricultural History, Reading).

ments for different tasks. In the early stages of tractor development similar equipment was pulled either by a team of large horses, or by a tractor. However around 1920–1930 toolbars were developed for the front, side and rear of tractors to which different implements could be attached. During the period 1930 to 1960 several manufacturers sold multipurpose toolbars for use with various tractors. The use of rear toolbars became common and was combined with the use of standard three-point linkages. This system had particular advantages for combining depth control during working operations with ease of transport to the field.

It was from this tractor-based concept of a toolbar combined with ride-on equipment that the idea of animal-drawn toolcarriers appears to have been developed. Some early implements were designed in such a way that they could be modified for use either with animals or with a tractor. Most early workers in the field strongly emphasised the clear tractor analogy (they were called bullock tractors in India) and stressed that these implements would assist in the rapid transition to full tractorization (Labrousse, 1958; Chalmers and Marsden, 1962; Khan, 1962; Constantinesco, 1964; Willcocks, 1969; Nolle, undated).

Fig. 2-4: Vielfachgerät Model "Hassia 54" fitted with attachment for making holes for planting potatoes. (Troster catalogue, 1957).



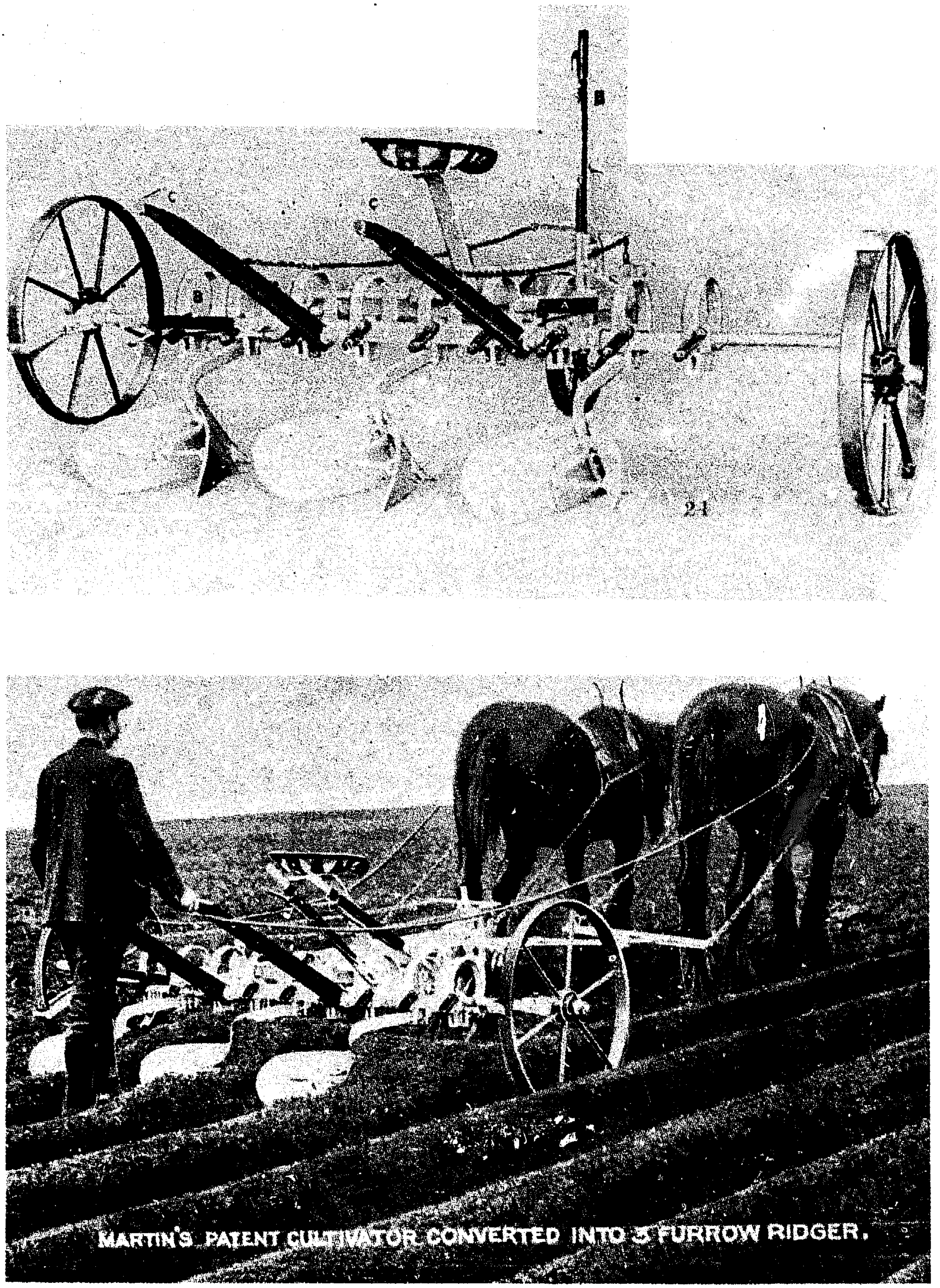


Fig. 2-5: Martin's Patent Cultivator fitted with ridging bodies, 1920. (Photo: Institute of Agricultural History, Reading).

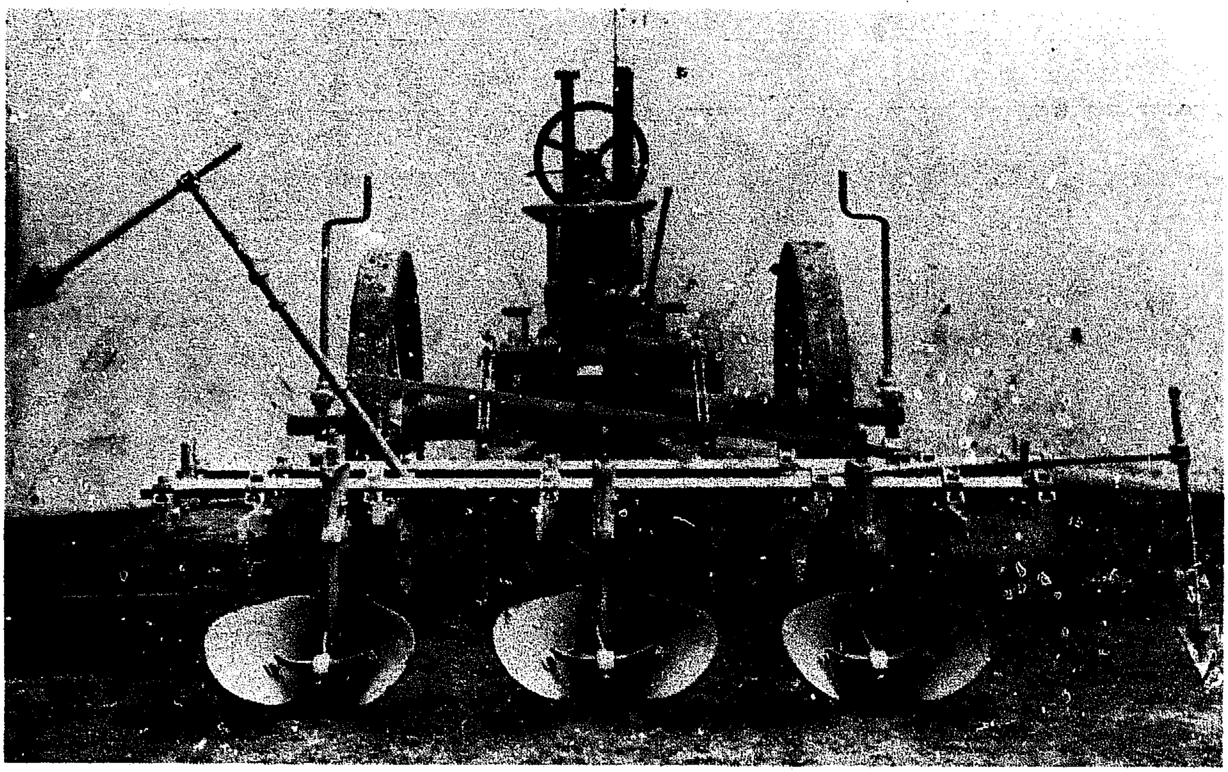


Fig. 2-6: Toolbar with ridging bodies on a John Deere tractor, 1938. (Photo: Institute of Agricultural History, Reading).

2.3 Pioneering work on wheeled toolcarriers

While there have been many different designs of multipurpose wheeled toolcarriers developed in five continents in the past thirty years, there have been three main centres of promotion and development: France, Britain and India. Prototypes and production models from these countries have been distributed throughout the developing world and have often been the basis of modified designs for local production.

During the 1950s there were several researchers working independently on multipurpose implements for use with horses on French farms (Pousset, 1982). However, much of the pioneering work on toolcarriers was carried out in Africa by the French agricultural engineer Jean Nolle, who has recently published a detailed and semi-autobiographical account of his innovations during the period 1955 to 1985 (Nolle, 1986). Nolle attempted to develop his three principles of simplicity of design, multipurpose use and standardization of components into a philosophy to which he later gave the acronym MAMATA (Machinisme Agricole Moderne à Traction Animale).

Jean Nolle's first design developed in Senegal in 1955. "Le Polyculteur Léger" incorporated many of the the characteristics found in present day wheeled toolcarriers. It comprised a metal chassis and drawbar supported on two wheels with pneumatic tyres. There was an operator's seat and a handle for raising or lowering the implements that included a mouldboard plow, up to three seeders, flexible tines, groundnut lifter, harrow and ridger. A platform could be fitted to make the toolcarrier into a cart. As will become apparent, this first design made in Senegal was the basis for many more designs in subsequent years.

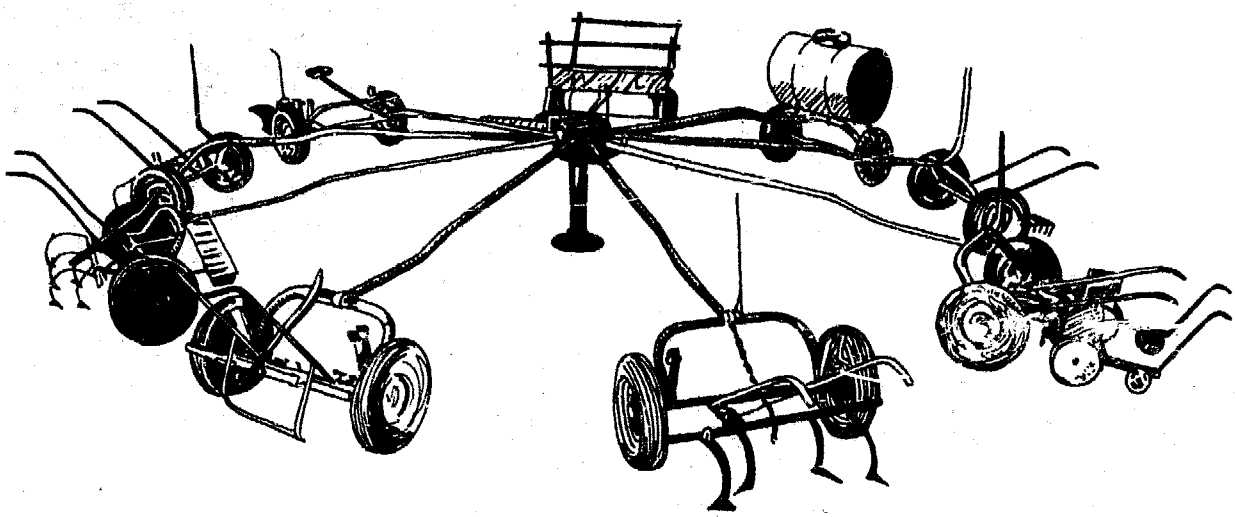


Fig. 2-7: "Polyculteur Attelé Nolle" from publicity leaflet c. 1962.

In the late 1950s there was no large agricultural implement factory in Senegal (this was established in the early 1960s) and French manufacturers, notably Société Mouzon, were quick to see a potential market. Thus the first large-scale production of Nolle's polyculteur design was in France, and wheeled toolcarriers were shipped from France to Senegal and many other countries. Having left Senegal in 1960, Jean Nolle travelled extensively in Africa, Asia and Latin America and continued to expand his range of designs. In the early 1960s he worked on a series of more complicated toolcarriers de-

Fig. 2-8: Nolle Hippomobile used as "Sulky" plow in France, 1961. (Photo: Jean Nolle).

signed to be pulled by up to three horses, primarily for use in France. Prototypes were known as "hippomobiles" and a total of fifty toolcarriers derived from this design were manufactured by the French company Mouzon under the acronym AVTRAC. These had tractor style three-point linkages that could carry a range of implements including reversible plows.

From 1962 and 1963 following visits to Madagascar and Uganda, Nolle developed the "Tropicultor" which was to be his most important design of wheeled toolcarrier and one that he was continually to modify and refine during the next twenty years. This wheeled toolcarrier was initially called the Tropiculteur, but Nolle himself changed this to Tropicultor, a name designed to be international and more acceptable to speakers of English and Spanish. The principles of the Tropicultor were similar to his previous designs, and they could take a wide range of up to twenty different implements, including plows, seeders, cultivation tines, groundnut lifters and ridgers. They could all be used as basic carts, and some were modified for specialist applications such as logging, pesticide application and even (using a petrol motor) for mowing and harvesting. The Tropicultor had a chassis of tubular steel bowed upwards to give high ground clearance for weeding operations. The Tropicultor had independently adjustable wheels, a raisable, adjustable bar for tool attachment and a metal drawbar with adjustable angle (Nolle, 1986). The Tropicultor and its derivatives became the most widely manufactured design of wheeled toolcarrier, accounting for over half of world sales.

In 1982 Jean Nolle refined his Tropicultor concept still further, and created the "Polynol", which incorporated several design improvements on the Tropicultor and could take thirty different implements. However this more expensive version of the Tropicultor was not commercially successful, and only thirty were sold by Mouzon between 1982 and 1987.

Derivatives of Nolle's early work have now been commercially manufactured in France for thirty years and due to Nolle himself, the manufacturers, the agricultural engineering centre for tropical countries (CEEMAT) and many bilateral and multilateral aid projects, France became the primary focal point in the history of wheeled toolcarriers. Jean Nolle himself has carried out development and advisory work in 72 countries.

Nolle (1985) observed that the English had been quicker to realize the significance of his innovative Polyculteur design than the French. Certainly in 1958, only a few years after Nolle's early work in this field, the National Institute of Agricultural Engineering (NIAE) in Britain started work on its own design of wheeled toolcarrier. NIAE (now known as "AFRC-Engineering", the Institute of Engineering Research of the Agriculture and Food Research Council) subsequently became the second world focal point of wheeled toolcarrier development, and continued to be closely associated with this technology for the next twenty five years. The NIAE toolcarrier (sometimes known as ADT – animal-drawn toolbar) had some basic similarities with the Nolle designs in that it also comprised a steel chassis and drawbar supported on pneumatic tyres, that could be converted for use as a cart. There was an operator's seat and a pivoting toolbar that could be raised and lowered, onto which was attached a variety of cultivation equipment. The objective of the NIAE design was to provide "a simple means for a gradual breakaway from hand work and traditional implements" that would "help the farmer to become toolbar minded and eventually ready for full mechanization" (Chalmers and Marsden, 1962; Willcocks, 1969). In the early development stage NIAE considered putting emphasis on the use of single

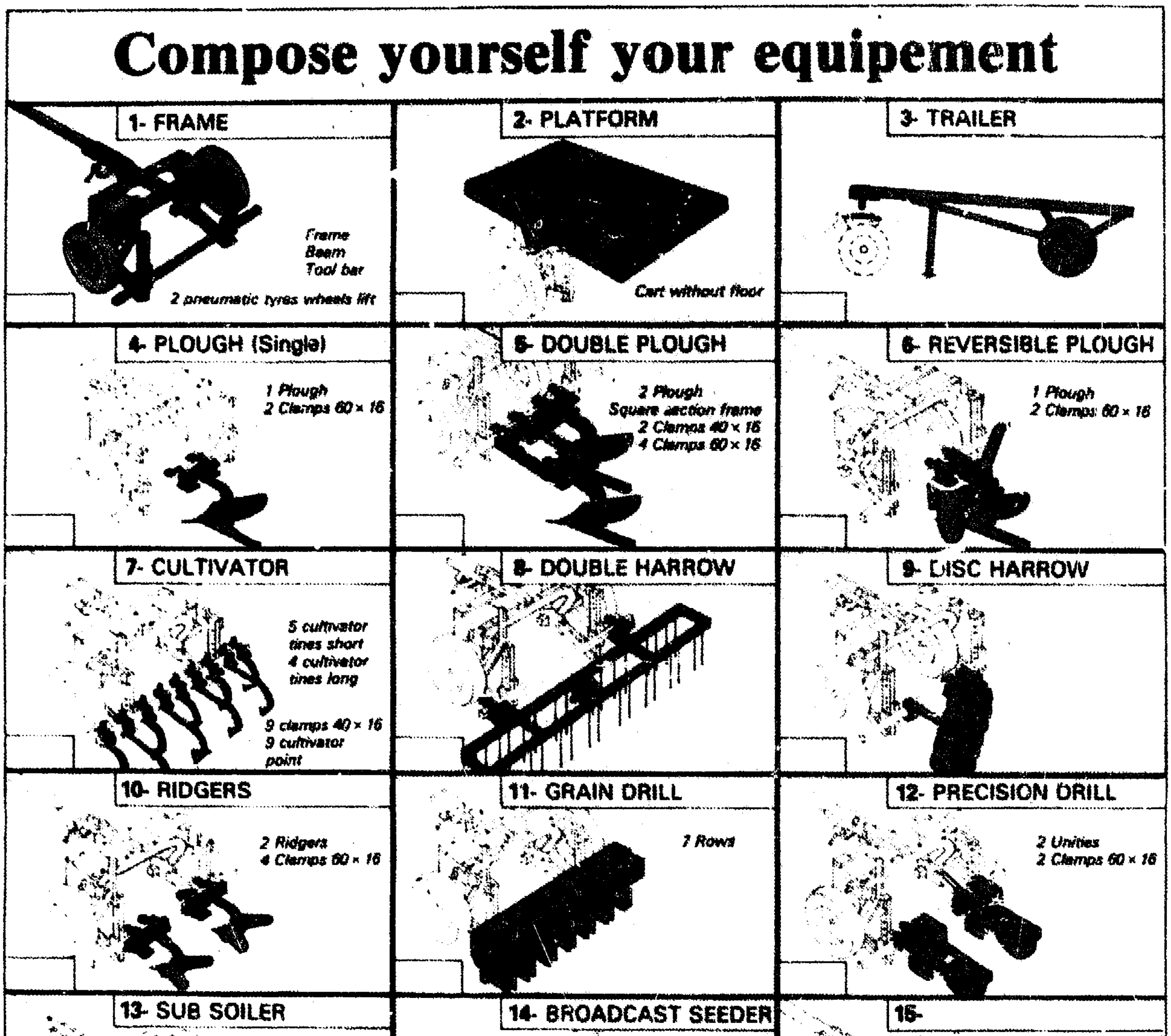


Fig. 2-9: The diversity of operations of the Tropicultor (Mouzon brochure, c. 1978).

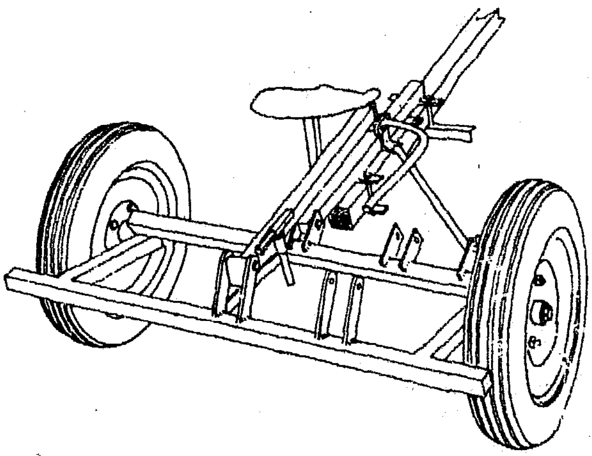
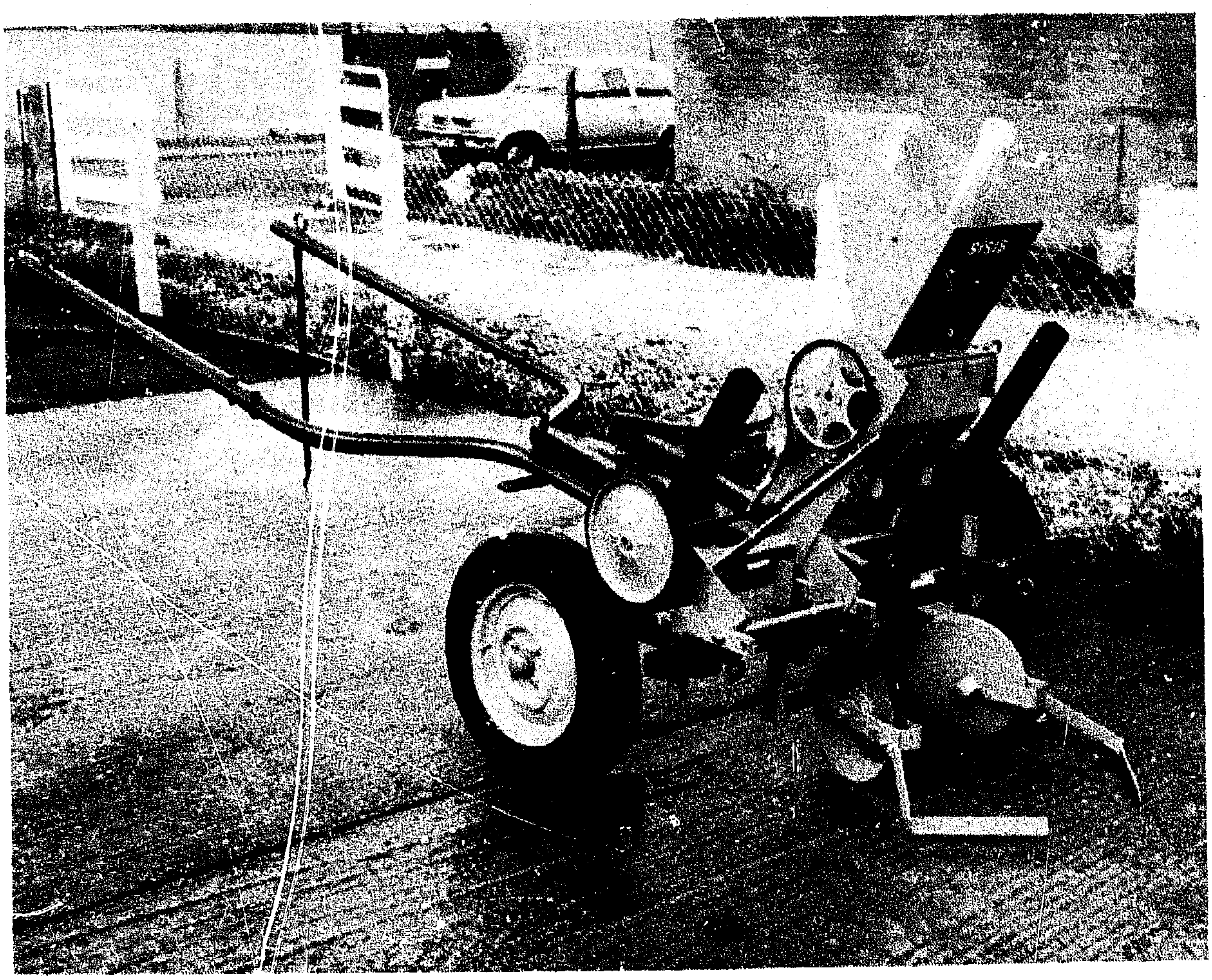


Fig. 2-10: NIAE ADT wheeled toolcarrier (Willcocks, 1969).

purpose implements, but this was rejected in favour of the wheeled toolcarrier concept which it was felt would encourage the drilling of crops in parallel rows, thereby establishing the principles and practices associated with sophisticated machinery (Willcocks, 1969).

Prototypes of the NIAE toolcarrier were tested in Uganda and Tanzania in 1960 and an early version was demonstrated at a Commonwealth Directors of Agriculture conference in 1961. As a result of this demonstration, NIAE research reports and publicity relating to the "French" designs, small numbers of toolcarriers commercially manufactured in Britain under trade names such as Aplos and Kenmore were sent to many developing countries in the 1960s and 1970s. The main thrust of research and development on the NIAE toolcarrier itself occurred in the early 1960s and a report of this work was published by NIAE in 1969 (Willcocks,

Fig. 2-11: NIAE toolcarrier with SISIS seeder, fitted with shafts designed for single animal use in Latin America, Silsoe, U.K. 1976. (Photo: AFRC-Engineering archives).



1969). Subsequent involvement of NIAE staff at Silsoe in the U.K. in the late 1960s and early 1970s was limited to the intermittent development and testing of a range of toolcarrier attachments including plows, ridgers, harrows, weeders, sprayers and several types of seeder. In addition to its research and development functions, the Overseas Division of NIAE assisted with technical advice to relevant projects supported by British Aid (ODA), and in this capacity NIAE staff were associated with the evaluation of wheeled toolcarriers in several developing countries.

During the 1960s and early 1970s about 900 toolcarriers based on the NIAE design were exported to The Gambia and much smaller numbers were sent to about 25 countries in Africa, Asia and Latin America including Brazil, Chile, Costa Rica, Ethiopia, India, Kenya, Malawi, Mexico, Nigeria, Pakistan, Tanzania, Thailand, Uganda and Yemen. Subsequently NIAE collaborated with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in the production of a completely new design of wheeled toolcarrier. This new toolcarrier is generally known as the Nikart, although officially this is just the name of the version manufactured near ICRISAT's headquarters in India.

At about the same time as the initial French and British initiatives, some original Indian designs of toolcarrier were developed and entrepreneurs started to manufacture them (Khan, 1962; CEEMAT, 1964). While early models were not commercially successful, research and development on different designs continued in India. Later, when the technical, financial and promotional resources of a major international research centre (ICRISAT) working with both Jean Nolle and NIAE were channelled into wheeled toolcarriers in India, local factories were able to benefit and to export toolcarriers from India to other developing regions. Thus India has been the third main focus for research, development and manufacture of wheeled toolcarriers.

2.4 The development of simpler toolbars

Soon after Jean Nolle had designed his Polyculteur in Senegal in 1955, it was clear to him that while the wheeled toolcarrier would be suitable for larger farms, of say 10 ha, that had strong animals, the majority of farms in Senegal were smaller, and many only had the power of one donkey. Thus although he described it as a regression in technology, in the late 1950s Nolle designed a simple longitudinal implement which he called the Houe Sine. This was in many ways similar to a plow in design, with a single depth wheel, a hitch for attaching the traction chain and a steel beam. Various simple cultivation or weeding shares could be clamped to the toolbar, and also a fertilizer applicator. After some time, Nolle became aware that his original Houe Sine design was being used simply as a single purpose weeding implement, which was against one of his major principles of "polyvalence" or multipurpose use. Thus in the early 1960s Nolle worked on diversifying the Houe Sine, giving it a T-frame, with a small transverse toolbar at the end of its longitudinal beam, to which could be attached a plow body, ridger, discs, cultivating tines or a groundnut lifter. Although the Houe Sine has been continually evolving, the principles of its design have remained unchanged since the early 1960s and these include the simple longitudinal toolframe with a variety of attachments and the standardization of components such as clamps. Comparable toolbars include the heavier Arara, the lighter Houe Occidentale and several designs developed by the British engineer Alan Stokes such as the Unibar, the Anglebar and the Pecotool.

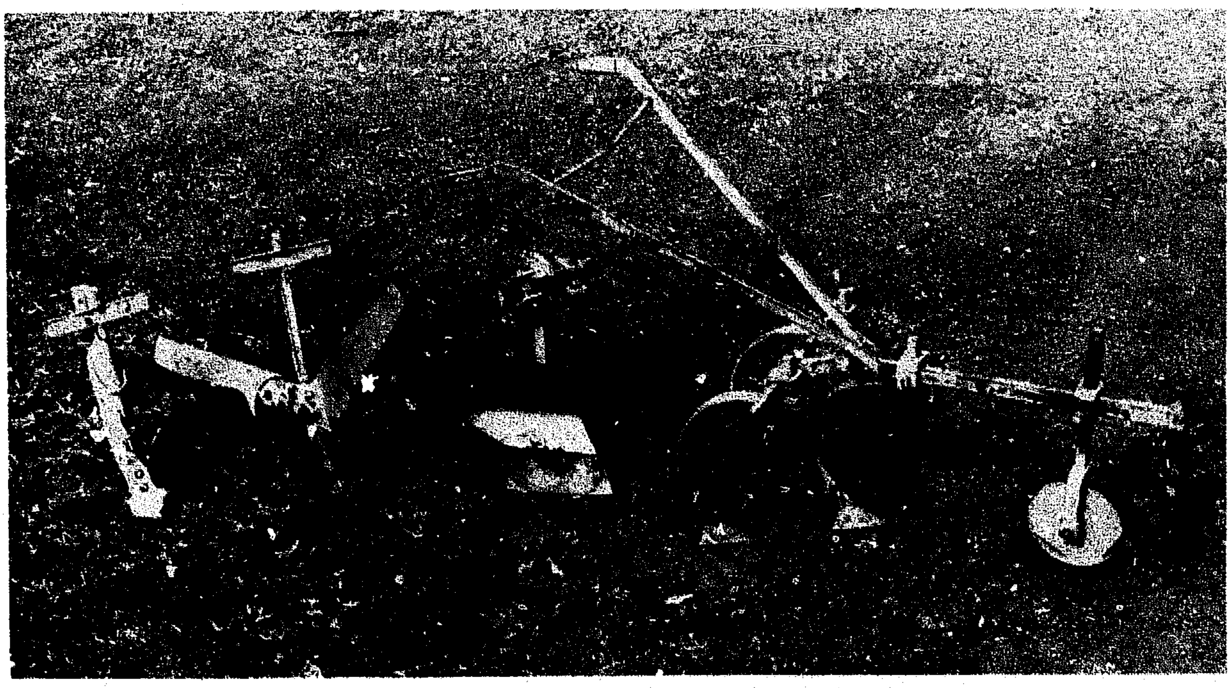


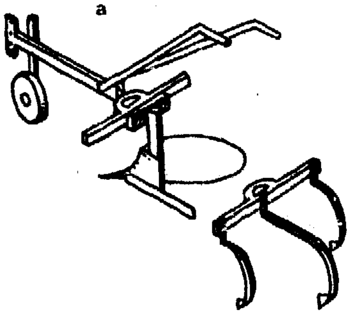
Fig. 2-12: A "simple toolbar" (SISCOMA Houe Sine) fitted with cultivating tines, with alternative attachments of groundnut lifter, earthing body and mouldboard plow. (Photo: P.H. Starkey).

2.5 Distinction between wheeled toolcarriers and simple toolbars

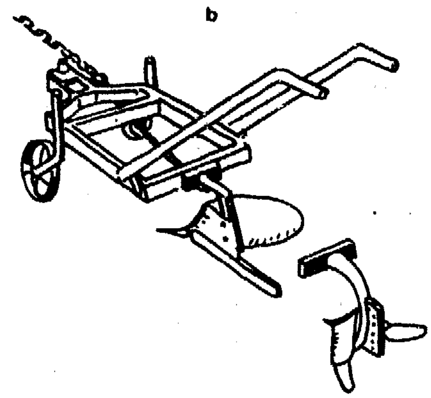
Although the Houe Sine and comparable implements are multipurpose toolbars, they are very different in operation, weight and price to the wheeled toolcarrier. However, as will become clear in subsequent sections, there has been considerable confusion, particularly in the English literature, between simple toolbars and wheeled toolcarriers. Both have been referred to as "multipurpose toolbars" and often they have been put together in statistics, with the result that misleading

Fig. 2-13: Definitions: a) simple toolbar b) intermediate toolframe c) wheeled toolcarrier.

a



b



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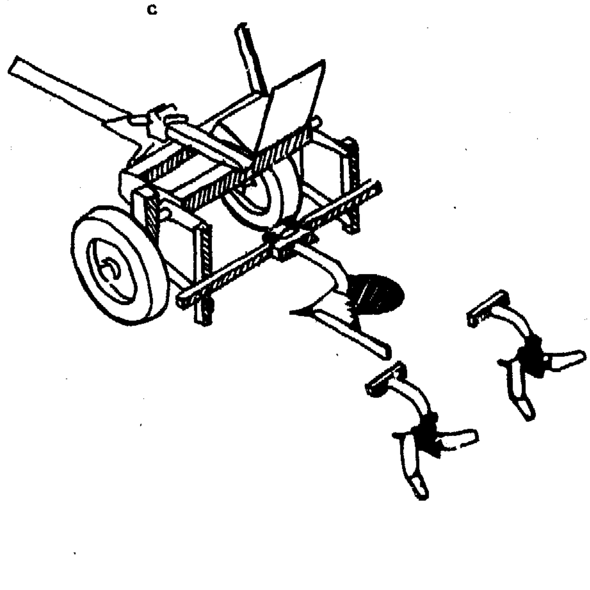
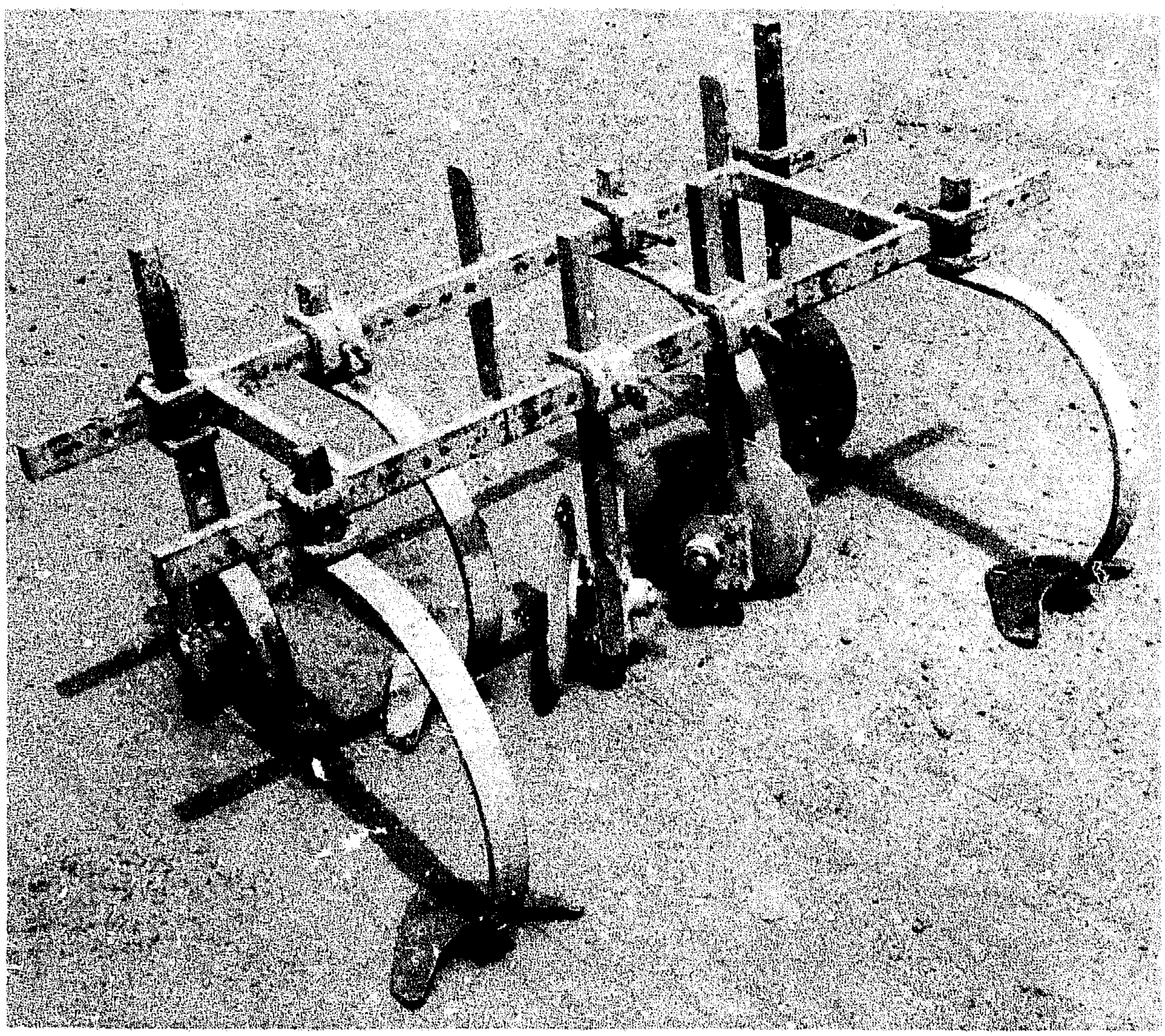


Fig. 2-14: A range of three "toolbars" made in Brazil: Policultor 300 (simple toolbar); Policultor 600 (intermediate toolframe); Policultor 1500 (wheeled toolcarrier). (CEMAG, undated).

conclusions have been drawn. In French, a clear distinction was made between the large "Polyculteur" wheeled toolcarriers and the smaller "Multiculteur" toolbars such as the Houe Sine (CEEMAT, 1971). Unfortunately no clear distinguishing definitions have been adopted in English. Therefore in the following analysis the term "wheeled toolcarrier" will be used to describe the "Polyculteur" type of implement, which is generally based on a transverse chassis, two wheels and a long beam. The term "simple toolbar" will be used to describe the lighter multipurpose implements based on a longitudinal beam, known in French as Multiculteurs.

Although there is a very clear difference between the heavy wheeled toolcarrier and the lighter simple toolbar, there have been some intermediate designs, starting in the late 1950s with Jean Nolle's Houe Saloum, a weeder and groundnut lifter. In 1961 this was developed into the Ariana, which has the general appearance of two parallel Houe Sine toolbars joined to form a rectangular frame. The Ariana resembles the Houe Sine in many respects, particularly as (in accordance with Nolle's principle of standardization) many of the components, including twin depth wheels, implement attachments and clamps are of the same design. Also it is

Fig. 2-15: An "intermediate toolframe". This prototype from The Gambia is similar to the Ariana (Photo: P.H. Starkey).



designed to be pulled by a traction chain and to be steered from behind and it is not convertible to a cart. However it does share some of the characteristics of the wheeled toolcarrier as it is heavier, more expensive and more difficult to manoeuvre than a simple toolbar, and it does allow for multiple row seeding and weeding. Intermediate implements such as the Ariana are not as important, in this discussion, as either the simpler or the more complicated models. Although more intermediate implements have been made in the past twenty-five years than wheeled toolcarriers (about 15 000 Ariana-type implements compared with 10 000 wheeled toolcarriers), they have not had either the adoption success of the simple toolbars (over 350 000 Houe Sine type toolbars sold worldwide), nor the promotional efforts that research centres and development agencies have given to the wheeled toolcarriers. A certain small element of confusion relates to them in national statistics, as they are sometimes included with the wheeled toolcarriers and sometimes with the simpler toolbars. In the following discussion they will be referred to as "intermediate" type toolframes, and they will not generally be considered with the wheeled toolcarriers.

2.6 The three phases of wheeled toolcarrier development

The developmental history of wheeled toolcarriers has been a continuous process, but it seems convenient to consider it in three main evolutionary stages. The first stage is represented mainly by a few early initiatives in Africa from 1955 to 1975 supported by French and British technical cooperation. During this same period there were also some attempts to develop wheeled toolcarriers for farmers in France (Pousset, 1982), Poland (Kosakiewicz and Orlikoswski, 1966) and India (Garg and Devnani, 1983), but these programmes did not appear to have significant impact either in their own countries or elsewhere. During this first phase small numbers of wheeled toolcarriers manufactured in Britain and France were also tested in Latin America and Asia.

Fig. 2-16: Designed in 1962, modified by ICRISAT, and promoted worldwide, the Tropicultor spans all phases of development. Here seen with seeder and fertilizer distributer at ICRISAT Centre, 1985. (Photo: P.H. Starkey).

The second developmental phase started in India in 1974 when the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) started a major research programme using wheeled toolcarriers, drawing on existing French, British and Indian designs. The research station trials were very encouraging, and reports became increasingly optimistic between 1975 and 1981. Optimistic reports have continued to emanate from ICRISAT up to the present time. These together with complementary reports from organizations in Britain and France, have encouraged the third stage of wheeled toolcarrier development – the wider international evaluation of this technology.

This third phase at present spans the years 1976 to 1987, and at the time of writing this text was continuing largely unabated. During these last ten years an increasing number of bilateral and multilateral donors dispersed significant sums of money assisting national programmes in at least thirty countries in Africa, Asia and Latin America to test or promote wheeled toolcarriers. While there have been attempts to develop toolcarriers suited to smallholder farmers in Britain (Barton, Jeanrenaud and Gibbon, 1982) and France (Morin, 1985), most of the effort has been directed at the Third World. In early 1987 there were development workers in at least twenty different countries actively engaged in evaluating or promoting this technology.

In the following chapters case histories from all three phases are reviewed in as much detail as practicable. Then some generalizations arising from the case histories are discussed, and finally potential lessons from wheeled toolcarrier development and promotion are highlighted.

3. Early Experience in Africa: 1955—1975

3.1 Senegal

Much of the pioneering work on wheeled toolcarriers was carried out by the Secteur Expérimental de Modernisation Agricole (SEMA) in the central groundnut basin area of Senegal. In 1954 SEMA employed the French agriculturalist Jean Nolle, who was charged with others with developing a modern, socially and economically acceptable system of farming using animal traction (Nolle, 1986). Nolle's first design of wheeled toolcarrier was developed in 1955. *Le Polyculteur Léger* comprised a metal chassis and drawbar supported on two wheels with pneumatic tyres. There was an operator's seat and a handle for raising or lowering the implements that included a mouldboard plow, up to three seeders, flexible tines, groundnut lifter, harrow and ridger. A platform could be fitted to make the toolcarrier into a cart. Nolle continued to work on his design and in 1956 he developed the *Polyculteur Lourd,* which used wheels of the same diameter as the local taxis, and which could be modified to become a water tanker or tipping cart. Nolle's Polyculteur design quickly passed from being a prototype to being manufactured commercially in France, and by 1958 a photograph of the Mouzon-

Fig. 3-1: Polyculteur "léger" with three seeders, Senegal, 1955. (Photo: Jean Nolle).

Nolle Polyculteur in action in Senegal had appeared in the journal Agronomie Tropical (Labrousse, 1958).

At the same time as this early work on wheeled toolcarriers, Nolle while working in Senegal also designed some cheaper intermediate type of toolframes known as the *Houe Saloum* and later the *Ariana*. These had two small wheels but unlike the Polyculteurs they were not designed for ride-on operation or for use as carts. More importantly Nolle also designed multipurpose toolbars such as the *Houe Sine* which were not based on two wheels. This work was extremely significant as simple longitudinal toolbars derived from these early designs have since been sold in tens of thousands in West Africa.

Nolle considered his designs would allow small farmers to improve rapidly the profitability of their enterprises, and described how in 1958 at Bambey in Senegal a display of ten toolcarriers each with a different implement was organised, with a sign indicating that the technology would bring new freedom to the peasants. He also describes how one farmer was able to make so much profit using the toolcarrier that he could buy a second-hand Landrover. It is clear that from his perspective as a designer of animal-drawn equipment, Nolle regarded his innovations as highly successful, as his toolcarriers allowed farmers to work greater areas with less drudgery than alternative implements (Nolle, 1986). Although there were some early reservations concerning the high cost and complexity of the wheeled toolcarriers (Nourrissat, 1965), economic models were developed at Bambey Research Station which illustrated how the wheeled toolcarriers could allow cultivated surfaces to double, relative to alternative equipment, while at the same time allowing returns to both area and labour to increase (Monnier, 1967).

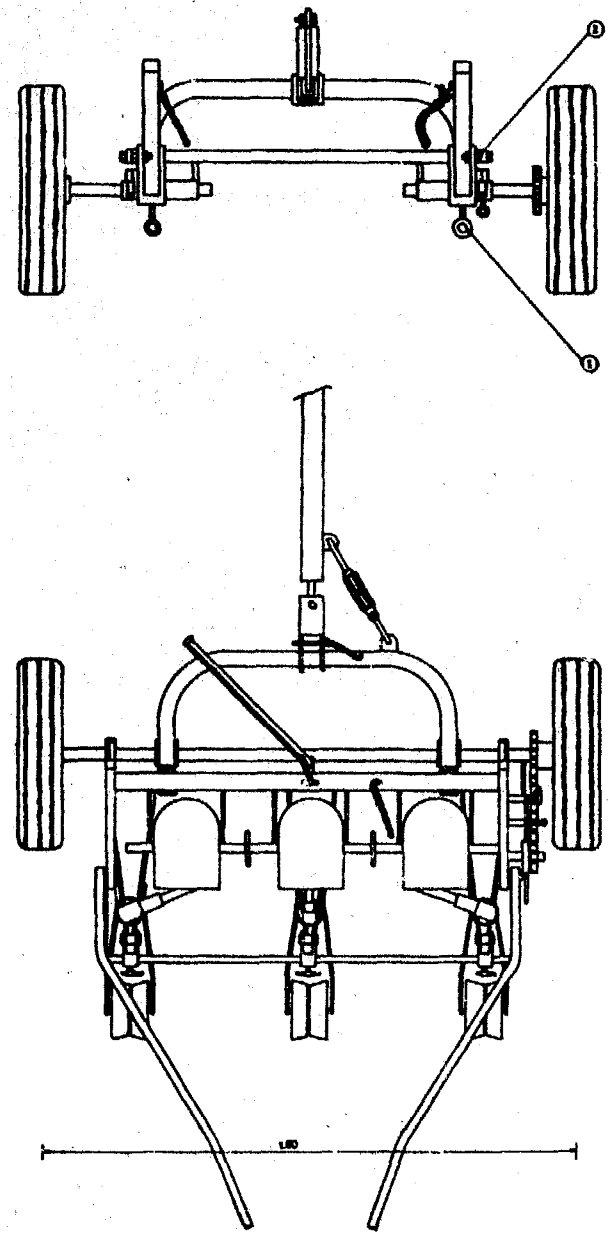


Fig. 3-2: Polyculteur à grand rendement developed at CNRA Bambey, Senegal (CEEMAT/Monnier and Plessard, 1973).

Nolle's innovations were further developed in Senegal, and the perceived benefits of the wheeled toolcarriers were made clear in the name of one model known as "Matériel à grand rendement", or high output machine. This was designed for use with two oxen and with its three row seeder it was recommended for the small proportion of the farms that were over 15 ha and which had destumped areas (Monnier, 1971; Monnier and Plessard, 1973).

Following the work of Nolle, Monnier and others, the toolcarriers were actively promoted and credit was made available to facilitate purchase. As early as 1958 toolcarriers had been commercially manufactured in France by Mouzon-Nolle and were imported into Senegal (Labrousse, 1958). The main importation and promotion was in the years 1961–1967. During these years the numbers of intermediate toolframes and wheeled toolcarriers distributed first rose and then fell dramatically as shown in Table 3.1.

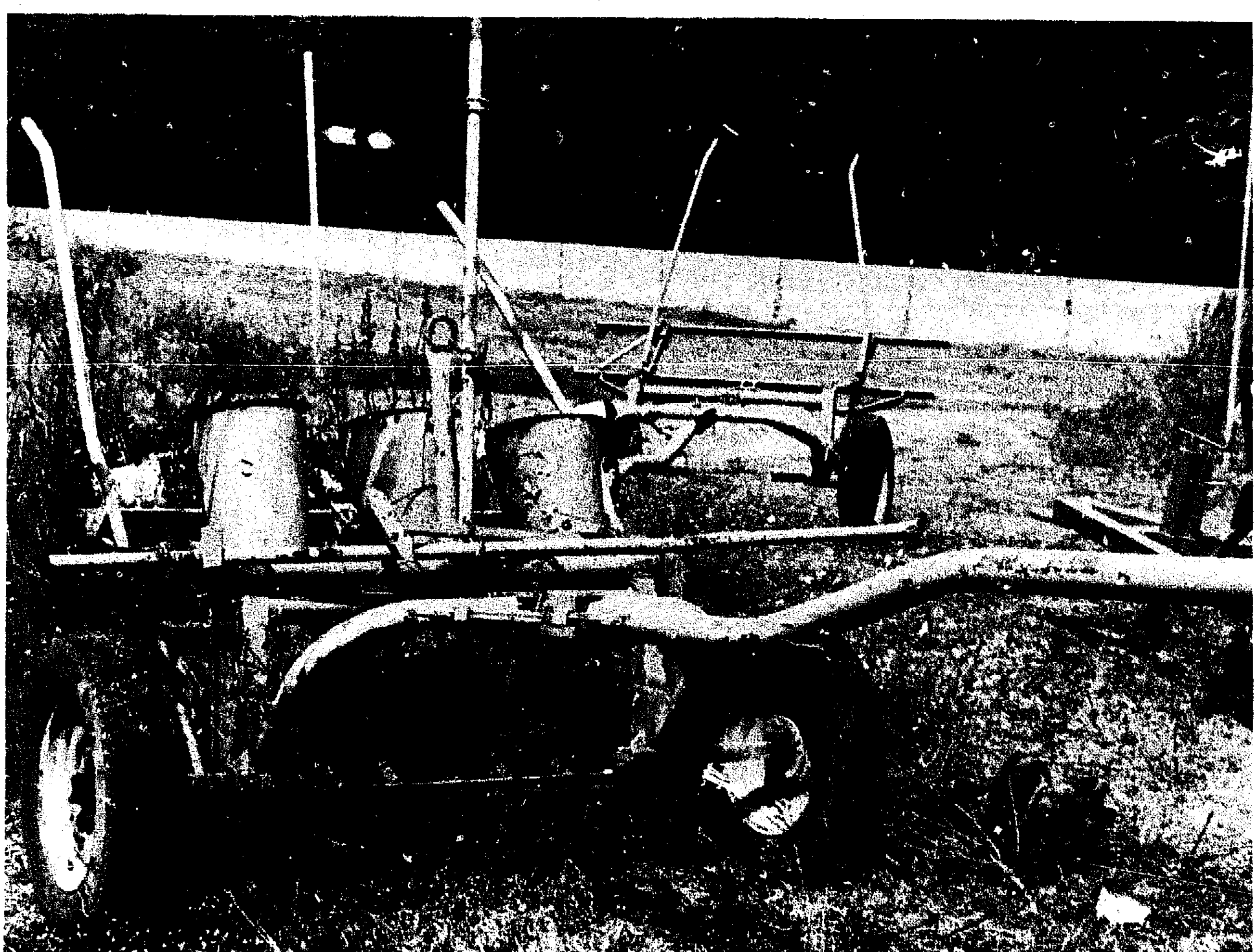
As a result of the promotion, numbers of intermediate toolframes and toolcarriers on farms in Senegal increased from 200 in 1958 to 700 in 1960, and to 7800 in 1968 (Havard, 1985a; Havard, 1985b). Of these, the majority were Ariana-type toolframes but about 500 were the more expensive

Table 3.1: Toolframes and toolcarriers distributed in Senegal, 1961–1967

Year	Toolframes distributed*
1961	83
1962	3 151
1963	2 026
1964	1 311
1965	291
1966	104
1967	72
Total for period 1961–1967	7 038

**Note:* These figures combine the intermediate type of toolframes such as the Houe Saloum and Ariana with wheeled toolcarriers such as the Polyculteur. Only about 500 implements (7% of this total) would be wheeled toolcarriers, but the pattern of rapid rise and fall was similar for both categories of implement.
Source: Havard, 1985a.

Fig. 3-3: SISCOMA/SISMAR Baol Polyculteur on research station in Senegal, 1987: foreground with seeders; background with steerable toolbar. (Photo: Fadel Ndiamé).



wheeled toolcarriers. However farmers mainly used both implements as multirow seeders as this operation imposed only a small draft on the animals and timeliness was all important. Since farmers were not making full use of the multipurpose potential of the Polyculteurs, as soon as the early promotional benefits were reduced, farmers found it preferable to purchase several cheaper and lighter implements to one wheeled toolcarrier and research attention turned to single purpose seeders.

While about 200 000 plows, seeders, simple (Houe Sine) toolbars and ordinary carts were sold in Senegal between 1968 and 1983, only about 100 wheeled toolcarriers were sold during this period, and numbers remaining in use declined rapidly. 1983 estimates of equipment in use put the numbers of simple toolbars (Houe Sine) at 100 000–150 000, the numbers of Houe Grecos (another simple toolbar design) were about 500, the numbers of Ariana (intermediate) toolframes were even lower at "very few", and the numbers of wheeled toolcarrier were neglected altogether, as they were considered of only marginal importance (Havard, 1985c).

The large SISCOMA (subsequently SISMAR) factory that had started toolcarrier production in 1961 continued to make and sell small numbers of wheeled toolcarriers during the 1970s, during which time the customers were increasingly aid projects and research stations rather than farmers. Total sales of wheeled toolcarriers in Senegal during the years 1976 to 1979 were only 51 in the Sine Saloum Region and three in the rest of the country (Havard, 1985a). After total sales of just three units were recorded for the year 1983 (representing 0.18% of production) the SISMAR factory decided that the routine manufacture and sale of wheeled toolcarriers would cease altogether, and production would be restricted to special orders (SISMAR, 1984 and 1985). Between 1983 and 1987 about thirty Polyculteurs were made to order, but the factory considered demand was practically nonexistent (SISMAR, 1987).

In present-day Senegal at least 30% of the farmers use animal traction employing a total of 430 000 oxen, horses and donkeys. In the SISMAR (formerly SISCOMA) factory, Senegal has one of the largest manufacturers of animal traction equipment in Africa, with a quarter of a century of experience in fabricating various toolcarriers within a free-market economy. Yet in Senegal, a country that could be considered the "home" of the modern toolcarrier concept, the wheeled toolcarrier that has been both known by and commercially available to farmers for thirty years, appears to have been rejected and forgotten.

3.2 Eastern Africa, 1960–1975

3.2.1 Tanzania

Animal traction was introduced into Tanganyika in the early years of the century, and about 600 000 of the country's 12 million zebu cattle are used for work. Early testing of wheeled toolcarriers was carried out in 1960 and 1961, in the context of cooperation between NIAE, TAMTU (Tanganyika – later Tanzania – Agricultural Machinery Testing Unit) and the colonial authorities. One objective of the toolcarrier research was to produce a gradual break from traditional methods that would help the farmers to become ready for mechanical cultivation.

The initial NIAE design work had been carried out between 1958 and 1960 in Silsoe, U.K. The toolcarrier comprised a tubular drawbar attached to a cranked axle carried on pneumatic tyres. A pivoted toolbar could be raised with handles that could also be used for steering. The prototype survived field trials, although it was noted that

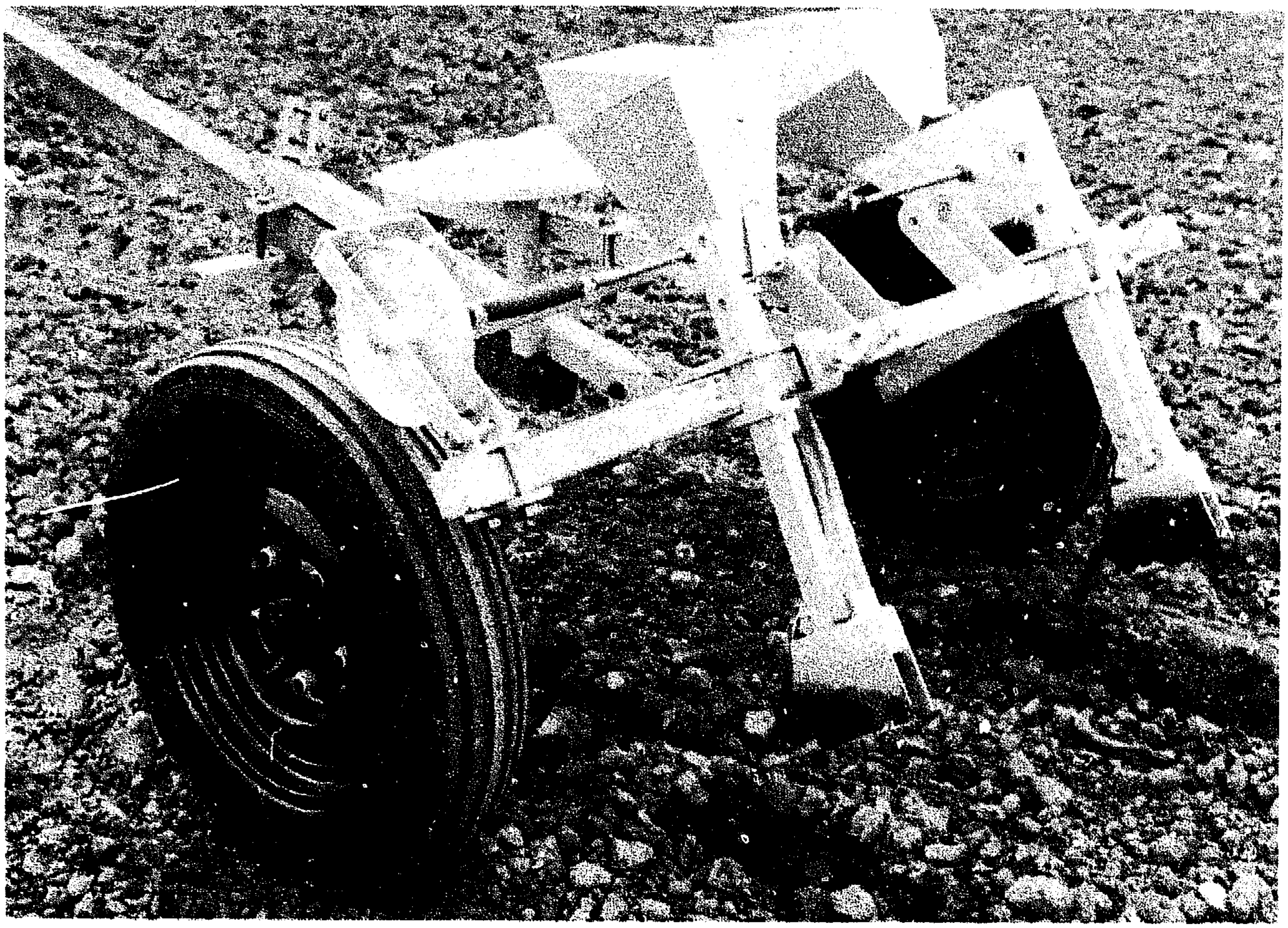
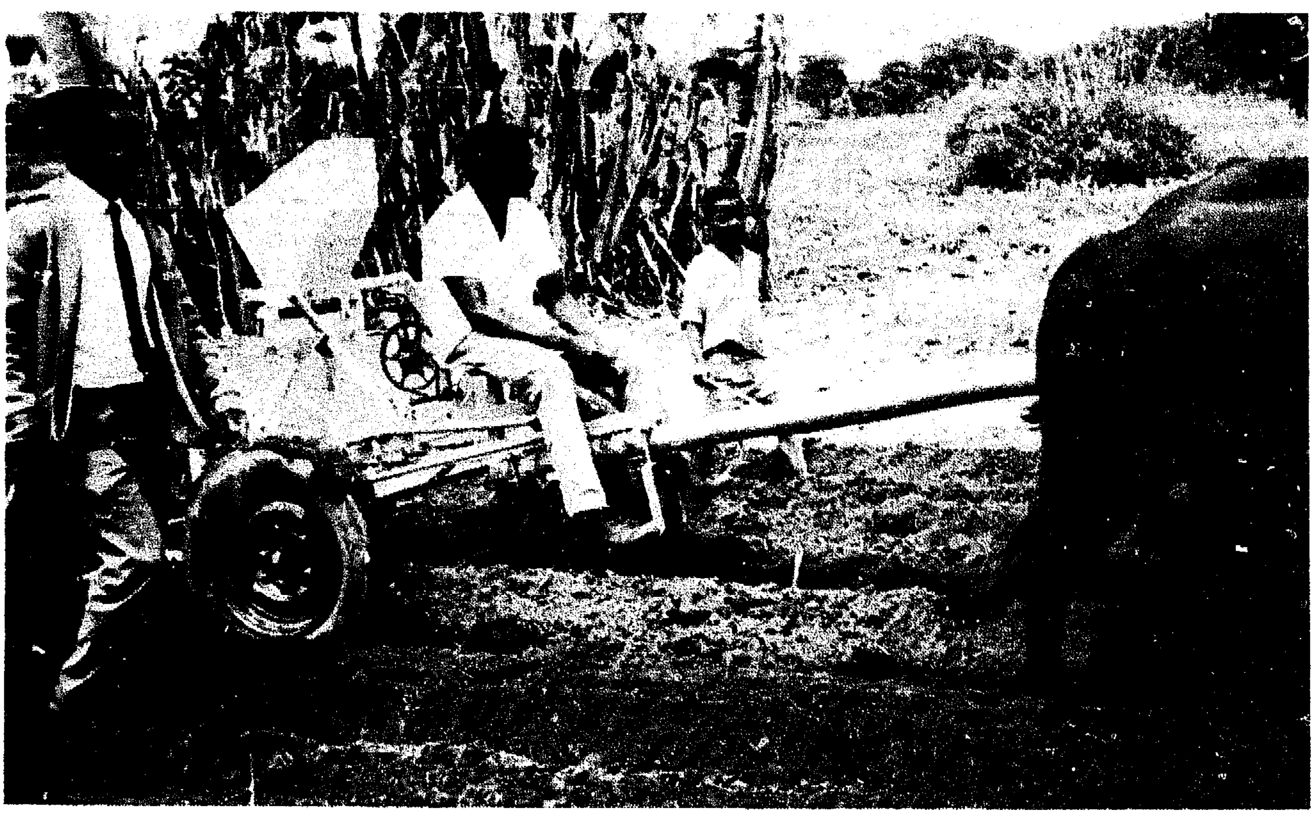


Fig. 3-4: NIAE ADT wheeled toolcarrier with simple friction drive seeder in the U.K., 1967. (Photo: AFRC-Engineering archives).

Fig. 3-5: NIAE wheeled toolcarrier with SISIS roller seeder being tested in Malawi, 1969. (Photo: AFRC-Engineering archives).



the equipment needed strengthening to withstand peak loads of up to 400 kg attributable to implements striking roots. Some nuts and bolts in the initial design were replaced with clamps with retained screws. The prototype was designed for use with one pair of animals, but TAMTU suggested that in order to work the recommended 0.9 metre ridge spacings a larger toolcarrier with a 1.8 metre wheel spacing would be useful. This it was suggested could be used with teams of four or more animals as found in some parts of the country. While there were distinct reservations over the additional weight and cost of a larger unit, a 1.8 metre prototype was developed and initial trials were considered very promising (Chalmers and Marsden, 1962). However the larger toolcarrier was heavy, requiring 4–6 animals, and difficult to manoeuvre and it was decided not to proceed with the design.

In 1962/1963 a 0.9 metre toolcarrier was developed, based on the lessons learned from the earlier models and from studies of European and Indian models. This incorporated a commercially available tractor toolbar, arched for crop clearance. The use of the existing International tractor toolbar was intended to make it easy to progress to motorized applications. The toolcarrier had an adjustable wheel track and a driver's seat and was used at TAMTU's Tengeru farm for plowing, harrowing, weeding, ridging, planting and as a cart (Constantinesco, 1964). It had been hoped that this model would be extensively tried out throughout East Africa, but it does not appear to have been manufactured in significant numbers and toolcarriers never spread in Tanzania.

Small numbers of commercially produced versions of the NIAE wheeled toolcarrier were evaluated in Malawi, Kenya and Ethiopia. In Malawi an Aplos toolcarrier was tested at Chitedze Research Station in 1969 with seeding and ridging attachments. It was shown to be effective, but it was not promoted. Instead emphasis was placed on the development of a simple toolbar (Kinsey, 1984). Similar decisions not to promote wheeled toolcarriers were taken positively, or by default, in most eastern African countries, and only Uganda attempted to subsidize and promote them. Wheeled toolcarriers were never adopted by more than a few farmers anywhere in the region (Ahmed and Kinsey, 1984).

3.2.2 Uganda

The development of animal traction in Uganda has been well documented and the equipment innovations in the cotton-millet farming systems in the northern and eastern areas of the country have been reviewed by Kinsey (1984). Ox-cultivation grew rapidly during the period 1900–1930, so that by 1930 the plow was becoming the universal implement for primary tillage in Teso District, and it was spreading into many nearby areas. During the period 1929–1960 there were several attempts to introduce harrows and cultivators but these were generally rejected by farmers as too heavy, too expensive or inappropriate to the local farming systems (Kinsey, 1984).

In 1960 and 1961 prototypes of the NIAE designed wheeled toolcarrier were tested in Uganda (Chalmers and Marsden, 1962) but these were considered heavy and difficult to adjust (A. Akou, personal communication, 1986). French manufactured Polyculteurs and later Tropiculteurs were also imported and, following two years of tests from 1960 to 1962, officers at the Serere Research Station in Teso concluded that the Polyculteur was the preferred design. The Tropiculteur designer Jean Nolle undertook a consultancy mission in Uganda in 1963 and redesigned a mouldboard plow for the Tropiculteur suitable for plowing land covered with the difficult grass *Imperata cylin-*

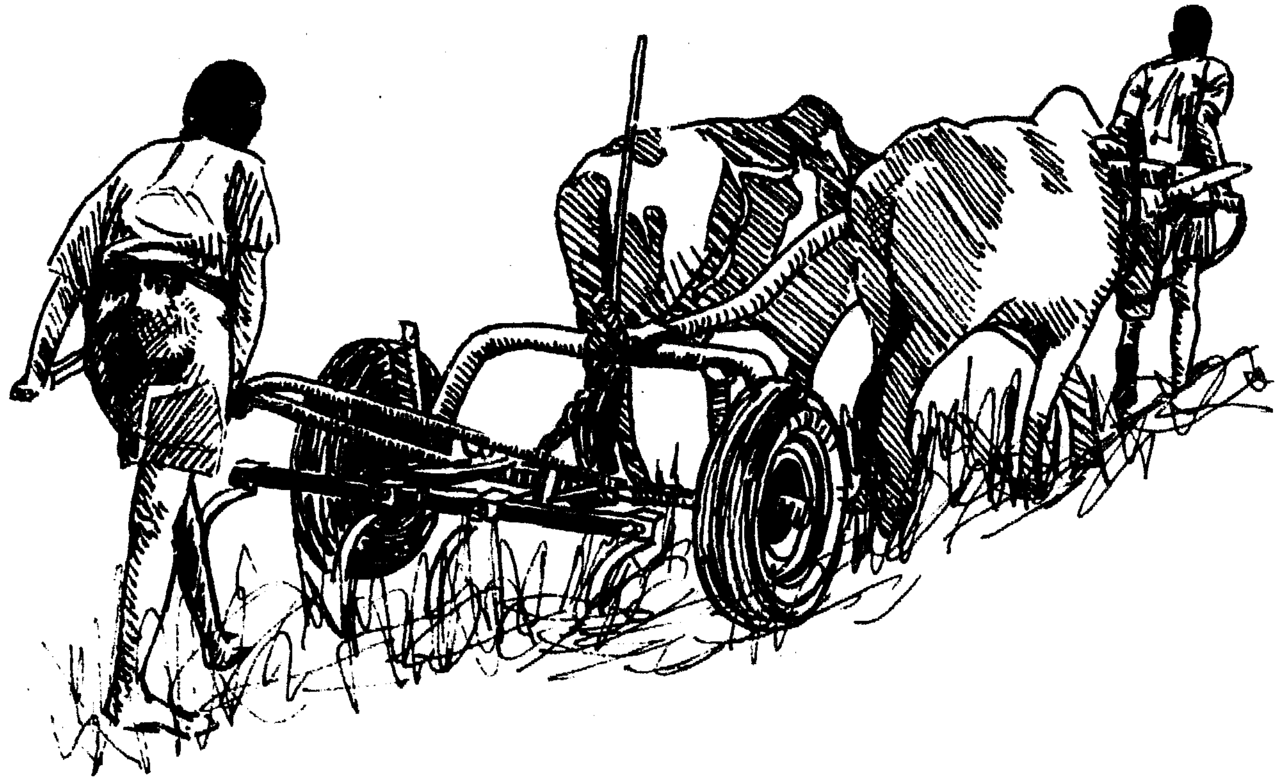


Fig. 3-6: Polyculteur being demonstrated to farmers in Uganda c. 1969. (Based on photo: A.D.R. Ker).

drica. Tropiculteurs were distributed to the sixteen district farm institutes. In 1965 some Aplos toolcarriers based on the NIAE design were imported, but they were still considered "heavy" (Akou, 1986).

From 1962 to 1968 comparative trials in which tractor operations were compared with a range of ox-powered implements were carried out on the farm of the Arapai Agricultural College near Soroti in eastern Uganda. For six years Polyculteurs were in use daily for cultivation (weeding and seeding) or transport on the college farm and in 1964 they were used to weed forty hectares of crops. A report concluded: "Despite this hard and continuous use over six years, apart from replacing the wooden cart bodies occasionally, maintaining tyre pressures, and mending a few punctures, the Polyculteurs are almost as good as new. Their designer should be congratulated on the success of this implement." (Ker, 1973).

The Polyculteur had a fixed 1.3 metre wheel track and was difficult to use for plowing and ridging. It was used mainly for weeding, seeding and transport and work at Serere led to the following observations on it: "One disadvantage is that it cannot plough. Secondly, as it has low clearance, it is limited to weeding only crops at early stages. But for transport alone this tool is much better than the Tropiculteur. It has the best toolbar for sowing with seeders attached, as it is a steerable toolbar." (Akou, 1975).

The Tropiculteur package was about twice the price of the Polyculteur and was tested in several locations. At Arapai it was concluded that its additional cost was not justified, while at Serere its versatility was particularly appreciated, for with its high-clearance chassis it could be used for the spraying of cotton. The cheaper intermediate Ariana toolframe was also assessed, but at Arapai it was found to be difficult to control for planting and inter-row weeding, and since it was expensive compared with single purpose implements, it was concluded that its usefulness was limited (Ker, 1973). Work at Serere led to the conclusion that while the Ariana was a versatile and relatively simple and cheap implement, a farmer beginning with animal traction should use a simple

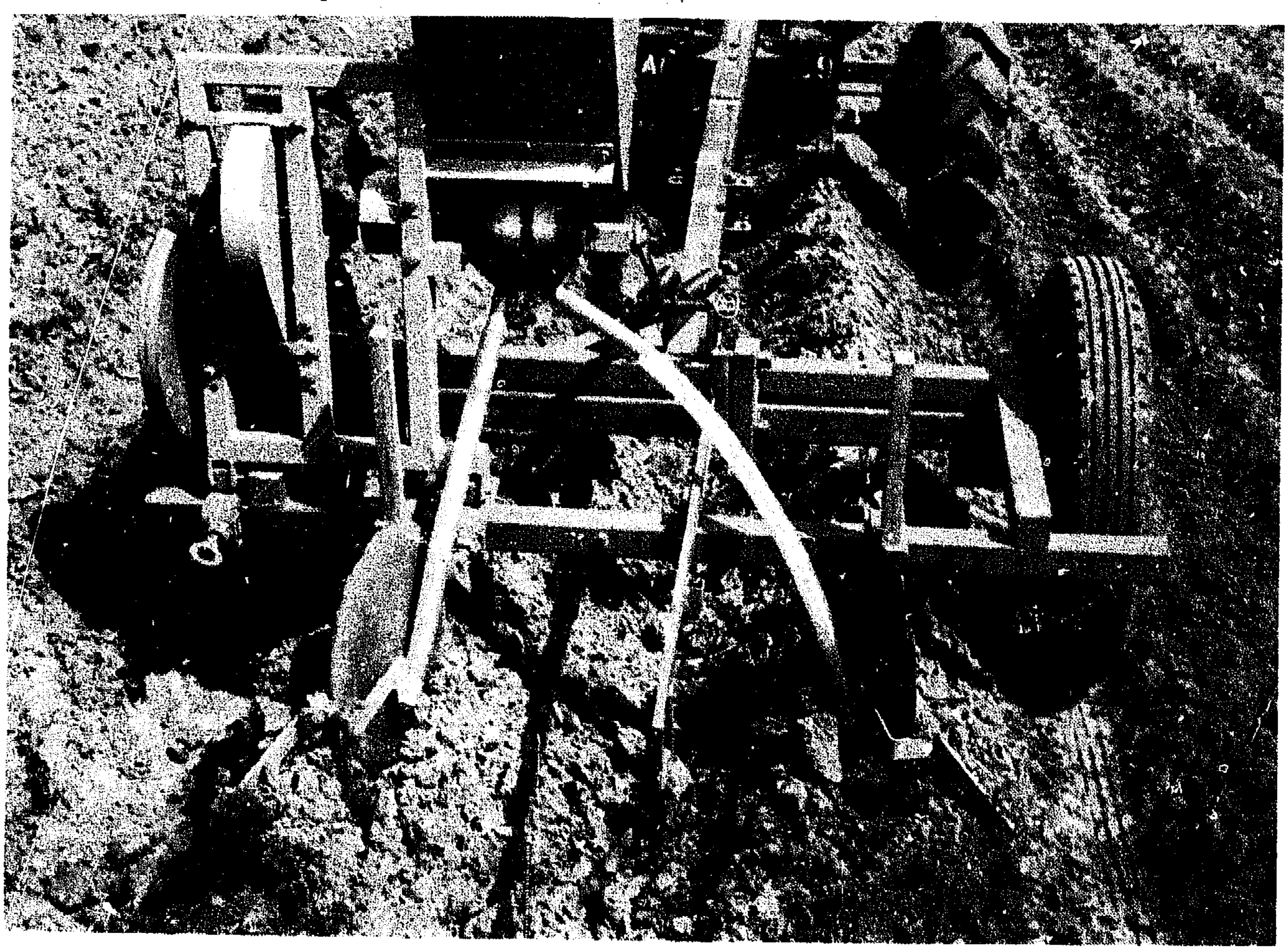
plow and cultivator and later progress to a Tropiculteur or Polyculteur (Akou, 1975).
From 1962, the Polyculteur and Tropicultor were actively promoted by the Department of Agriculture and were eligible for 50% price subsidies. Kinsey (1976) noted that the government subsidy element on each wheeled toolcarrier was equivalent in value to the cost of ten simple plows. The 50% subsidy continued for over a decade, and was still in operation in 1973/1974 (Akou, 1975). However, while single purpose implements, either unsubsidized or with a much lower rate of subsidy, continued to be purchased in significant numbers, very few toolcarriers were ever sold. Of the sixty implements purchased about thirty went to progressive farmers, while thirty went to local politicians and dignitaries (Akou, 1986). The 1965 Northern Region Annual Report put the number of privately owned Polyculteurs in the region at twenty. Hunt (1975) followed up the progress of five farmers who had received loans to buy Polyculteurs in 1963 and 1964 and found that by 1966 two were not in use at all, the reasons being given as lack of trained animals, difficulty in using the implements on land with some stumps, and lack of extension advice on how to assemble and operate the equipment. Three wheeled toolcarriers were still in use, but they were used for very few operations and they had made no obvious impact on timeliness, area cultivated or labour substitution of the farmers using them (Hunt, 1975). By 1971, when a survey was carried out of 67 farms selected by extension workers as "progressive", it was found that while there were an average of 1.7 conventional plows per farm in the survey, no wheeled toolcarriers were in use (Kinsey, 1984).
In the early 1970s the Department of Agricultural Engineering of the Makerere University made its own wheeled toolcarrier based on the NIAE design (Ker, 1973), but this did not progress beyond the prototype stage. Thus, while wheeled toolcarriers were proven to be very effective on-station in Uganda, and while they were promoted for many years with generous subsidies, they did not pass the test of farmer adoption in Uganda.

3.3 The Gambia

In the early 1960s, interest in the newly developed wheeled toolcarriers spread from neighbouring Senegal to The Gambia. Six French-manufactured "Polyculteur" units were tested at ox-plowing schools in the early 1960s (Davidson, 1964). At about the same time the British National Institute of Agricultural Engineering (NIAE) had been testing its own Animal-Drawn Toolbar in Tanzania and Uganda (Chalmers and Marsden, 1962; Willcocks, 1969). Britain was the major bilateral aid donor to The Gambia during the 1960s and from 1965 to 1975, with funding from the British Overseas Development Administration (ODA/ODM), there was close collaboration between NIAE and the Department of Agriculture in The Gambia. The history of this initiative has been well reviewed (Peacock et al., 1967; Matthews and Pullen, 1974; Mettrick, 1978; Kemp, 1978; Cham, 1979).
Between 1965 and 1973 the Gambian Department of Agriculture, with technical advice from NIAE, actively promoted the use of the NIAE Animal-Drawn Toolbar, manufactured under the name of *Aplos*, and its derivative the *Xplos*. These toolcarriers had a steel chassis, pneumatic tyres and a wooden drawbar. The models imported into The Gambia were relatively simple and had fixed axles without adjustments for height or width, although a more expensive adjustable version was available (Willcocks, 1969). As with the Nolle-designed equipment these toolcarriers could be converted for use as carts.

Fig. 3-7: NIAE wheeled toolcarriers being assembled in The Gambia, 1968. (Photo: AFRC-Engineering archives).

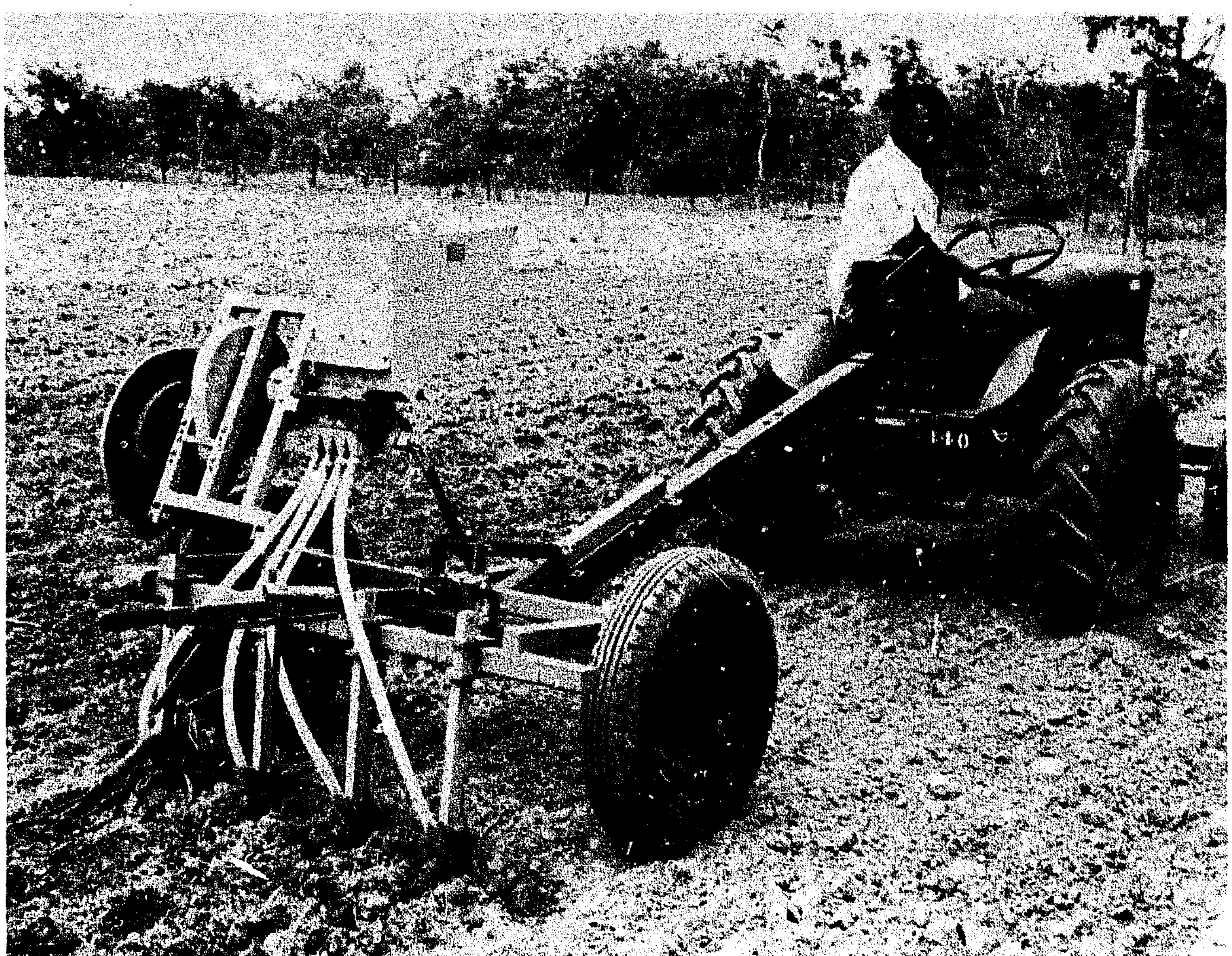
Fig. 3-8: NIAE wheeled toolcarrier with prototype roller planter and disc openers, The Gambia, 1968. (Photo: AFRC-Engineering archives).



It appears that few (if any) trials were conducted with these implements and no programmes were undertaken to identify suitable cultivation systems in which they could be employed (Kemp, 1978). The main justification for their introduction appears to have been the concept of a "mechanical ladder", in which they represented a stage between simple animal-powered implements and small tractors. However the logic of this ladder was subsequently questioned by Mettrick and his co-authors in their evaluation of the scheme (Mettrick, 1978).

By 1966, the Department of Agriculture had distributed 300 sets of Aplos wheeled toolcarriers throughout the country. The package comprised the toolcarrier complete with plow, weeder, ridger and cart body, and they were sold at the subsidized price of £ 66. Already by 1966 some problems were apparent and were identified during a survey carried out by Wye College (University of London) to gauge the effect of the work oxen training programme of the Mixed Farming Centres (Peacock et al., 1967). 24 out of the 49 compounds studied had bought Aplos wheeled toolcarriers. Of the compounds for which the Aplos was the only type of animal traction equipment, one third did not use it for plowing and two thirds did not use it for weeding. In compounds in which alternative implements were available, the utilization was much lower, with only 54% using the Aplos for plowing and only 20% using it for weeding. Problems with their use included insufficient farmer training in adjustments,

Fig. 3-9: NIAE wheeled toolcarrier with prototype planter being tested with a tractor as surrogate oxen, The Gambia, 1968. (Photo: AFRC-Engineering archives).



the heavy weight and draft of the equipment, and farm land in which the occurrence of stumps made the use of wheeled toolcarriers impracticable.

The observation was made that: "If the Aplos is to be introduced on a large scale throughout the country, then it is essential that the first examples in any area should be used successfully. Considerable damage is being done to the reputation of the Aplos by the *high proportion presently lying unused.* Every effort should be made to get the Aplos working efficiently so that farmers can see the advantages of this type of plough. This means that the Aplos should only be sold to trainees who have sufficient knowledge of how to use the plough properly and land suitable for cultivation by the Aplos. This will mean considerable reduction in the volume of sales over the next few years, but eventually a demand will be created *rather than sales being forced, as at present.*" (Peacock et al., 1967, *emphasis added.*)

It is not clear what influence, if any, this report had on the authorities in The Gambia. Apparently the British Ministry for Overseas Development (ODM/ODA) that had been assisting the Gambian Ministry of Agriculture was unhappy with the conclusions of the Wye College team and refused to assist in the publication of its report (J.M. Peacock, personal communication, 1986). Certainly the active promotion continued for several more years, and a total of 900 units (worth about one million US dollars at 1986 prices) were imported into The Gambia before it was concluded that the toolcarriers were inappropriate for Gambian farmers (Mettrick, 1978). Among the major problems was the unsuitability of the toolcarriers for use on land with stumps, due to their limited manoeuvrability, and farmers did not accept that full destumping was beneficial. The implements were too heavy for the N'Dama oxen, particularly if the farmer sat on the seat. Early models had plain steel bearings that rapidly wore out and were expensive to replace, although later models came with sealed roller bearings. Matthews and Pullen (1974) also cited that there had been an inadequate extension and training programme, while Mettrick (1978) noted that even at its subsidised price, it was too expensive. Adjustments to the Aplos required a spanner and were relatively difficult, while the later Xplos model was even more complicated. Although the toolcarriers could act as carts and implements, their cost was comparable to the combined price of a cart *and* a more simple toolbar, and farmers did not like the complication of converting, nor the added risk that one breakage could leave the farmer with neither cart nor plow.

Some of the toolcarriers remained in service for several years, but only as single purpose carts (Cham, 1979). Following the rejection of the wheeled toolcarriers, a range of other equipment was evaluated between 1973 and 1975, and it was recommended that the Gambian Department of Agriculture should standardize on the much cheaper and simpler Houe Sine implement from Senegal (Matthews and Pullen, 1974, 1975, 1976). Since 1974 there has been no further interest in wheeled toolcarriers for The Gambia.

3.4 Botswana

3.4.1 Background

Botswana is a sparsely populated country in southern Africa with a variable semi-arid climate which makes crop production risky and marginal. Since the introduction of animal traction in the nineteenth century, draft animals have become integral components of most farming systems. The combination of climate and soils results in only a few days each year that are suitable for land preparation so that farmers start cultivation as soon as the ground has been softened by the rains.

To achieve the necessary tillage in a short time they use wide mouldboard plows pulled by teams of 6–8 animals, and sometimes as many as 16 cattle (bulls, oxen and cows) are hitched into a single team.

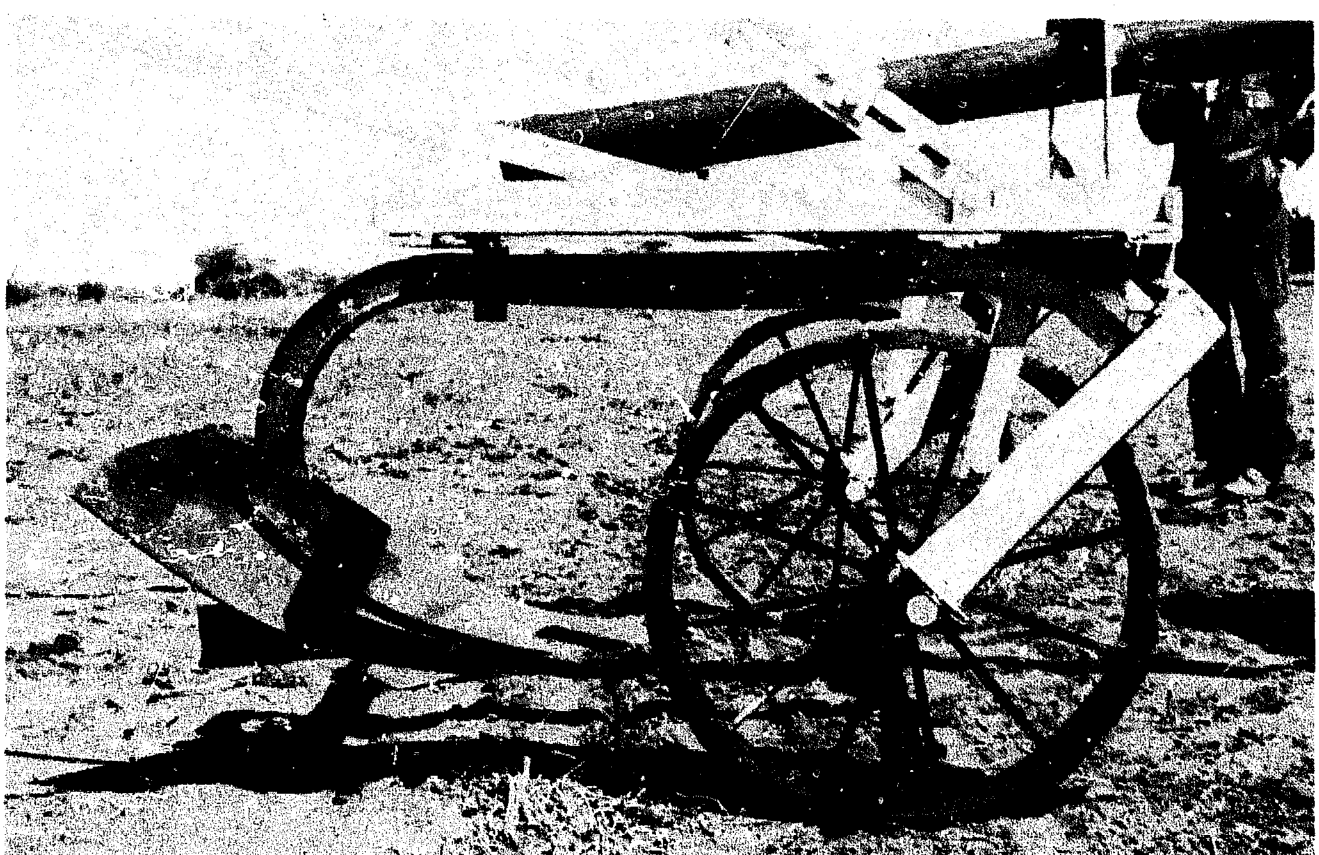
There has been considerable debate as to the necessity for such large teams of draft animals, with farmers arguing that they are technically essential, with additional value as a means of conveying social status. Several researchers over the years have suggested that a system using less power should be employed, particularly as many farmers have insufficient animals to make a full team. During the 1970s wheeled toolcarriers were proposed as the basis for low-draft and minimum tillage systems. However, as will be seen, the numbers of animals required to use wheeled toolcarriers in Botswana was progressively modified upwards from the intended single pair, to teams of 4–6 strong animals, equivalent to the 6–8 indifferent animals commonly used in the "traditional" systems.

The case history of wheeled toolcarrier development in Botswana spans several years, with an enthusiastic phase in the early 1970s, disillusionment in the late 1970s and a brief second period of evaluation in the 1980s. The case is also unusual in that two separate toolcarriers were developed in the same country, in the same period and only a few miles away. Although one project involved several British technical cooperation personnel, the new toolcarrier was not based on the earlier NIAE design.

3.4.2 The Makgonatsotlhe

The first, and more successful, toolcarrier initiative in Botswana was started by the Mochudi Farmers Brigade, a project of the Kgatleng Development Board, a non-govern-

Fig. 3-10: Early prototype of Mochudi toolcarrier "Makgonatsotlhe", Botswana c. 1971. (Photo: Eric Rempel).



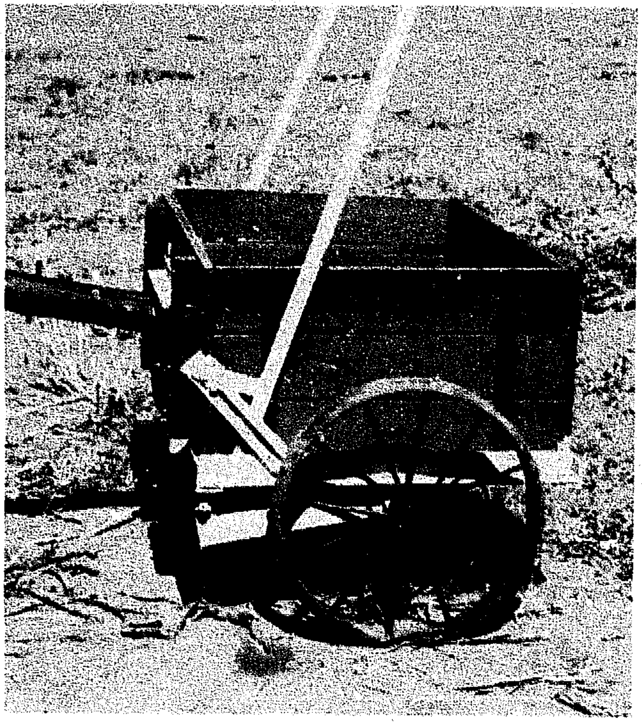
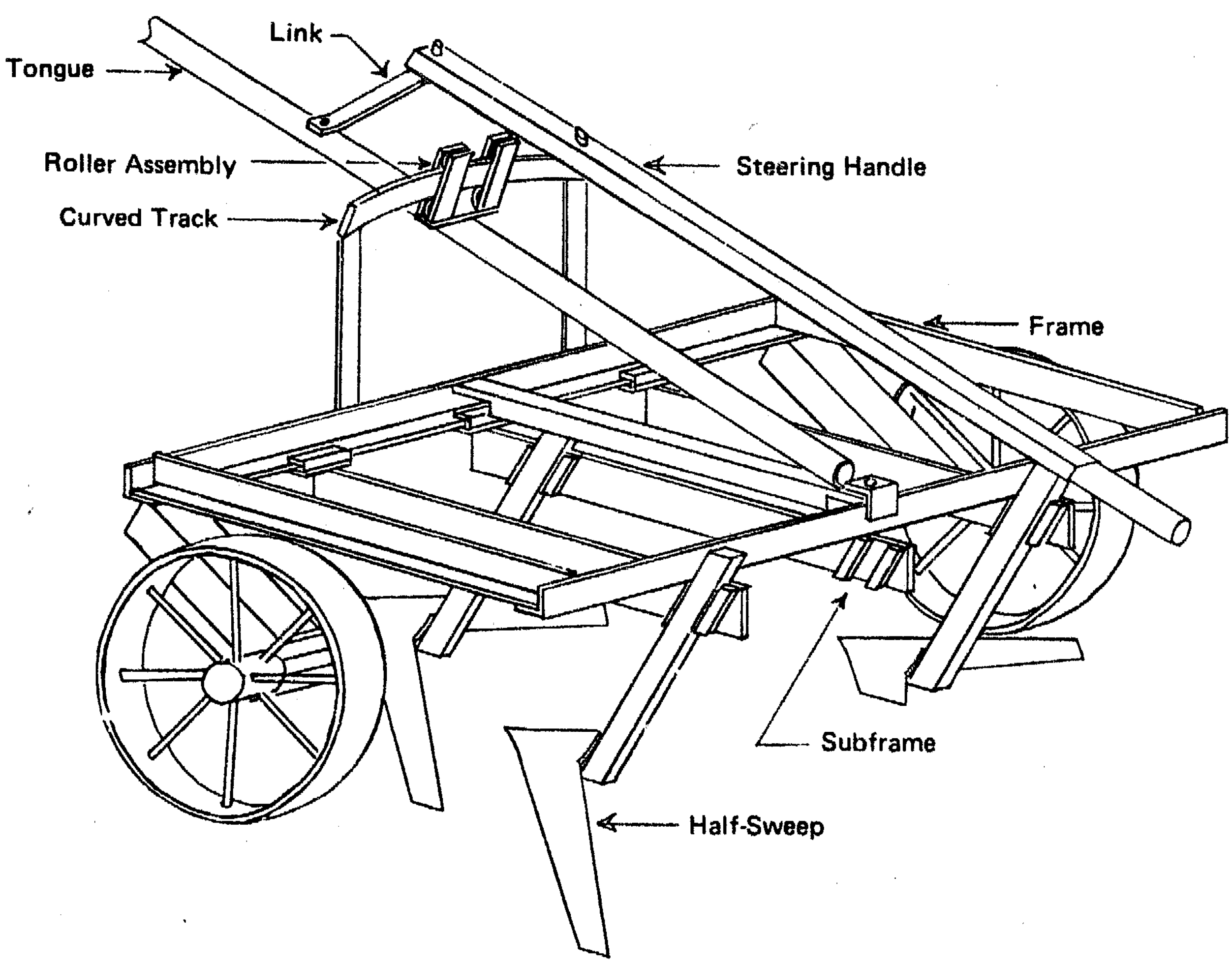


Fig. 3-11: Early prototype of Mochudi toolcarrier "Makgonatsotlhe", fitted with cart, Botswana c. 1971. (Photo: Eric Rempel).

mental development agency. Work began on the Mochudi toolcarrier in 1971 with assistance from Oxfam and the Mennonite Central Committee. The toolcarrier was intended as part of a drylands minimum tillage system, and the design concept was influenced by the till-plant system developed by the University of Nebraska for the southwestern United States. The minimum tillage was considered important to overcome the problem of draft power since less wealthy farmers owning only four cattle or a few donkeys sometimes did not cultivate at all due to their perceived shortage of draft power. Thus the Mochudi toolcarrier was designed to be pulled by just one pair of animals. The relatively high cost of the implement for such farmers was justified by the supposition that farmers owning a few cattle would be able to afford the implement by selling the oxen that would be made redun-

Fig. 3-12: Drawing of Mochudi toolcarrier "Makgonatsotlhe" (Eshleman, 1975).



dant by the low draft technology (E. Rempel, personal communication, 1986).

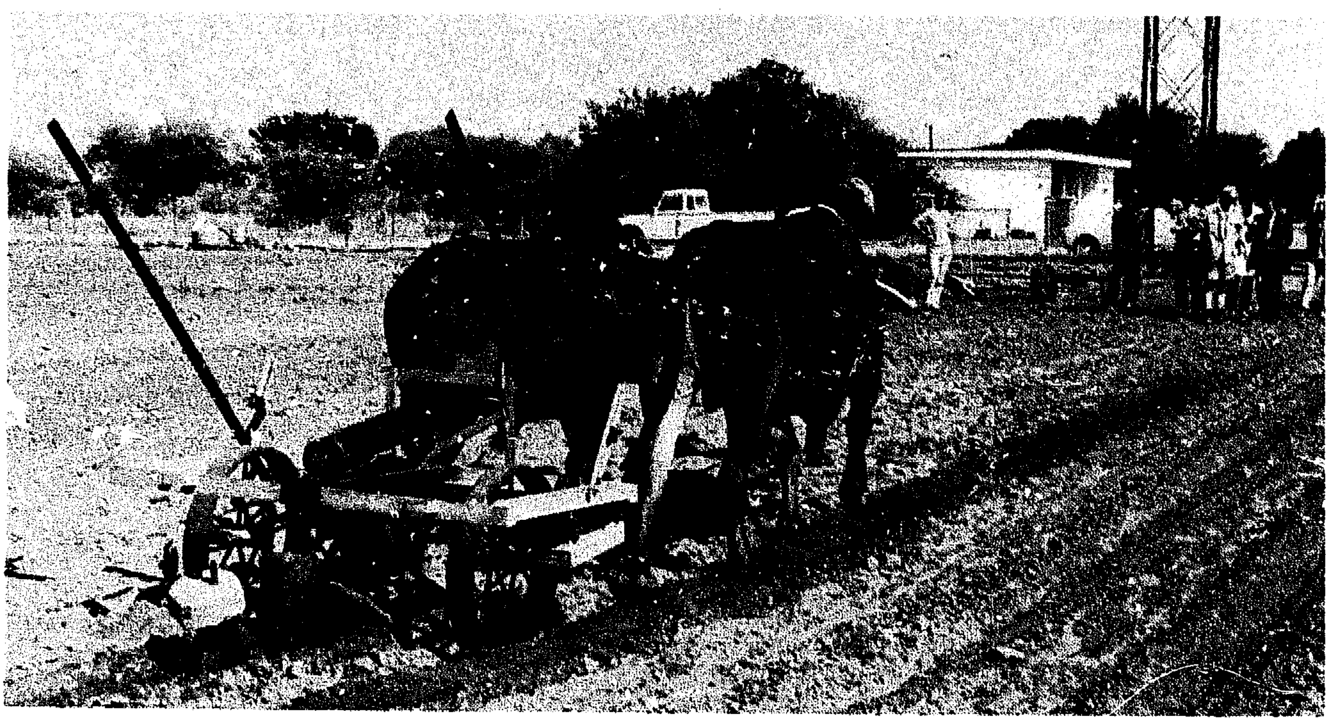
The Mochudi toolcarrier comprised a rectangular chassis of heavy angle iron, with independently mounted wheels. The stub axles were reversible so that the wheels could be mounted inwards (to give a narrow track) or outwards. In early prototypes metal wheels were used, but pneumatic tyres became standard. Onto the chassis was bolted a subframe that could take one or two seeders (of a design from Texas), fertilizer applicators, weeding sweeps, disc hillers for earthing maize, and subsoiling tines. The frame could also be used to support the standard mouldboard plows widely used by farmers, although plowing was not an element of the minimum tillage system for which the toolcarrier was initially designed. The chassis could hold two 200 litre drums for water transport, and an expanded metal cart body could also be bolted to the frame (Mochudi, 1975; EFSAIP, 1977).

The Mochudi toolcarrier was launched in 1973 with the name *Makgonatsotlhe* or *the machine that can do everything.* After further testing, the Makgonatsotlhe was "perfected" in 1975 and medium-scale production from imported components and steel was started at a special workshop at Mochudi (Eshleman, 1975). Using the toolbar and the tine cultivation system, it was claimed that erosion would be reduced and ground moisture would be conserved through mulching, that weeds would be better controlled with the sweeps and disc hillers, and that germination, seed survival and fertilizer effects would be higher through use of the seeder and fertilizer applicator.

From 1975 to 1978 some 125 toolcarriers were manufactured, of which 72 were bought for testing by various government agencies. The Evaluation of Farming Systems and Agricultural Implements Project (EFSAIP) carried out both on-station and on-farm evaluation of the Makgonatsotlhe from 1977 to 1984, and monitored the progress of farmers and farmers' groups who had purchased the toolcarriers or to whom they had been lent by government agencies.

Some initial design problems were identified by EFSAIP including weak chassis and wheel arm construction, drawbar breakages, and

Fig. 3-13: On-station demonstration of Mochudi toolcarrier, Botswana c. 1974. (Photo: FMDU archives).



inaccurate operation of the seeders and fertilizer applicators, and the Mochudi workshop took action to rectify these problems (EFSAIP, 1977). The use of second-hand tyres was discontinued as repeated punctures made this a false economy (EFSAIP, 1980). While designed as an implement of low draft requirement, the number of animals actually used to pull the Makgonatsotlhe toolcarrier tended to increase. For row work it was initially suggested that no more than two oxen be used, in conjunction with a single seeder and fertilizer applicator. Double seeders and fertilizer applicators required the use of four oxen, but with four animals accurate control of row spacing become difficult (Eshleman, 1975). For mouldboard plowing with an 8" share the power of at least four oxen was required. However the EFSAIP team found that the power requirements of sweeping under field conditions were also much greater than first imagined. Blockages of the sweeps with weeds (notably *Ananthospermum hispidum* and *Cynodon dactylon*) became a major problem (D. Horspool, personal communication, 1986) and farmers had to use six animals to pull the toolcarriers fitted with tines. Farmers often found it necessary to pass more than once to obtain a satisfactory seedbed and observing increasing weed problems farmers owning toolcarriers returned to traditional mouldboard plowing using large teams of 6–8 animals and often single purpose implements (Farrington and Riches, 1983).

3.4.3 The Versatool

Another initiative involving both minimum tillage concepts and wheeled toolcarriers was carried out by staff of the Dryland Farming Research Project from 1971 to 1974. This was a Government of Botswana project, supported by the British Overseas Development Administration (ODA). The British National Institute of Agricultural Engineering (NIAE) had no direct involvement in this toolcarrier initiative (D. Kemp, personal communication, 1987). The project investigated options for improving systems of crop production and the research team concluded that the existing animal-drawn equipment was inadequate, often unsuitable for the conditions of Botswana and of poor design. The researchers found that the conventional mouldboard plows covered the ground slowly and encouraged excessive water loss, and considered that implements such as chisels, sweeps, planters with press wheels and flat-bladed, inter-row hoes were "an essential prerequisite for the successful introduction of an improved crop production system" (Gibbon, Harvey and Hubbard, 1974).

Although they were aware of the Mochudi toolcarrier development work, and there was close liaison with the Mochudi Farmers Brigade, the Dryland Farming Research team designed and constructed their own wheeled toolcarrier named *The Versatool* (Hubbard, Harvey and Gibbon, 1974). This comprised a rectangular chassis made of box section steel, to which were welded stub axles, adjustable for frame height but not track width. The wheels were fitted with pneumatic tyres. Inside the chassis was suspended a hinged angle iron frame on to which implements could be bolted. The hinging allowed the subframe and tools to be raised by a long lever, and this could be useful at the end of a row, or for transport to the field. The Versatool could carry chisel plows, cultivation sweeps, subsoiler tines, and twin seeders or fertilizer applicators. The implement was drawn by a pair of oxen, and the system was designed to allow contour cultivation. Like other toolcarriers it could be modified to carry water drums or a cart body, although, as with the Mochudi toolcarrier, there was no provision for a driver's seat.

Fig. 3-14: Versatool demonstration, Sebele Research Station, Botswana, 1973. (Photo: FMDU archives).

3.4.4 The Versatool minimum tillage system

Following the on-station development of the Dryland Farming Research Project, it was concluded that the use of the Versatool toolcarrier could overcome two major problems. The first was inadequate availability of draft animals to form the very large teams traditionally used to pull large mouldboard plows. The second problem that could be overcome was the difficulty that farmers experienced in efficiently weeding crops that had been broadcast. Economic analyses suggested that the Versatool could be used on farms of about 10 ha, while allowing farmers to cover all costs, and in most years leave a cash surplus. As the median area of cleared land per farmer in Botswana was 9 ha, it was felt that many farmers would be able to use their own units, but it was also considered feasible for two farmers each with 6 ha to share one Versatool (Gibbon et al., 1974).

At the end of this first research phase, a memorandum was drawn up in 1974 between the Botswana Government and the British ODA defining the objectives of a follow-up programme, the Evaluation of Farming Systems and Agricultural Implements Project (EFSAIP). One of the major objectives was: "To establish the advantages of using an animal draught minimum tillage crop production system, including the DLFRS 1 toolcarrier, over present and alternative systems." (EFSAIP, 1981).

Consequently members of the research team that started the EFSAIP Animal Draught Systems Study in 1976 did not initially feel that they had been given an open ended re-

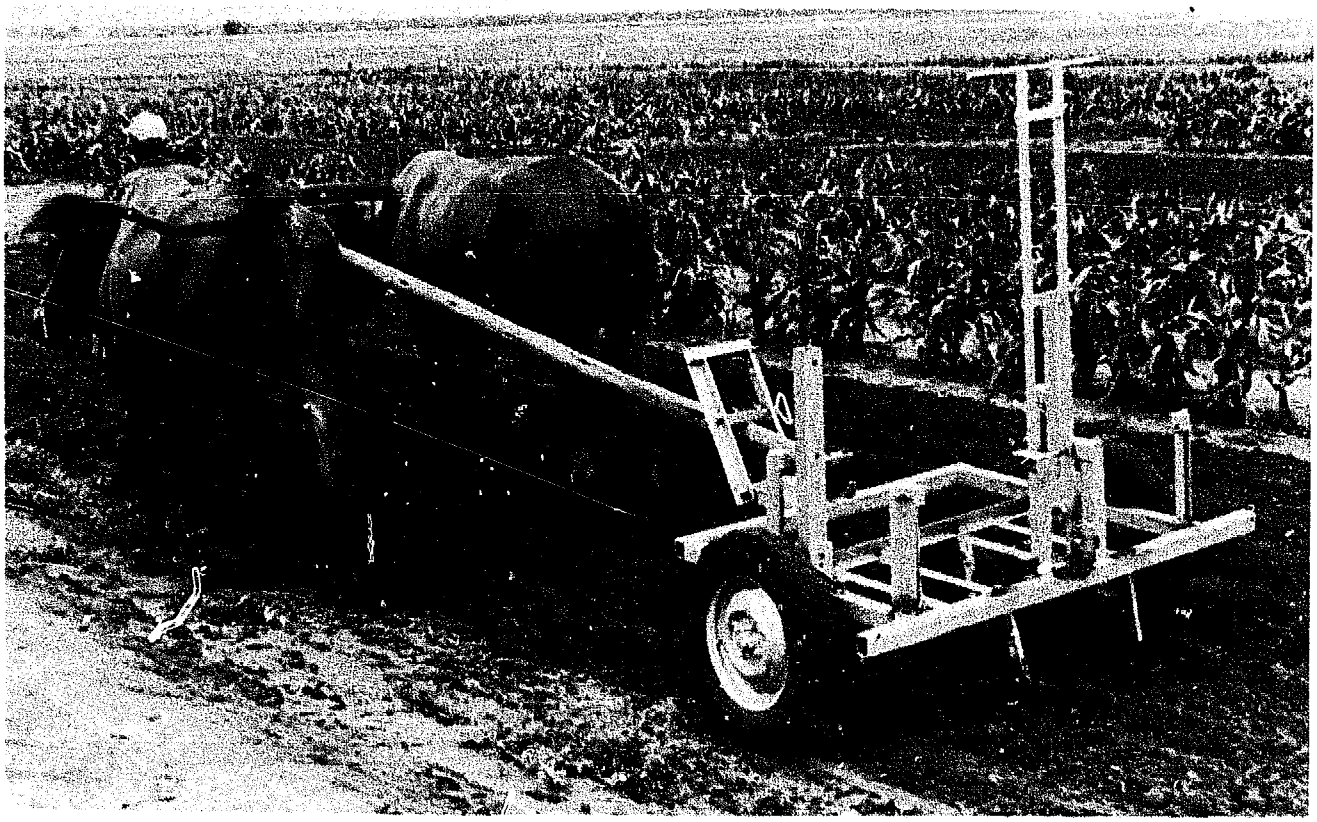
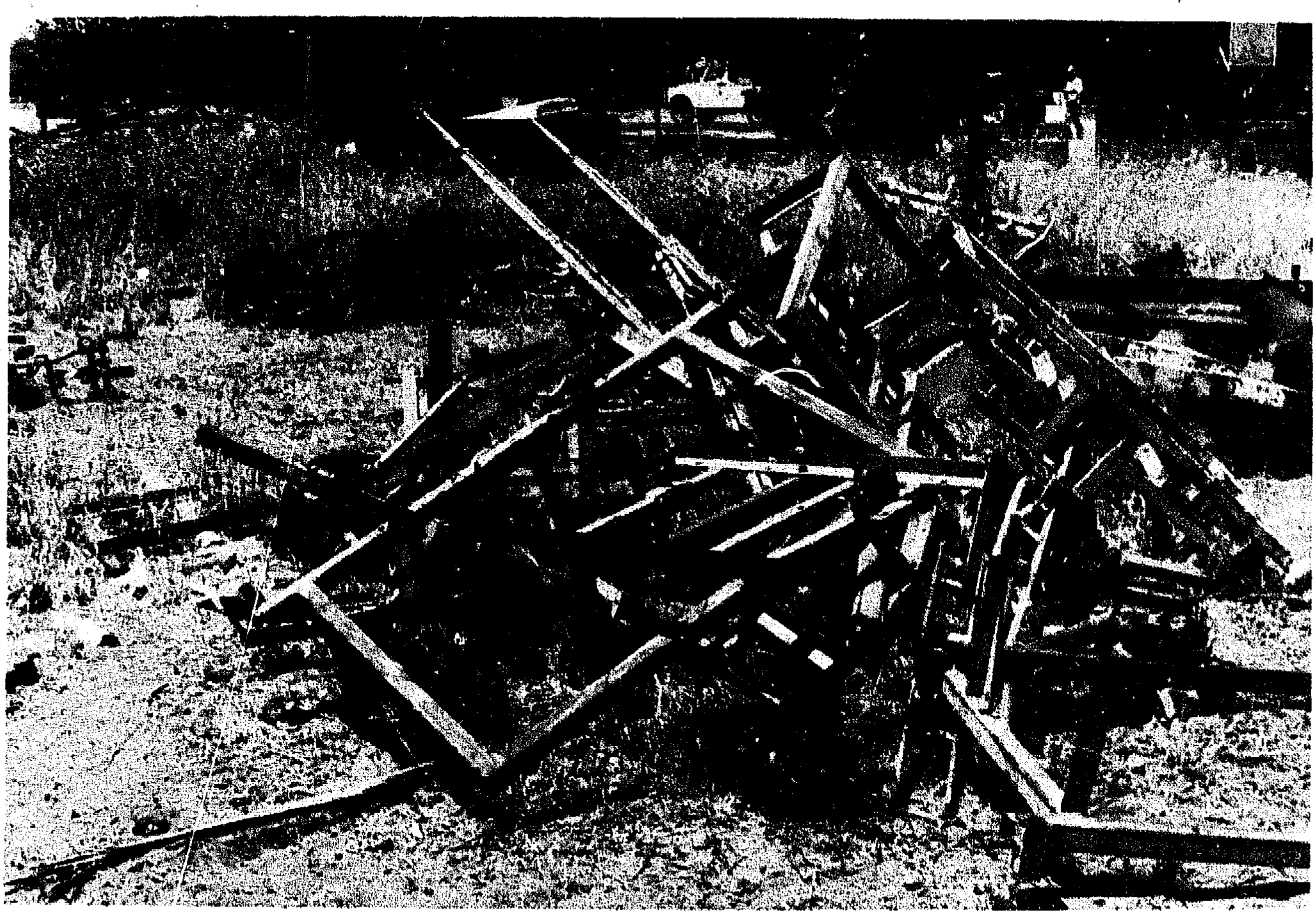


Fig. 3-15: Versatool with sweeping tines at Sebele Research Station, Botswana, 1973. (Photo: FMDU archives).

Fig. 3-16: Graveyard of Versatool frames and components at Sebele Research Station, Botswana, 1987. (Photo: FMDU).



search mandate. There was an apparent need to prove through on-farm trials that the DLFRS 1 (Versatool) system developed on station was indeed better than present and alternative systems.

In fact, despite the original project objectives, work with the Versatool was discontinued after just one season in favour of the Mochudi Makgonatsotlhe. At least ten Versatools had been made for evaluation, but once it had been decided to work only with the Mochudi toolcarrier they were naturally put to one side. Here they formed an example of what was to become an increasingly common sight in developing countries, a *toolcarrier graveyard,* which (like many others) could still be seen in 1987.

The Versatool was rejected owing to overall quality considerations, inferior performance of the sweeps, seeders and fertilizer applicators, and difficulties associated with trash clearance and in raising the tools (EFSAIP, 1977; EFSAIP, 1984). Through their programme of on-farm trials EFSAIP found the cultivation system devised in conjunction with the Versatool involved too many operations with high draft requirements and labour inputs, and that these were unacceptable in view of the associated low yields and poor crop stands. Post-harvest sweeping, an integral part of the system, was found impractical due to blockage by weeds and stover. Using the Versatool, three passes with 2–4 large oxen were required to achieve the post-harvest autumn chisel plowing, and combined subsoiling and fertilizer application was found impossible with small numbers of animals in hard soil. Great difficulty was experienced in getting oxen to follow the same indistinct lines for "precision strip" minimum tillage, planting and fertilizer placement operations before crop emergence (EFSAIP, 1977; 1981; 1984).

Essentially the new cultivation system had worked under the high management, research conditions in clean and relatively light soils of the research station, but was difficult to apply on the conditions of the small farms. The conclusion that on-station results may not be directly transferable to on-farm conditions is a common one. However in this case a compounding factor was the short-term horizon of the initial project. The highly variable climate that makes crop cultivation itself problematic, also makes short-term research difficult. For example the weed control techniques with sweeps that were found effective in a relatively dry year proved unsuitable the following year when rainfall stimulated additional weed growth causing implement clogging. It was fortunate that the EFSAIP was of longer duration and was able to gain from the lessons of methodology and timeframe taught by the earlier DLFSR Project.

3.4.5 Toolcarriers, mouldboard plows and plow-planters

Since the various tine-cultivation minimum tillage systems that had been developed had proved inappropriate in on-farm conditions, from 1978 onwards all "improved" systems tested on-farm by EFSAIP were based on mouldboard plowing rather than tine cultivation (EFSAIP, 1978; 1979; 1980). When fitted with a mouldboard plow and improved planter, the Mochudi toolcarrier performed well in on-farm trials, and although its routine production had stopped at this time, estimates of replacement costs were made to allow economic comparisons of its use. This showed that average returns to the toolcarrier use were high, particularly for growing sorghum, and could be very high, but some of the lowest returns also came from the toolcarrier users. The single purpose planters and the combined plow-planter also performed well, and these were much cheaper and simpler to set up and adjust. The overall conclusion was that farmers could substanti-

Fig. 3-17: Mochudi toolcarrier "Makgonatsotlhe" pulled by six oxen in an attempt at post-harvest sweeping during on-farm evaluation, Botswana, 1977. (Photo: FMDU archives).

ally improve yields and income over traditional methods using a plow-planter that required much lower capital investment and lower overall risk than that of the Mochudi toolcarrier. Thus it was the lack of clear economic benefits to justify the very high costs and the complexity that led the research team and Ministry to reject the toolcarrier (EFSAIP, 1981; 1982; 1984).

Despite the obvious enthusiasm of the Mochudi Farmers Brigade, displays at agricultural shows and promotion through on-farm demonstrations in which over seventy units were placed in farmer service and maintained by the Ministry of Agriculture, the Mochudi toolcarrier had not been adopted by farmers on any large scale. Notwithstanding the existence of subsidies and credit only 24 toolcarriers were ever sold to farmers. Routine production ceased in 1978 and was finally terminated in 1982, leaving significant stocks of components unused, and an operational deficit that made subsequent workshop diversification into other operations difficult. In 1982, the government finally decided to discontinue its toolcarrier extension programme (EFSAIP, 1984). Most toolcarriers loaned to farmers for evaluation were written off the government books and handed over without charge to the farmers. Although showing their age, the majority of the fifteen Mochudi Makgonatsotlhe toolcarriers left with farmers after the EFSAIP on-farm evaluation programme were still in service in 1987. However they were used only as ox-carts or donkey carts and never for cultivation (D. Horspool, personal communication, 1987).

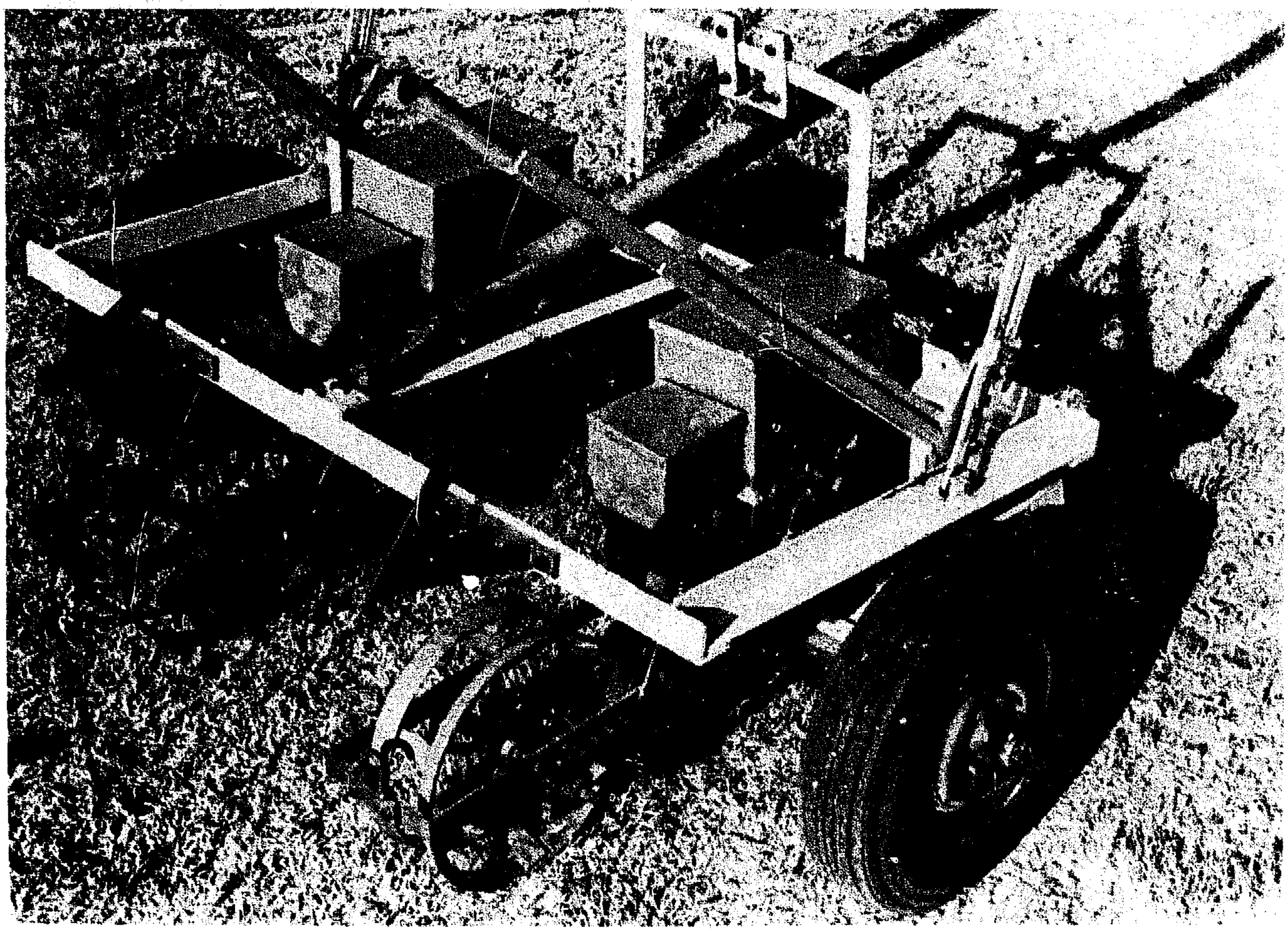


Fig. 3-18: Mochudi toolcarrier fitted with EFSAIP planter and fertilizer units, Botswana, 1980. (Photo: FMDU archives).

3.4.6 Further on-station trials

As will be briefly described in Chapter 5, subsequent research on toolcarriers in Botswana has involved only small-scale on-station trials to evaluate cultivation systems developed at ICRISAT in India. A modified Mochudi toolcarrier and very small numbers of British-manufactured GOM Toolcarriers (Nikart type) and French-manufactured Tropicultors have been used and have given variable results (EFSAIP, 1984). Toolcarrier performance has been generally acceptable, although for technical or traditional reasons four or six oxen were used for plowing and cultivation with toolcarriers. It was concluded that the broadbed system using wheeled toolcarriers had not been proved appropriate to needs and conditions of the small farms in Botswana.

Thus there have now been fifteen years of well-documented research and development on wheeled toolcarriers in Botswana, during which time several different designs have been proved capable of working on station. However the toolcarriers have been rejected by both farmers and research workers due to their cost, their heavy weight, and the inconvenience of changing operational modes. Most importantly for each operation that could be performed by the toolcarriers there were simpler implements capable of performing the operation at least as well as wheeled toolcarriers. Thus future animal traction equipment research and development will concentrate on less costly imple-

Fig. 3-19: One of the remaining Mochudi toolcarriers, now used only as a cart in Botswana, 1987. (Photo: FMDU).

ments such as a seeder attached to a simple mouldboard plow and there are no further plans to promote wheeled toolcarriers in Botswana (D. Horspool, personal communication, 1986).

3.4.7 Sudan

As a footnote to the Botswana experience it can be recorded that two of the team that had designed the Versatool subsequently worked in an agricultural development project in the Sudan. In 1975 and 1976 they and their colleagues worked on another toolcarrier, the *Atulba Toolbar* (Gibbon, Heslop and Harvey, 1983). The Atulba toolbar was a derivative of the Versatool experience but

Fig. 3-20: Atulba toolframe (a derivative of the Versatool), Sudan, 1975. (Photo: David Gibbon).

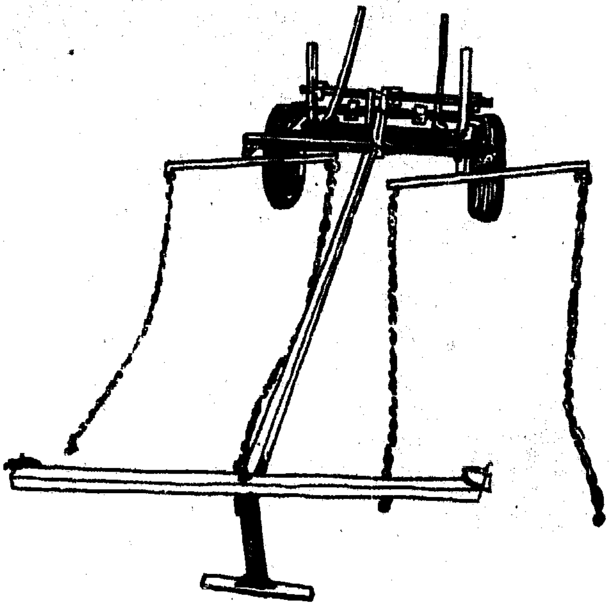


Fig. 3-21: Drawing of University of East Anglia toolcarrier (based on Atulba), with swingle-trees for harnessing.

differed significantly from the Versatool in that it used skids rather than wheels. It was not designed for adaptation for transport use. It had some of the features of an intermediate toolframe but it was heavier than the Ariana intermediate toolframe and was pulled by a draw-pole rather than a chain. The Atulba development did not pass the prototype stage in Sudan, but the design was further developed at the University of East Anglia (UEA) in Britain. On the UEA toolcarrier the skids were replaced with wheels. It was envisaged that the UEA toolcarrier might have applications for small farms in Britain or the tropics but it has not been commercially developed (Barton, Jeanrenaud and Gibbon, 1982).

3.5 Summary of experience in Africa: 1955–1975

The first twenty years of work with wheeled toolcarriers in Africa had been dominated by two designs: Jean Nolle's Polyculteur and the NIAE's animal-drawn toolcarrier. Derivatives of Nolle's designs of wheeled toolcarrier had been promoted in Senegal and several hundred were used by farmers in the 1960s. However it was soon clear to both farmers and the authorities that lighter, cheaper and simpler implements were preferable. Small numbers of Polyculteurs and Tropiculteurs were tested in several African countries, but only in Madagascar and Uganda were they actively promoted. Here also the farmers opted for simpler implements even when they carried lower rates of subsidy. The NIAE toolcarrier had been designed in the U.K. and tested in at least eight African countries, but only in The Gambia was it actively promoted. Large numbers were imported and through credit and subsidies distributed to farmers. However utilization rates were always very low and it was concluded that simpler implements were more appropriate. Several other toolcarrier designs were produced by projects, universities and agricultural engineering units in several parts of Africa. Of two designs produced in Botswana, one was actively promoted, but rejected by farmers in favour of lighter, simpler implements.

In the first twenty years project initiatives had been mainly sponsored by the bilateral aid agencies of France and Britain, with technical support from their agricultural engineers from CEEMAT and NIAE. Experiences were beginning to form a clear pattern of enthusiastic promotion followed by unequivocal rejection in favour of lighter, cheaper and simpler implements. However before the trends emerging in this first phase are discussed it will be interesting to go on to look at the second main phase – the internationalization of wheeled toolcarrier research, development and promotion.

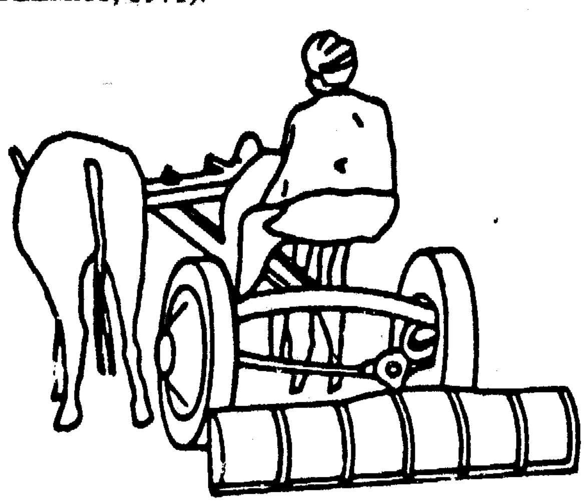
4. Experience in India: 1961—1986

4.1 Initiatives of manufacturers and state research stations, 1961–1975

In India animal traction is an integral component of most farming systems and perhaps 150 million draft animals, notably cattle, are employed, together with about 40 million traditional plows and six million steel plows. Farm machinery development has for many years involved both research institutes and private manufacturers.

The French agricultural engineering institute CEEMAT noted that research and development work in India on wheeled toolcarriers has had a long history and that commercial production of models such as the Nair toolcarrier started about the same time as the earliest French initiatives of Mouzon (CEEMAT, 1971; FAO/CEEMAT, 1972). An early photo of one Indian model, the *Universal Otto Frame* appeared in an international journal in 1962 (Khan, 1962). A review of many designs of Indian toolcarriers was prepared by Garg and Devnani (1983). These authors describe two early commercial developments, the *Universal Otto Frame* developed by Voltas Ltd. in 1962 and the *Balwan toolcarrier* developed by Escorts Ltd. of Faridabad in 1967. Both allowed a variety of tools including plows, ridgers, harrows, weeding tines and levellers to be attached to the chassis. Both had systems for raising and lowering the implements, adjustable wheel positions, pneumatic tyres of the type widely used on animal-drawn carts and drivers' seats. The Otto Frame had a seed drill option. In both cases manufacturing was discontinued due to lack of market demand (Garg and Devnani, 1983).

Fig. 4-1: Impression of a Nair toolcarrier with levelling blade in India in the early 1960s. (CEEMAT, 1971).



During the 1960s and 1970s toolcarriers were also developed at several research stations in India. These included the IIT *Kharagpur Multipurpose Chassis* developed by the Indian Institute of Technology in West Bengal in 1961. This was an intermediate toolbar design using small metal wheels and had similarities to the Ariana of West Africa. It did not develop past the research prototype stage.

In 1979 the firm of SARA Technical Services of New Delhi tried to obtain international funding to allow it to develop its own wheeled toolcarrier known as the *Bultrac* (SARA, 1979). This was a ride-on implement with steel wheels, designed initially for use with disc harrows. The prototype was not commercially developed.

4.2 Experience of national and state research institutes, 1975–1986

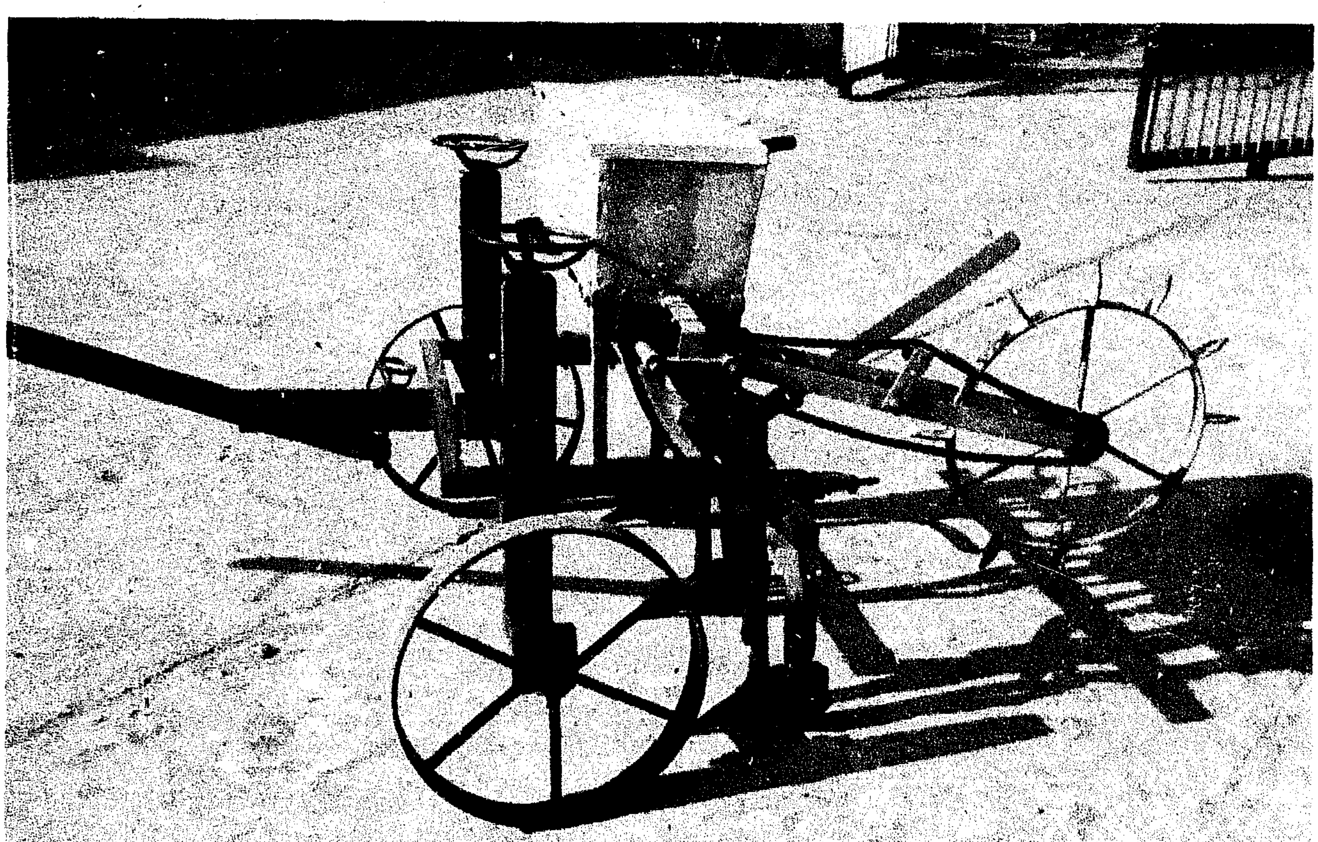
In the past ten years several different toolbars have been developed by the All India Coordinated Research Project for Dryland Agriculture (AICRPDA). These include three lightweight models based mainly on seeder/fertilizer units. By 1983, two of these designs had progressed to the stage of limited commercial production, being promoted mainly for their planting functions. By comparison, one heavier model designed for primary cultivation and transport as well as seeding, was still at a prototype stage.

The *Malviya Multi-Farming Machine* developed by AICRPDA at Baharas Hindu University, Varanasi is under commercial production and it is primarily a two-row seeder with cultivation possibilities rather than a comprehensive toolcarrier. It uses a square section chassis, and two steel transport wheels, and in addition to the seeder/fertilizer distribution attachments it can carry various weeding tines and a mouldboard plow. It is a lightweight implement and is not designed for transport and there is no operator's seat.

A somewhat similar lightweight toolcarrier, also designed mainly as a seeder is the *Shivaji Multipurpose Farming Machine* developed under the AICRPDA at Sholapur, Maharashtra. This comprises a single square section bar supported on two metal wheels designed for implement transport and not load-carrying. The main seed/fertilizer units can be mounted onto the toolbar, as can chisel points and intercultivation tines. All implements can be raised and lowered. This machine has also been commercially produced.

A third lightweight multipurpose tool based primarily on a seeder was developed by AICRPDA at the College of Technology and Agricultural Engineering of the University of Udaipur in Rajastan. It comprises a solid

Fig. 4-2: CIAE wheeled toolcarrier, Bhopal, 1986. (Photo: P.H. Starkey).



square section toolbar supported on small metal wheels. In 1983 it was still at a prototype stage.

A heavier machine using pneumatic tyres has been developed by the AICRPDA at Punjabrao Krishi Vidyapeeth, Akola, Maharashtra. The *Akola toolcarrier* has an angle-iron chassis, pneumatic tyres, adjustable wheel track, seats for two operators and a mechanism for raising and lowering implements. The implements included harrows and simple seeders. This had not passed the research prototype stage in 1983.

Another heavier machine based on the pneumatic tyres used on many bullock carts has been designed by the Department of Agricultural Engineering at Tamil Nadu Agricultural University, Coimbatore. The TNAU *Multipurpose Toolcarrier* based on a chassis made of steel pipe was initially designed for primary cultivation and transport, and the implements available include plows, tines, bundformers and a cart body. The operator sits on the frame and a pedal is used to raise and lower implements. In 1983 it was only considered a research prototype (Garg and Devnani, 1983).

The Central Institute for Agricultural Engineering (CIAE) at Bhopal having monitored developments in toolcarrier research and development at various institutions in India, including ICRISAT, felt it was important that a low cost wheeled toolcarrier should be developed. Thus CIAE decided to develop its own design based on a square section toolbar supported by small steel wheels, each adjustable using screw jacks. Plow bodies, ridgers, tines and seeders can be clamped to the toolbar. An operator's seat can be fitted and the toolcarrier can perform limited transport operations, but it is essentially a lightweight implement designed for low cost and simplicity rather than strength. Ten toolcarriers were made for on-farm feasibility trials in 1984, which proved encouraging and the toolcarrier was to be given wider testing in 1985–1986 (CIAE, 1985). In 1986 work was still being undertaken on prototype development, and it was considered that it still required further testing with farmers to establish its durability and economic appropriateness (Devnani, personal communication, 1986).

4.3 Work at ICRISAT in India, 1974–1986

4.3.1 The mandate of ICRISAT

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is an international research centre with its headquarters at Patancheru, near Hyderabad in India. It is one of the network of international centres established by the Consultative Group on International Agricultural Research (CGIAR) and through the CGIAR it is funded by several multilateral and bilateral donor agencies. ICRISAT is mandated to develop improved farming systems for the resource-poor farmers of the semi-arid tropics, to identify constraints to agricultural development and evaluate means of alleviating them, and to assist in the transfer of technology to the farmer through cooperation with national and regional research programmes. While ICRISAT's target group are farmers of limited means, cultivating primarily with family labour, with few inputs and without the benefit of regular irrigation, ICRISAT's immediate clients are the scientists of the national research institutions of the semi-arid countries who are responsible for producing new technologies for their countries (TAC, 1986).

Since 1974 ICRISAT has been closely involved with the development of wheeled toolcarriers and since 1980 it has been the leading organization in the world at promoting this technology through demonstrations, paper presentations, publications and training. ICRISAT began operations in 1973, and one objective was to develop improved farming systems for rain-fed agriculture in the semi-arid areas. ICRISAT has a long time horizon, estimating that it may take up to seven years to develop a technology under research conditions, one or two years of verification and project initiation, between one and ten years for initial adoption and up to twenty years for widespread adoption (ICRISAT, 1982).

4.3.2 Identification and refinement of the Tropicultor (1974–1977)

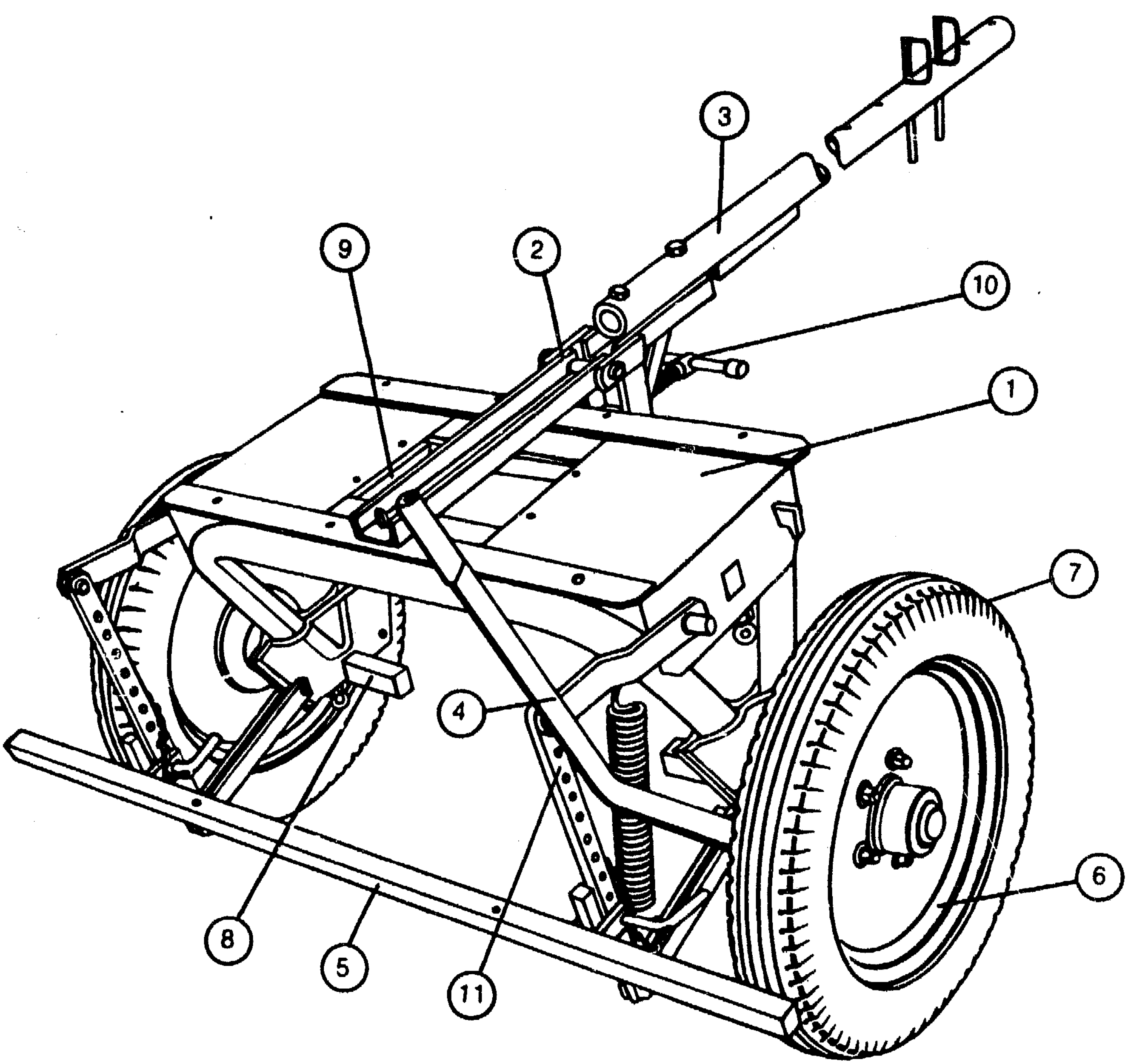
The ICRISAT research farm at Patancheru was started in 1973 with fifteen hectares of cultivation using both tractors and traditional bullock-drawn implements. Since 1974 most research at ICRISAT relating to Farming Systems and Resource Management has been carried out using animal power and hand labour and in 1974 the Farm Equipment and Tools Programme started using a wheeled toolcarrier, the *Kenmore*, manufactured in Britain (ICRISAT, 1975). The Annual Report for 1974–1975 was the first ICRISAT annual report to include a photograph of a wheeled toolcarrier and this seems to have started a precedent as all subsequent annual reports and about one third of all ICRISAT publications not specific to the mandated crops have also had photographs of wheeled toolcarriers. The ICRISAT Research Highlights of 1985 was one of the

Fig. 4-3: Tropicultor being used for weeding and hand-metred fertilizer application, ICRISAT Centre. (Photo: ICRISAT archives).

first general ICRISAT publications for a decade not to include photographs of wheeled toolcarriers.

Initially the main use of the wheeled toolcarrier at ICRISAT was to make ridges more quickly and more precisely than traditional implements. The ridges were needed to allow the rainy season cultivation of water-holding black soils (Vertisols) which are seriously underutilized in India during the monsoons. Subsequently in 1975 a broadbed system of cultivation was evaluated that might replace traditional narrow ridges as a means of soil and water conservation, and initial results were very encouraging. After trials with 75 cm beds, it was found that 100 cm beds with 50 cm furrows were more stable, better at controlling erosion and could permit crop cultivation in black soils during the rains. ICRISAT scientists considered that the implements available in India in 1975 were not suited to the broadbed system, as time for bed preparation was high, and planting precision was poor. It was therefore decided to

Fig. 4-4: The major components of a Tropicultor. 1. Platform over chassis (used as seat). 2. Channel assembly. 3. Beam or dissel boom. 4. Toolbar lifting handle. 4. Toolbar. 6. Wheel (can also be fitted on inside of frame). 7. Pneumatic tyre. 8. Stub axle. 9. Toolbox. 10. Pitch screw. 11. Adjustable toolbar supports. (Tropicultor Operator's Manual, ICRISAT 1985).



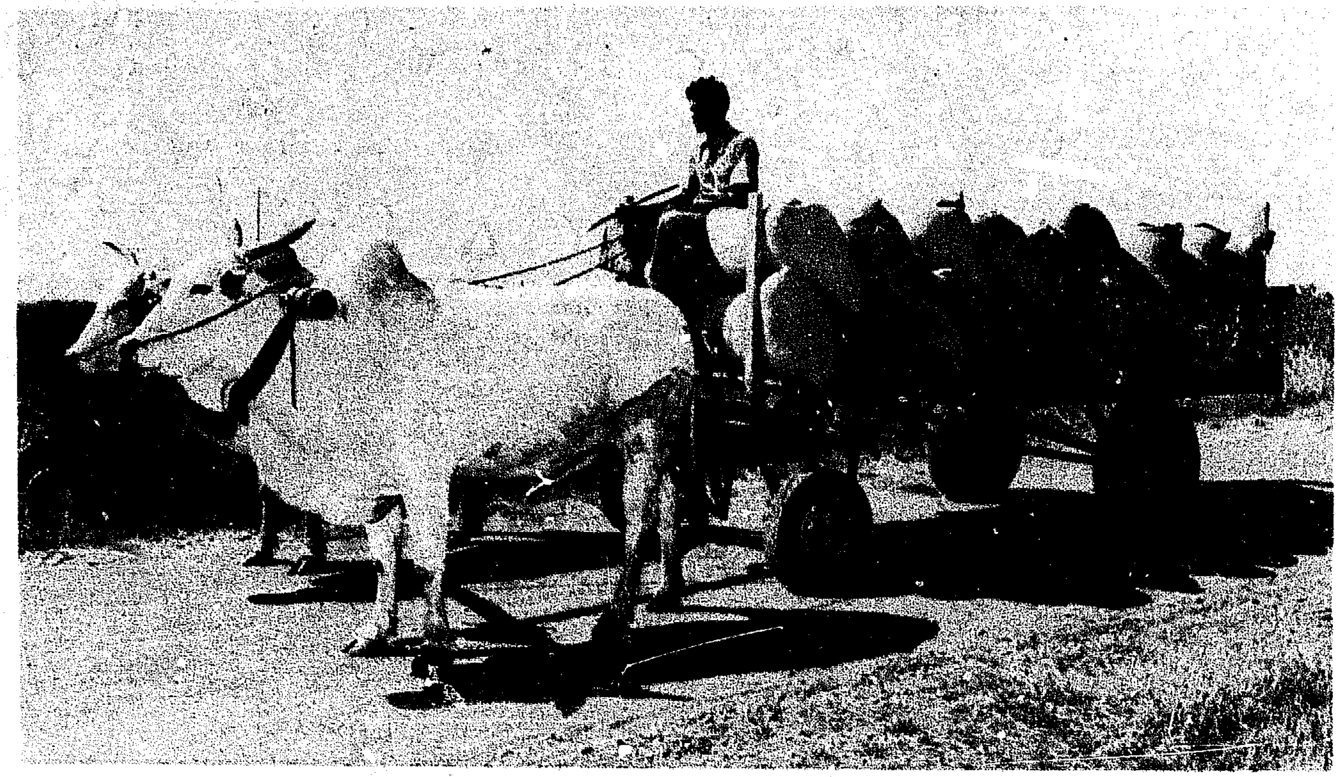


Fig. 4-5: Tropicultor fitted with four-wheel trailer, ICRISAT Centre. (Photo: ICRISAT archives).

search for animal-powered implements that could be used in the broadbed system and which could save both time and energy. Wheeled toolcarriers appeared most suitable, and several designs were evaluated in 1975 (ICRISAT, 1976).

ICRISAT did not attempt to re-invent the wheeled toolcarrier, but rather evaluated a variety of pre-existing models, including the Kenmore (UK), the Otto Frame (India), the Polyculteur (Senegal) and the Tropiculteur (France). The preferred design was the Tropiculteur, manufactured in France by Mouzon, and the 1975–1976 ICRISAT Annual Report contained three photographs of this toolcarrier looking remarkably similar to present-day models. ICRISAT obtained the services of the French agricultural engineer Jean Nolle, who since starting his pioneering work in Senegal had designed several wheeled toolcarriers including the Tropiculteur, and who therefore was the world's leading specialist in this field. Jean Nolle carried out consultancy assignments for ICRISAT in 1976 and renamed his design *Tropicultor* to make it more international (Nolle, 1986). ICRISAT subsequently purchased the rights to allow the local manufacture in India of the Tropicultor (ICRISAT, 1979).

Originally designed in 1963, the Tropicultor has been modified and refined over the years, but essentially it consists of a strong chassis made of steel tube supported on wheels with pneumatic tyres. The wheels which are mounted on stub axles give an adjustable track and can be fitted either inside or outside the chassis. A wide range of implements can be clamped to a square section toolbar hinged to the chassis, which can be raised and lowered with a lever. The Tropicultor can carry one or more operator and a one tonne payload. Following several years of technically successful on-station trials and some on-farm evaluation, in 1985 ICRISAT published a detailed and well illustrated manual on the use of the Tropicultor. This covers implement assembly and a range of field operations including plowing, tine cultivation, harrowing, making broadbeds, seeding and weeding. This manual was designed for publication in different languages, to aid the adoption of the Tropicultor in different areas (ICRISAT, 1985).

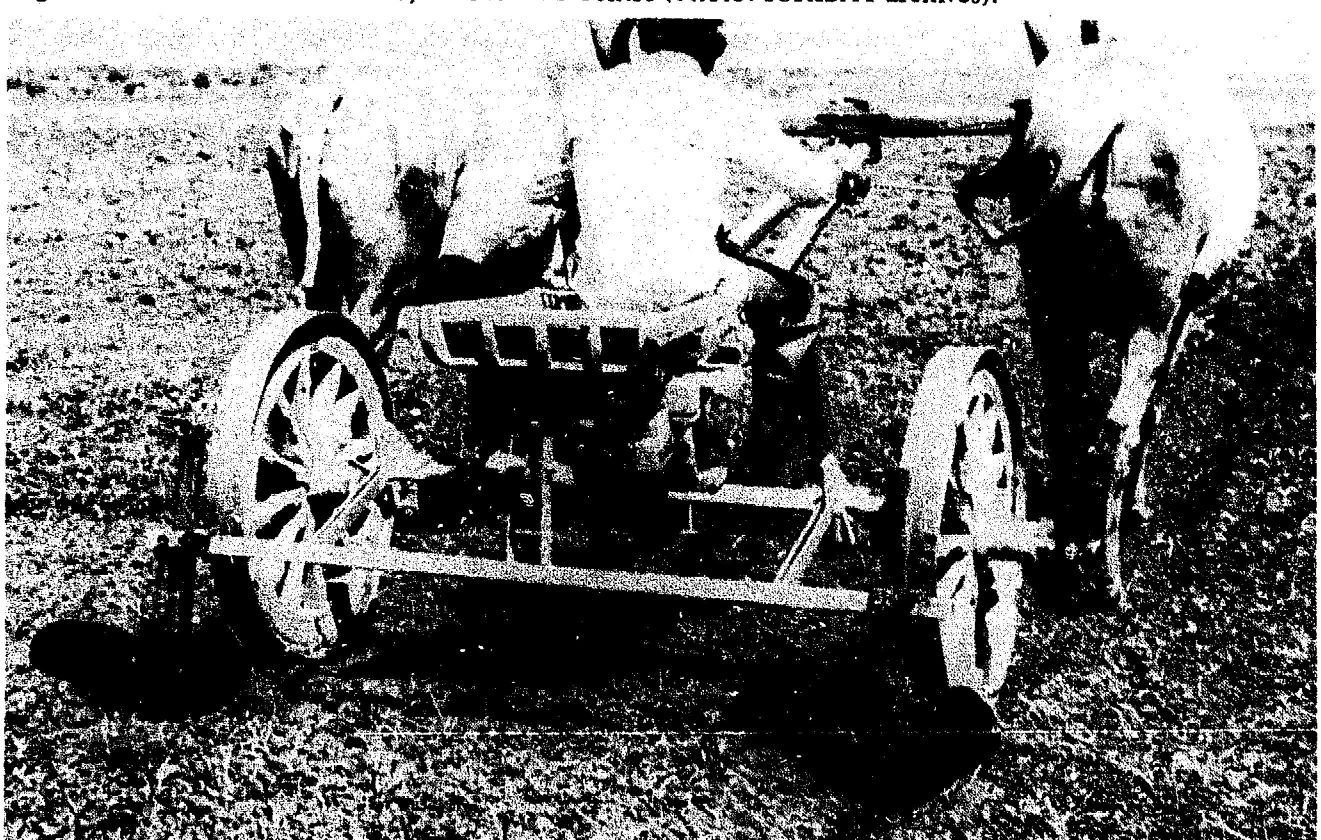
Even in the early years of research at ICRISAT there was concern over the cost of wheeled toolcarriers which were technically efficient but also too expensive for most farmers in the semi-arid tropics. Efforts to "decrease the cost" of the Tropicultor started as early as 1975 (ICRISAT, 1976) and subsequently three attempts were made by ICRISAT to develop cheaper toolcarriers.

4.3.3 The Akola cart-based wheeled toolcarrier (1978–1982)

One attempt to develop a low-cost toolcarrier started in 1978, and was the only toolcarrier to be developed at ICRISAT that was not derived from a French or British design. The toolcarriers were based on the relatively small and lightweight passenger bullock carts made of wood by artisans in the Akola region of the Maharashtra State of India. Akola carts were purchased and their axles were converted to take the implements designed for the Tropicultor. Four units were tested, and during on-station trials in 1978 and 1979 they performed operations with a precision comparable with that of the more expensive Tropicultor. Lal (1986) considered the cart-based toolcarriers were an important development, being based on existing artisanal technology and at an estimated cost of about $ 300 (primarily the cost of the implements) they were less than one third of the cost of the Tropicultor. Although it was based on traditional cart axles and wooden spoke wheels, the cart-based toolcarrier was not designed to allow easy conversion between cart and toolcarrier. Nevertheless load-bearing platforms could have been built onto the axle if required.

The initial trials with the Akola cart-based toolcarrier were sufficiently optimistic to

Fig. 4-6: Akola cart-based carrier, at ICRISAT Centre (Photo: ICRISAT archives).



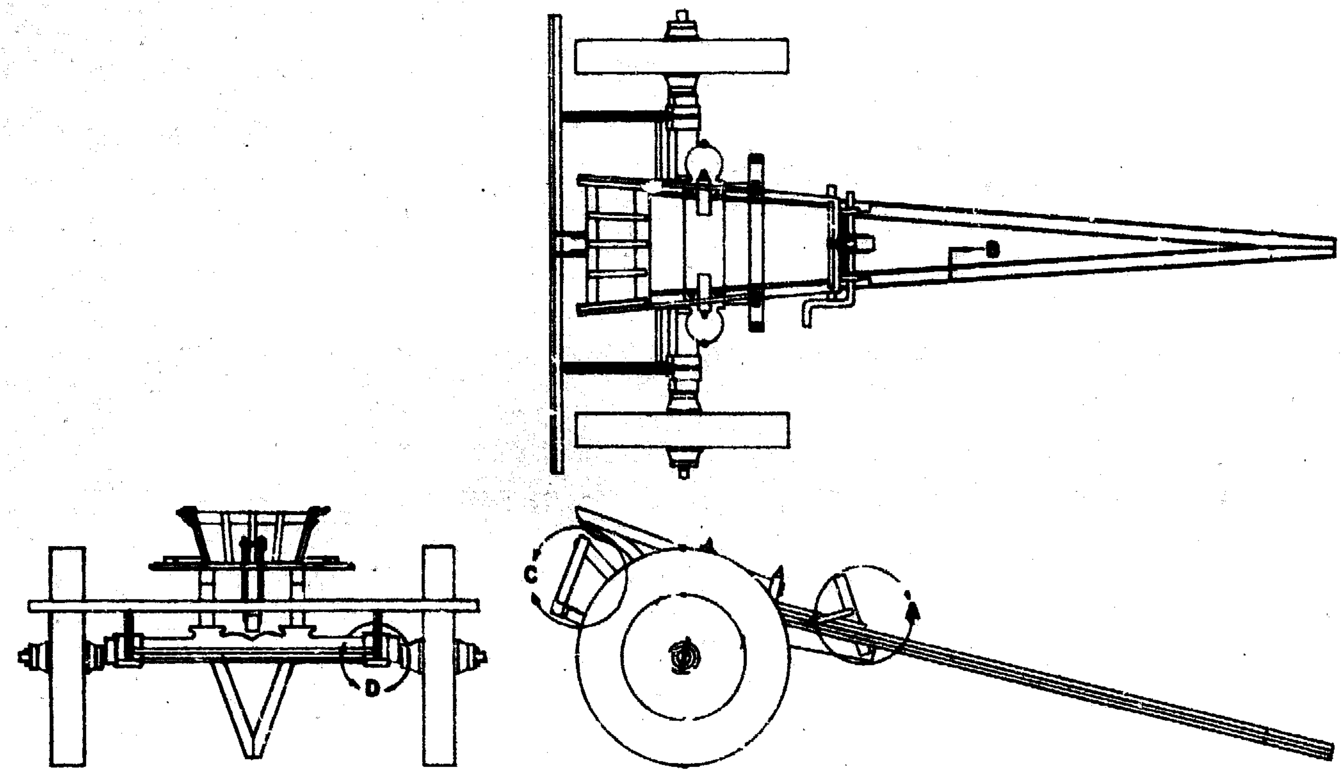


Fig. 4-7: Drawings of Akola cart-based carrier: A) Front levers of lifting mechanism; B) Tapering double wooden beam; C) Rear toolbar and lifting mechanism; D) Axle bracket. (Lal, 1986).

justify a season of comparisons with 22hp tractors at "operational" level (2–3 ha) in 1979 and one objective of these on-station trials was to "study the economics" of the cart-based toolcarrier (ICRISAT, 1980). Operations using the cart-based toolcarrier were easier and more trouble-free than with the tractor (ICRISAT, 1980) but work on the Akola toolcarrier was not continued. The reasons for the rejection of this toolcarrier were not given in the optimistic report of Lal (1986), who considered that it was due primarily to his own departure and the fact that no one else was sufficiently interested in taking on research on lower cost implements. Other researchers at ICRISAT cited problems of standardization of dimensions, structural weakness, limited endurance and rising costs of wood (ICRISAT, 1984; Bansal, Awadhwal and Takenaga, 1986).

It should be noted that the Akola cart toolcarrier was a hybrid of traditional and modern technologies, for it had been designed to use all the tools of the Tropicultor. The main reasons for its rejection seem to have been related to the engineering problems (and costs) of the hybridization process. This necessitated reliably *adapting* the carts to take *precision implements* made of steel. No attempt had been made to adapt other artisanal technology (such as traditional "Desi" plows and blade harrows) to the toolcarrier concept, or develop village-level artisanal solutions to the perceived engineering problems.

4.3.4 The NIAE/ICRISAT (Nikart) wheeled toolcarrier (1979–1986)

A second initiative to develop a cheaper toolcarrier started in 1979 when the British National Institute of Agricultural Engineering (NIAE) with funding from the British Overseas Development Administration (ODA) started to collaborate with ICRISAT on the design of a new toolcarrier intended to be simpler and of lower cost (ICRISAT, 1979).

A review of existing models was carried out, and it was found that none of these were being marketed at an acceptable cost.

Four major design problems were identified on existing toolcarriers:

– Implements were designed to be as versatile as possible. As a result farmers often had to pay for features they would not use. (For example Kemp considered that the NIAE wheeled toolcarrier of the late 1950s and 1960s had been excessively versatile.)

– The tool-lifting mechanisms were heavy and difficult to operate.

– The implements' designs were often unattractive to local manufacturers as they made use of materials not readily available.

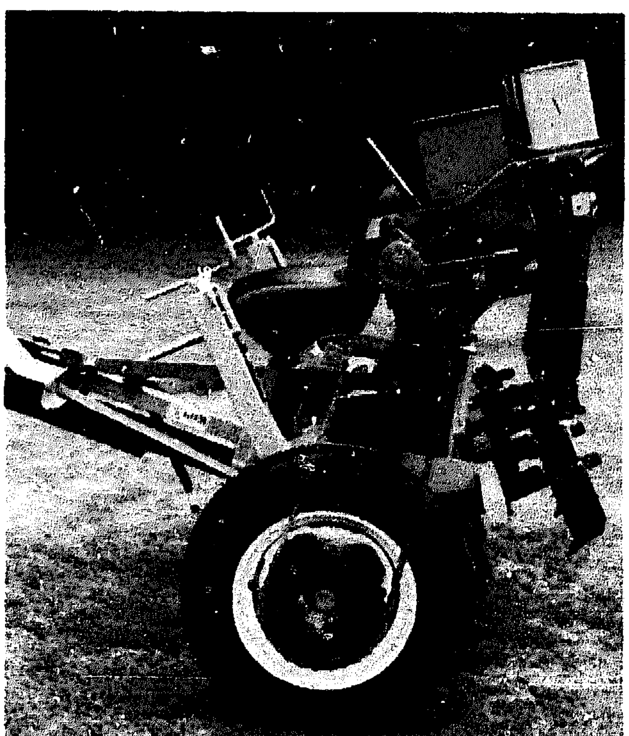
– Depth control during operation was much more difficult than on single purpose implements, resulting in poor work quality (Kemp, 1980).

As a result of the review, a design philosophy was adopted that would attempt to combine multipurpose use with simplicity yet would intentionally limit some of the options for versatility in favour of lower production costs. Among the design specifications were the capability to perform conventional tillage as well as the broadbed cultivation, one-man ride-on operation, on-the-move depth adjustment and rapid conversion to a one tonne cart (NIAE, 1981).

Fig. 4-8: Early NIAE/ICRISAT (Nikart) toolcarrier prototype being tested with tractor in the U.K., 1980. (Photo: AFRC-Engineering archives).

Early prototypes of the new wheeled toolcarrier, which became widely known by the name *Nikart*, were made at NIAE and were tested by ICRISAT at Patancheru in 1979. In 1980 four slightly modified units were successfully tested at Patancheru, and there was then a need for further examples for on-farm testing. The British Intermediate Technology Development Group (ITDG) was contracted in 1981 to supervise the start of local production at the privately owned Mekins Agro Industrial Enterprises workshop at Hyderabad. The ITDG consultant found that although the Nikart had been designed to be made from locally available materials, there had still been the need to make certain design changes to take account of the *actual* availability of different steel sizes and qualities. The consultant concluded that the original Nikart design had in practice been separated from the realities of the resources and skills available to the small-scale producers (Barwell, 1983), although one specific objective of the design team had been to avoid this problem (Kemp, 1980). NIAE considered that there had been no contradiction between design philosophy and practice, as the contracting of IT-Transport to assist in establishing the manufacturing process and identifying any necessary changes had been an integral part of the research and development programme (D. Kemp, personal communication, 1987).

Fig. 4-9: Early Nikart-type implement with fertilizer-planter, manufactured in the U.K. as GOM Toolcarrier, 1980. (Photo: AFRC-Engineering archives).

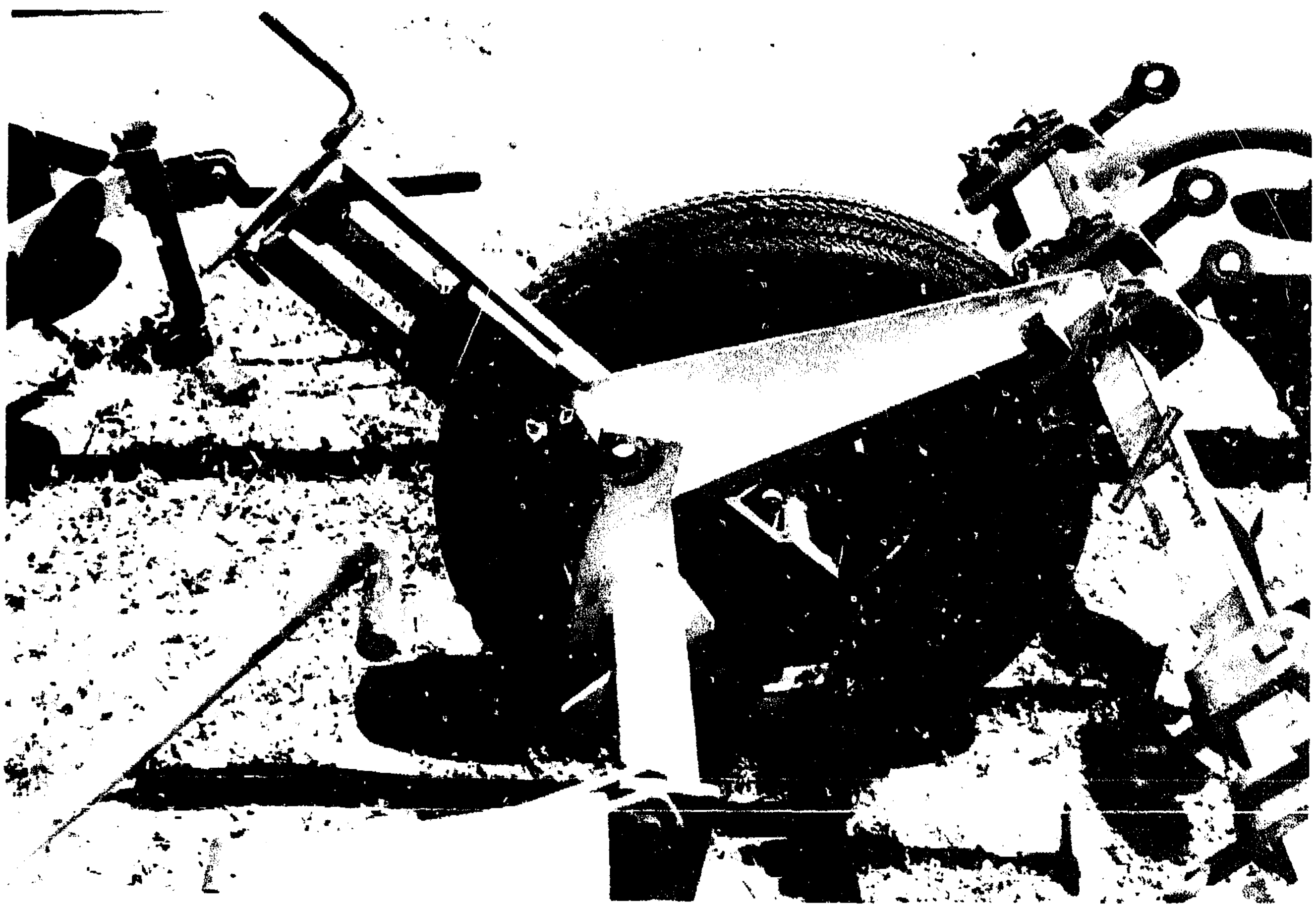


The Mekins workshop produced about 100 Nikart wheeled toolcarriers during the period 1981 to 1984 (Fieldson, 1984; Kshirsagar, Fieldson, Mayande and Walker, 1984) and 32 in the period 1985–1987 (Agarwal, personal communication, 1986). During the same time it also manufactured about 1100 Tropicultors. Almost all sales have been to development projects and institutions, some of which have lent them to farmers or sold them with 50–80% subsidies. Several other workshops in India including Medak Agricultural Centre, Kale Krish Udyog (Pune) and Sri Lakshmi Enterprises (Bangalore) made small numbers of Nikart-type prototypes between 1981 and 1984, but all preferred to manufacture Tropicultors, and all subsequently stopped making toolcarriers.

ICRISAT and NIAE have also promoted the Nikart design in other semi-arid areas. The version most widely distributed has been the *GOM Toolcarrier* manufactured in the U.K. by Geest Overseas Mechanization. Between 1981 and 1986 about 100 GOM Toolcarriers were sold to aid agencies and development projects in at least twenty different countries including Botswana, Burma, Ethiopia, Mali, Mexico, Mozambique, Philippines, Sudan and Zimbabwe. Most were sold in small numbers for evaluation, and by early 1987 there had not been any significant follow-up orders. By 1986 Geest was pessimistic about the prospects for its own manufacture of these toolcarriers due to the inability of small farmers to afford them, and the prohibitive costs of manufacturing such items in the U.K.

Fig. 4-10: Mekins Nikart with fertilizer-planter (Photo: ICRISAT archives).

Fig. 4-11: Precise and simple screw depth adjustment on early Nikart: on later models the mechanism was encased to protect it from dirt. (Photo: FMDU, Botswana).



The British ODA, in cooperation with NIAE, assisted the start of production in Mexico of the *Yunticultor toolcarrier* based on the Nikart research and development. A smaller initiative, also with technical support from NIAE, was started in Honduras, and a prototype *Yunticultor Mk II* was developed to make local fabrication more easy. By 1986 about 100 Mexican and 20 Honduran Yunticultors had been made. Few had been bought by farmers and most sales were to government agencies, development projects and research stations. These Latin American experiences are discussed further in Chapter 6.

One of the main objectives of the Nikart project had been to reduce the price of the basic toolcarrier by at least $ 150 in comparison with the cost of the Tropicultor. Initially this objective appeared to have been achieved for in 1985 prices quoted by the Mekins workshop were $ 400 for the Nikart without implements and $ 600 for the Tropicultor without implements. (The implements were interchangeable, and the basic set for either was about $ 500 excluding a seeder.) This price differential had been maintained in deference to the assistance the workshop had received to start Nikart, but the quoted prices were largely theoretical as there was negligible demand for the Nikart.

In practice the savings in manufacturing cost of the Nikart due to lower weight and lack of wheel track adjustment, had been offset by the relatively complex system of height adjustment and the amount of precision welding required to manufacture the frame. In addition the early cost-saving device of the use of old car tyres for the Nikart had ceased due to problems of supply, quality and convenience of manufacture, and Indian-manufactured Nikarts were supplied with new Animal-Drawn Vehicle (ADV) tyres. The Mekins Director considered that the actual manufacturing costs of both the Nikart and the Tropicultor were similar, and by October 1986 the Mekins price differential between the basic toolcarriers almost disappeared in India at Rs 5 750 for the Tropicultor frame and Rs 5 500 for the Nikart frame ($ 500 for export sales). Other Indian manufacturers had previously also shown preference for the Tropicultor over the Nikart and unpublished data of Ghodake and Mayande (1984) suggested that even with economies of scale and the stimulus of competition, the supply prices of the Tropicultor and Nikart would be within 3% of each other.

In Europe in early 1987, the anticipated price savings of the Nikart design might be indicated if one were to compare the price of a GOM Toolcarrier with a simple set of implements (about US $ 1250) with a comparable Mouzon Tropicultor set (about US $ 1450). However any such price comparisons should be treated with great caution, since both the products and also the sales conditions of the two firms are very different, and both prices are liable to fluctuate with currency movements.

Operationally the Nikart was found to be effective, although even at an early stage it was found that few users changed between the cart mode and the cultivation mode (Kemp, 1983). While it was at first cheaper than the Tropicultor, at $ 400–500 for the basic carrier (without cart or implements) it was still very expensive. Thus even before the Nikart project had been completed, in 1978–1979 an even simpler tool, the *Nolbar* or *Agribar* was being developed.

4.3.5 The Agribar (Nolbar) wheeled toolcarrier (1978–1986)

The *Agribar* was the name given in 1981 to a derivative of the Nolbar. The *Nolbar* (presumably named after the designer Jean Nolle) had been tested at Patancheru in 1978, and in 1979 comparative trials had been carried out between the Nolbar, the Akola cart-based toolcarrier, the Tropicultor and a 22hp tractor. The Nolbar/Agribar had been designed to simplify still further the toolcarrier concept, and reduce cost (and flexibility) still further. It was designed as a simple, transverse toolbar (rather than a full chassis) pulled with a long, integral steel draw-pole. The bar is supported on two small (30 cm) wheels, with independent levers that raise or lower each end of the bar. On early models there was no operator's seat, and when one was provided it tended to give the driver a feeling of insecurity and instability. Handles in the centre of the bar can be used for implement guidance by an operator walking behind the toolcarrier. There is no provision to convert the bar to a cart. The attachments are the same as those for the Tropicultor or Nikart except that, being lighter, it cannot support as many soil preparation implements at the same time. In some respects the simplicity of the Agribar gives it some resemblance to the Ariana intermediate type of toolbar, but it differs significantly in that it uses a drawbar, and the toolbar can be raised and lowered.

In comparative trials in 1979–1980 the Nolbar/Agribar was found capable of all broadbed operations, but the time and effort required to raise and lower the implements at the end of each row made it less efficient in operation than the other toolcarriers. From 1978 to 1984 the Agribar was tested and adapted at Patancheru and was also (briefly) tested at Sotuba and Cinzana Research Stations in Mali. In 1985 it was tested by farmers in India but to date it does not appear to have been tested by farmers in Africa (ICRISAT, 1984 and 1985). In theory the Agribar is being commerically manufactured at the Mekins workshop, but to date total sales have been only thirty, of which fifteen have been exported for evalua-

Fig. 4-12: Agribar, fitted with seat, with ridging bodies, ICRISAT Centre. (Photo: ICRISAT archives).

Fig. 4-13: Agribar with hand-metred planter and fertilizer applicator, ICRISAT Centre. (Photo: ICRISAT archives).

tion in West Africa and Somalia. Priced at Rs 1500 in India and at $ 200 for export (without implements), the Mekins Agribar is only 25–33% of the cost of a Tropicultor. Although it has been under development for nine years at ICRISAT, farmer evaluation, sales and promotion have been minimal. In 1987 ICRISAT will publish a manual on its use, using the style of the Tropicultor manual.

On the ICRISAT station at Patancheru, the preferred toolcarrier has been the Tropicultor, and the on-station uses of this have been further diversified with the development and testing of prototype high-clearance pesticide sprayers and dust applicators and rolling crust breakers (ICRISAT, 1984 and 1985). At the ICRISAT research stations in Mali and Niger, the Nikart is preferred for its greater precision of depth control (see Chapter 5).

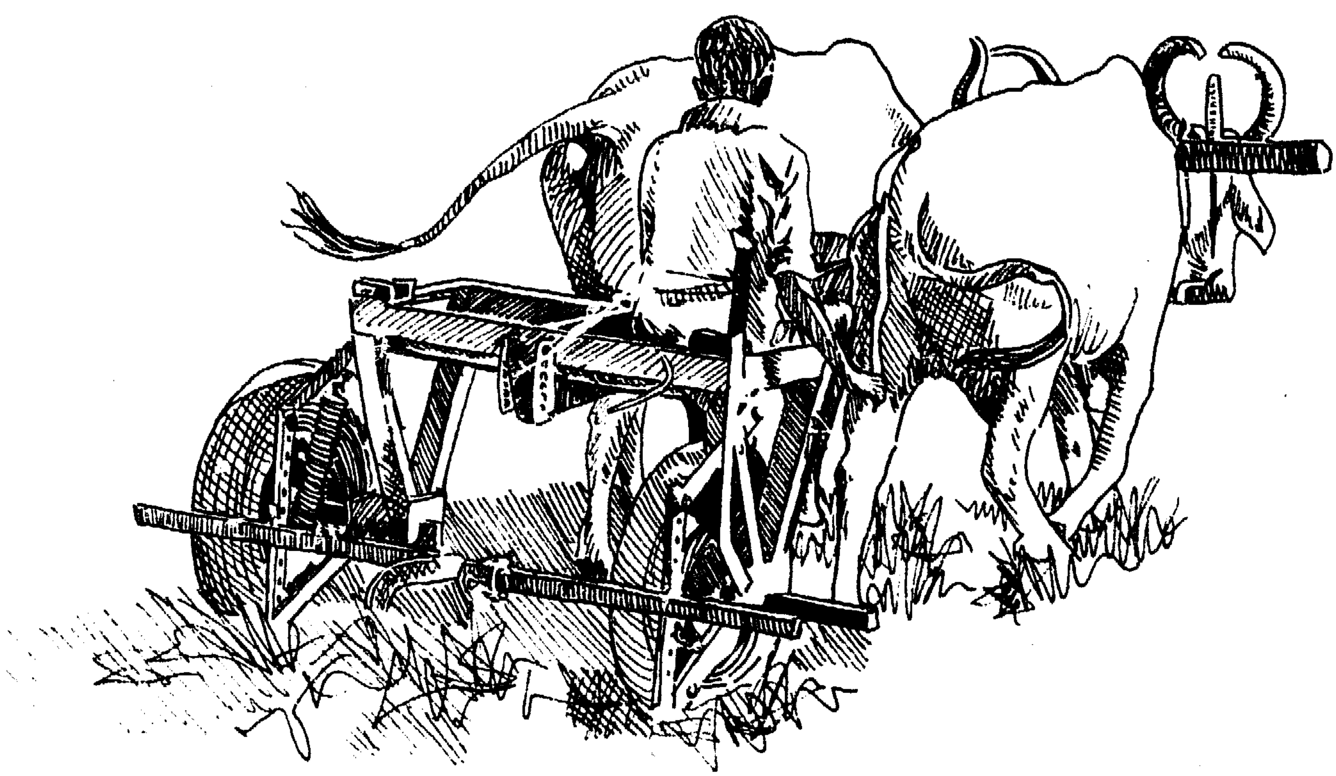
4.3.6 On-station and on-farm "verification" trials

Since 1975 wheeled toolcarriers have been used to cultivate over 100 ha of crops a year at ICRISAT's Patancheru research station (Bansal and Srivastava, 1981). From 1976 to 1981 the Farming Systems Research Program and the Economics Program of ICRISAT combined to evaluate at an operational scale the use of a complete package of "improved watershed-based technology" of which wheeled toolcarriers were considered an integral component (Virmani, Willey and Reddy, 1981; Ryan and Sarin, 1981). Small watersheds were systematically developed on the research station and from the carefully recorded and monitored trials it was clear that the combination of watershed bunding, the broadbed and furrow system using wheeled toolcarriers and the use of fertilizers and high yielding varieties produced significantly greater yields than traditional agricultural practices. This on-station work gave rise to great optimism, and a series of on-farm "verification" trials were initiated, in collaboration with Indian national programmes.

In 1978–1979 ICRISAT supervised small plot experiments in the villages of Aurepalle in Andhra Pradesh and Shirapur and Kanzara in Maharashtra State. These were followed in 1979 to 1981 with the development of watersheds of about 12 ha in each village, and the use by farmers of the broadbed and furrow technology. ICRISAT provided all relevant inputs of equipment, fertilizers, seeds and pesticides (Sarin and Ryan, 1983). Early results suggested some problems with the technology, which had not proved successful in Alfisols (red soils), medium-deep Vertisols (black soils) or in areas affected by variable rainfall. Emphasis was therefore placed on the use of the technological package in deep Vertisols in regions of assured rainfall. The village of Taddanpalle (or Taddanpally) 40 km northwest of the ICRISAT Center was selected as representative of the appropriate conditions and in 1981 a watershed of 15 ha was developed by fourteen cooperatting farmers, with intense scientific and technical guidance from ICRISAT scientists (Ryan and von Oppen, 1983). The relative success of the first season's work at Taddanpalle led to a similar scheme in the nearby village of Sultanpur in 1982. A great deal of information was collected from the village studies and this showed there were both advantages and disadvantages to the new technology. As discussed in a following section, there are several examples of the positive aspects of the "on-farm verification" being selectively reported. However the final outcome in *all* the villages in which watersheds were developed is that none of the farmers continued with the technology and in general farmers were not prepared to buy

Fig. 4-14: Tropicultor with steerable weeder being used in on-farm verification trials in India. (Photo: ICRISAT archives).

Fig. 4-15: Agricart wheeled toolcarrier plowing on farm in India (note RH wheel is inset). (Based on photo: ICRISAT archives).



or hire the wheeled toolcarriers, even at subsidized prices.

Thus by 1986 ICRISAT was not aware of *any* villages in India in which the wheeled toolcarrier and broadbed and furrow system had been proven by sustained farmer use and adoption. There were only a few examples of any use of broadbeds or wheeled toolcarriers. In one village, Antwar, about 100 km from Patancheru, three land-owning brothers had been experimenting with the broadbed and furrow system for three years and had obtained six Tropicultors and one Nikart. In this scheme the toolcarriers had been used on family land and had been loaned to twenty farmers without charge. The toolcarriers were only used as carts when all traditional carts were unavailable and in December 1986 the dry season cultivation of fields was being undertaken with traditional Desi plows due to the high draft of the toolcarriers. In 1986 visiting dignitaries were taken to this village as an example of the ICRISAT technology in use. Other examples of users of the technology in 1986 were also atypical and included a community research farm at Adgenar near Aurangabad, where the organizers and farmers are interested in the wheeled toolcarriers but none of the three toolcarriers provided by a development project had been used in 1986 (a dry year), and previous utilization rates had never been high. At the village of Neoli near Latur, the father of an ICRISAT researcher had purchased a Tropicultor and in 1986 used it for plowing about three hectares of upland rice (not on the broadbed system) and for fifty days of transport.

Such isolated examples indicate that to date "verification" (in the sense of farmers proving that the claimed benefits of a technology are real) has not yet been achieved. However this has not prevented some highly optimistic reports being produced as recently as September 1986 claiming that the wheeled toolcarrier technology has been "verified".

4.3.7 Optimistic economic studies on wheeled toolcarriers (1979–1986)

Relatively early in the ICRISAT research programme, studies were carried out on the economic costs and benefits of the use of wheeled toolcarriers (Binswanger, Ghodake and Thierstein, 1980). This study tried to estimate the hire rate a contractor would have to charge to pay for a toolcarrier over a period of ten years assuming he bought the toolcarrier with a commercial loan, and required a 10–20% profit over his actual outgoings. Several models with different assumptions were presented but although the toolcarriers were assumed to have significant working rate advantages over traditional implements, even a low cost toolcarrier (with steel wheels) with high utilization rates for agricultural use (eighty days a year) and transport (one hundred days a year), and only a 10% margin of profit appeared more expensive than existing hire rates for traditional cultivation services. Thus, while the toolcarrier could undoubtedly save time and drudgery, it was concluded "even under the most favourable circumstances assumed such machines cannot compete on a cost basis with the traditional implements in traditional agriculture."

Binswanger et al. noted that there was a social cost involved, for wheeled toolcarriers would make 1.5 bullock drivers unemployed on each 15 ha on which it was assumed they would operate. However the authors noted that the toolcarriers might become both socially and economically justified if there were compensatory yield increases. If such increases were large enough they could generate sufficient extra work to offset the unemployment of the bullock drivers. In on-station research carried out between 1976 and 1978, significant yield advantages had been attributed to the soil management systems associated with the toolcarriers, and while these had not been fully verified in on-farm conditions, there was an indication that particular benefits might be achieved on the deep Vertisols (black soils). Thus the authors concluded that on-farm research relating to wheeled toolcarriers was amply justified, but cautioned that wheeled toolcarriers would not be competitive unless they could generate yield advantages in excess of 200–400 kg/ha (Binswanger, Ghodake and Thierstein, 1980).

Binswanger et al. intentionally avoided the problem of relating farm size to toolcarrier ownership by assuming that a contractor would be able to hire out such an implement to several farmers and thereby cultivate a total of 15 ha. This has been considered to be a realistic maximum for the area that could be cultivated with a toolcarrier and this figure allows costs per unit area to be minimised. However another ICRISAT worker discussed this particular problem, noting that the majority of farmers in India have much smaller farms than 15 ha (Doherty, 1980). Doherty argued that small group ownership of toolcarriers would be sociologically difficult and if large groups could be formed they might find greater benefits from tractor ownership. He also argued that farmers prefer individual ownership of implements to hiring from entrepreneurs. Doherty pointed out that some of the assumed potential yield advantages of the toolcarrier would come from the associated soil management techniques involving developing small watershed areas. However he highlighted the likely social problems of redeveloping drainage patterns between farms owned by different families of different social and economic backgrounds. Thus, while also advocating more on-farm research in this area, he emphasised the need for developing low cost implements that could be afforded by individual farmers, on-farm yield increases that could justify the investment and socially viable systems for transferring such technology (Doherty, 1980).

Despite the cautions of Doherty voiced in 1979, from 1979 to 1985 ICRISAT economists continued to base economic assessments of toolcarriers on the "optimising" assumptions of Binswanger et al. (1980).

An example of the optimism of ICRISAT economists is seen in the paper of Ryan and Sarin (1981) who stated: "We discuss the economics of the improved technologies that have been evolving from research at ICRISAT Center and in villages, aimed at enabling crops to be grown in deep Vertisols in the rainy season. . . This improved system utilizing graded broadbeds and furrows has generated profits . . . These profits represent a return to land, capital and management, as the cost of all human and animal labor, fertilizers, seeds and implements have been deducted . . . Based on these figures the extra profits from the new system could pay for the wheeled toolcarrier in one year provided that it was utilized along with improved technology on at least four hectares." Although the details of the cost assumptions used in the calculations were not provided in these papers, the profits quoted were based on "annual costs of implements". Towards the end of the paper the high cost of the toolcarrier was acknowledged, but it was pointed out that attractive rates of return would be available to entrepreneurs hiring out wheeled toolcarriers for 180 days a year.

Perhaps the most optimistic economic analyses by ICRISAT were presented by Ryan and von Oppen in 1983 and were based on initial on-farm verification. Referring to results from the village of Taddanpalle for 1981–1982, the authors stated: "These data show a 244% rate of return on the added expenditure, confirming the experience at ICRISAT Center (250%), and giving us confidence about the technology options on village farms . . . The relative success of the Taddanpalle experiment led to a further experimental area in adjoining Sultanpur village in 1982–83."

They then attempted to make a benefit-cost analysis, admitting that at the early stage of adoption, this was a hazardous exercise. The assumptions included an annual growth of toolcarriers of 45% per year (rising to 0.5 million units in use in the year 2003) and additional profits based on Taddanpalle experience of Rs 1434/ha. This gave a benefit to cost ratio of 5 : 1 by the year 2000 if each toolcarrier could work on ten hectares (a 300% internal rate of return), and 7 : 1 if the toolcarriers were used on fifteen hectares. The additional costs of the provision of extra agricultural officers, fertilizers stores and banks to service the new technology were not included, nor were any benefits attributable to soil conservation considered (Ryan and von Oppen, 1983).

Highly optimistic economic statements relating to wheeled toolcarriers continued to be made by ICRISAT economists until 1985. Ghodake (1985) drew heavily on the content of Ryan and Sarin (1981) and repeated the suggestion that a wheeled toolcarrier could be paid for in one year on four hectares although he did note that the wheeled toolcarrier might not actually be an essential component of broadbed technology for which it was being advocated.

The agricultural engineers at ICRISAT have seldom included any economic data in their reports and papers. However, in 1985, a paper was published giving an economic comparison of the Akola toolbar, the Tropicultor, the Nikart and the Agribar. Assumptions were based on 14 ha annual use, plus 400 transport hours for the toolcarriers that could be used as carts. With these assumptions the Tropicultor had the best marginal benefit-cost ratio attributable largely to the reduction in hourly cultivation costs achieved by assumed transport operations. However, in terms of simple cost per hectare, the Agribar appeared most promising, and was suggested as a low cost alternative to the heavier machines for the broadbed technology (Mayande, Bansal and Sangle, 1985). In another approach, wheeled toolcarrier technology was promoted for its energy efficiency (Bansal, Kshirsagar and Sangle, 1985).

4.3.8 General promotion of toolcarriers by ICRISAT (1981–1982)

While most of ICRISAT's work on wheeled toolcarriers had actually been based on the broadbed and furrow system of cultivation, and their economic justification derived from on-station trials using that system, ICRISAT publications started to consider wheeled toolcarriers as a valuable technology in their own right. Thus Information Bulletin No. 8 on "The Animal-Drawn Wheeled Tool Carrier" (ICRISAT, 1981) stated:

"The animal-drawn wheeled tool carrier . . . is able to perform virtually all operations that can be done with a tractor, thus providing to many farmers the versatility and precision previously available to only a few . . . The present multipurpose machine permits farmers to carry out their basic operations of tillage, planting, fertilization and weeding in a timely and precise manner to increase productivity and, as a bonus, it can be used as a cart to provide transportation. . .

Such a system of machinery promotes agriculture by increasing farmers' income and making available to them machinery that enables:

– rapid execution of cropping operations (timeliness of planting, weed control, etc.),
– better use of fertilizer (quantity and placement),
– alleviation of labour bottlenecks,
– rational use of animal power,
– more precise planting of crops." (ICRISAT, 1981).

The picture presented in this Bulletin of what seemed almost ideal equipment, perhaps a panacea of agricultural engineering, was short-lived, as feedback reached ICRISAT from village experiences.

In response to the general promotion of wheeled toolcarriers by ICRISAT and cooperating manufacturers, a large toolcarrier project (the largest to date in India) was undertaken in Nasik District of Maharashtra State. In the planning stages it was envisaged that 350 Nikart toolcarriers would be sold, but when offered the choice of Tropicultors and Nikarts, the farmers opted for Tropicultors. In 1982/1983 about 266 farmers had been sold Tropicultors at 80% subsidies under the Maharashtra Integrated Rural Energy Project. The toolcarriers had been supplied complete with plow bodies, tines and carts, and in line with the promotion for general use there had been a clear emphasis on the transport potential of the toolcarriers (Fieldson, 1984; Kshirsagar, Fieldson, Mayande and Walker, 1984).

It is illuminating to follow the progress of this scheme. After only one or two seasons, by 1984 few farmers used the Tropicultors on any significant scale for cultivation, generally perceiving them as too heavy and the implements not suited to local soil conditions. By 1986 it was relatively difficult to find any farmers who used their Tropicultors for cultivation. One farmer was specially contacted because he reportedly still used his toolcarrier, but in practice he only used the Tropicultor on one small plot and it was clear from the lack of wear on the implements that they had not been extensively used since manufacture. Many farmers had stopped using their Tropicultors even as carts, preferring the more stable and more easily repairable traditional carts. During village visits in 1986 several Tropicultor carts were seen to be still in use, but more significantly, considering the cost of the toolcarriers and research predictions concerning potential for transport use and life expectancy, abandoned frames and cart bodies were also seen. Thus this general promotion project showed a pattern very similar to some of the early African schemes: an early rejection of toolcarriers for cultivation and a slower abandonment for transport purposes. This has implications for both technical and economic assessment, for if farmers actually own implements but stop using them, the problem is not simply one of cost or profitability for they have already invested in the technology. It implies some technological problems relating to the use of wheeled toolcarriers in local farming systems and village life.

As the results of the on-farm trials and promotional schemes became known to ICRISAT scientists, doubts slowly started being expressed in papers and publications.

4.3.9 Doubts relating to wheeled toolcarriers (1981–1986)

Doubts about the overriding economic advantages of wheeled toolcarriers only slowly entered the ICRISAT literature. Ghodake, Ryan and Sarin (1981) warned that exacerbated labour bottlenecks could lead to the rejection of broadbed technology. Sarin and Ryan (1983) noted that on-farm verification trials in Alfisols (red soils) in Aurepalle village near Hyderabad had failed to show advantages for the broadbed and furrow technology. In Shirapur village in Maharashtra State the deep Vertisols (black soils) were too hard to allow plowing with wheeled toolcarriers and a single pair of bullocks, and the toolcarrier could not control weed infestation on the raised beds. In medium-deep Vertisols at Kanzara village in Maharashtra State plowing with the wheeled toolcarrier required multiple pairs of bullocks and did not lead to greater profitability when com-

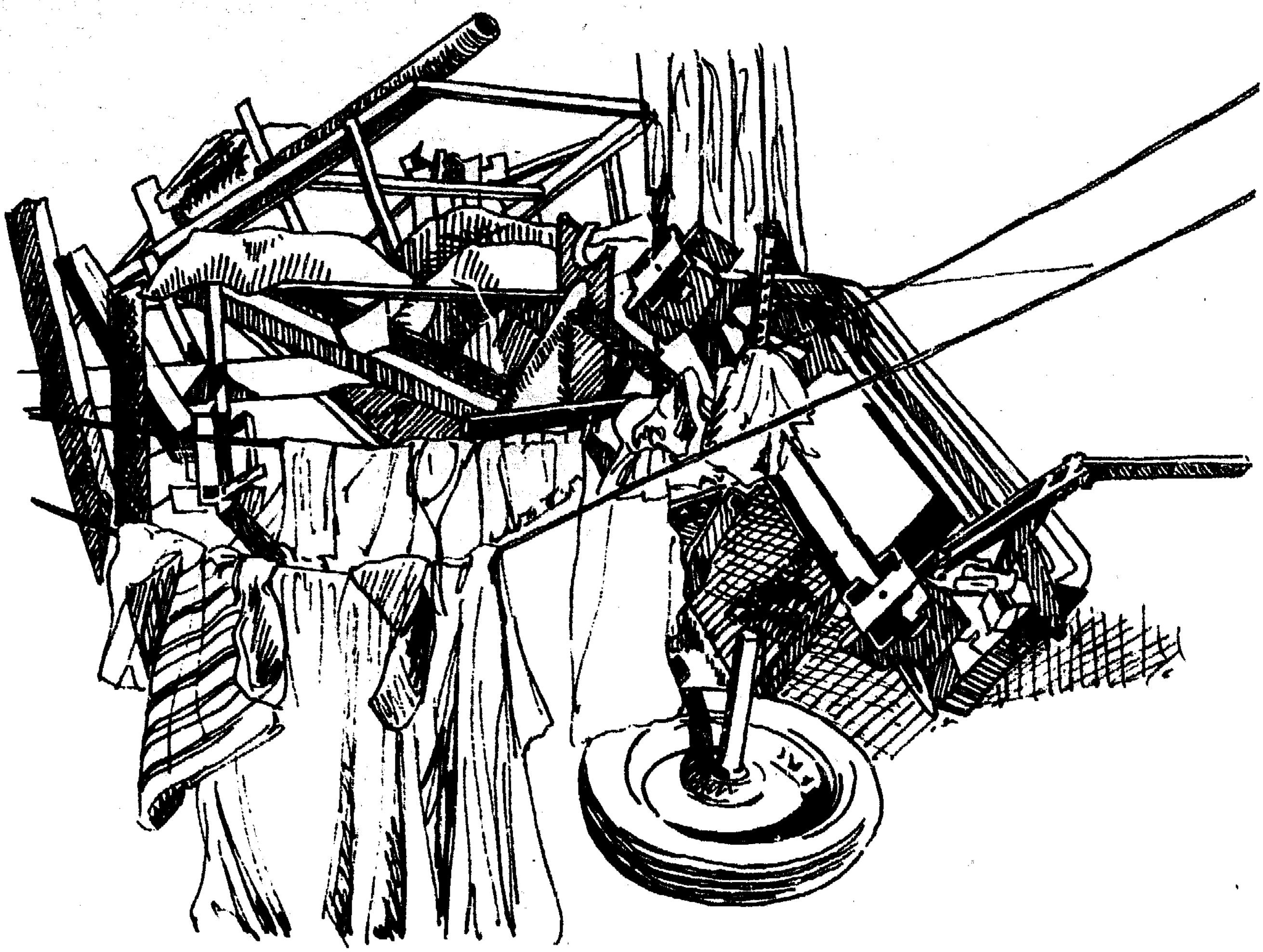


Fig. 4-16: Some toolcarriers and components bought by a Maharashtra State project in 1982 were still unused (for agricultural purposes) in 1986. (Based on photo: P.H. Starkey).

pared with traditional techniques. It was concluded that while wheeled toolcarriers were efficient, less costly alternatives should be explored (Sarin and Ryan, 1983).

Further questioning of the applicability of the station-derived technology was provided by von Oppen, Ghodake, Kshirsagar and Singh in 1985. The authors confirmed that the Vertisol technology had been consistently successful on station but admitted that "the continuing need for management support, and input supplies and the emergence of further constraints seem to impose much narrower limits on the technology than had earlier been anticipated." Constraints identified by on-farm trials included exacerbated human labour peaks, bullock power and fodder constraints, inadequate credit, difficulties in fertilizer supply, increased weed growth and technical problems of repairs and maintenance of wheeled toolcarriers. It was noted that the farmers involved in the on-farm verification trials did not consider wheeled toolcarriers as indispensable to the broadbed and furrow technology, and were not prepared to pay realistic hire or purchase costs for the wheeled toolcarriers. It was concluded that further research was needed into the various components of Vertisol technology, including the development of lower cost wheeled toolcarriers. It was also suggested that such research should be carried out in closer cooperation with farmers, perhaps by national programmes rather than by ICRISAT.

Hints of possible doubts entered the Information Bulletin No. 8 on "The Animal-Drawn Wheeled Tool Carrier" between the

1981 and 1983 editions (ICRISAT, 1981 and 1983). Many changes between the two editions were small and provided additional technical information relating to the toolcarriers, such as weight, use of the Nikart and the additional operation of land shaping. Small subtle changes were related to possible problems when the toolcarriers are used off the research station, for example indicating that farmers must adjust the load to the capacity of their animals. However perhaps the most important change was that, while the 1983 booklet was still very positive and stressed the potential benefits of toolcarriers, it also had a new heading "Drawbacks of the toolcarrier" which noted that they cost more than small farmers could normally afford and their maintenance might be difficult under village conditions. The 1981 conclusion that "such a system of machinery promotes agriculture by increasing farmers' income" was subtly modified to "in the long run it can increase agricultural production and farmers' income particularly in regions where there is a high ratio of land per farmer."

This last change is interesting as in much of India holdings are small, and the ratio of land to farmer is generally higher in Africa and Latin America than Asia. The 1983 toolcarrier promotional booklet (ICRISAT, 1983) was also given a very distinct change in its overall impression through the inclusion of photographs of toolcarriers in use in Brazil, Botswana, Mexico and Mozambique in addition to India. This reflected the increasing interest of ICRISAT in the potential for toolcarriers in other parts of the world, in addition to their use in India. However it also tended to create the impression that the technology had diffused worldwide.

The greatest doubts to date have been expressed in the report of the British NIAE by Fieldson (1984) and the resulting paper by Kshirsagar, Fieldson, Mayande and Walker (1984). These observed that few wheeled toolcarrier machines had been sold in India without large subsidies; annual utilization had been low; hire markets had not developed; farmers did not perceive that the wheeled toolcarriers had overriding advantages over traditional implements; most manufacturers had stopped making wheeled toolcarriers due to insufficient market demand and future prospects were not bright.

4.3.10 Continued optimism (1985–1986)

Despite the doubts expressed in internal papers, few externally circulated ICRISAT papers have shown *any* indication of the problems being faced in the field by wheeled toolcarriers. In a paper presented at a seminar at IRRI in 1985, ICRISAT staff managed to cite Fieldson's very pessimistic report and still present a very optimistic overall picture: "Now the farmers in SAT regions of India have started appreciating the usefulness of WTC. This trend is rather encouraging. It reflects the collaborative efforts by the Government extension agencies and national research institutions. Occasional subsidies from the Government also assist. As a result of all this the sale of WTC in India is improving, even though direct purchase by individual farmers and non-governmental agencies is only about 11% (Fieldson, 1984)." (Awadhwal, Bansal and Takenaga, 1985).

In April 1986 an article in the newsletter of the Regional Network on Agricultural Machinery (RNAM) described the farm machinery research of ICRISAT and the development of wheeled toolcarriers (Bansal, 1986). No mention was made of farmer response to the wheeled toolcarriers, and the impression was given that they were being increasingly used by Indian farmers. Most recently three ICRISAT scientists participated in the "Animal Power in Farming Systems" workshop in Sierra Leone in September 1986 and pre-

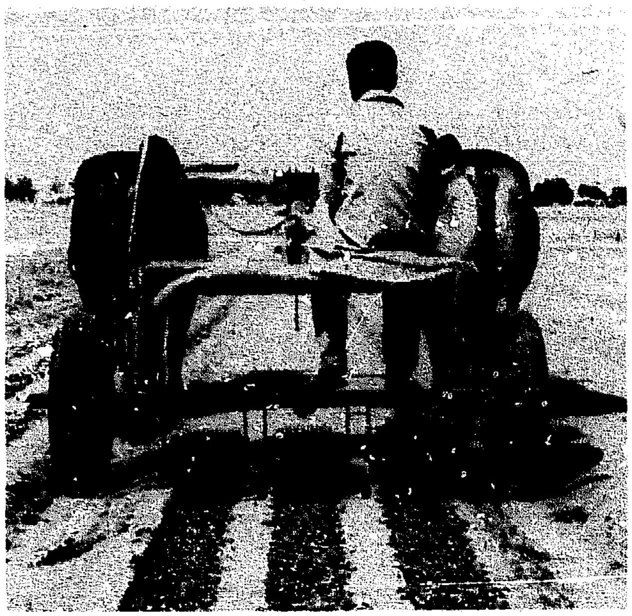


Fig. 4-17: Tropicultor with rolling crust breaker, at ICRISAT Centre, 1986. (Photo: N.K. Awadhwal).

sented a highly positive picture of the progress of wheeled toolcarriers in India (Bansal, Klaij and Serafini, 1986). The overall optimistic tone presented can be gauged by the following quotations:

"In the past decade a successful "technology package" for Vertisols was developed . . . The WTC has been used to overcome the problems of working these soils . . . After the successful experiences at the ICRISAT Centre with the Tropicultor . . . The Nikart is about $ 80 (US) less expensive than the Tropicultor that cost $ 500 (US) . . . It is also well suited to the manufacturing capabilities of small industries in developing countries. At the ICRISAT Centre animal-drawn WTCs have been successfully integrated in improved farming systems developed for the management of Vertisols. On-farm verification has been carried out in different regions of the Indian SAT. Data from two villages, Taddanpally in Andhra Pradesh and Farhatabad in Karnataka State, illustrate the role of improved farm equipment in a new farming system. . . In Taddanpally . . . the use of the WTC led to substantial labor savings for field operations . . . higher yields . . . increased labor productivity . . . ICRISAT has demonstrated that a properly conceived animal-traction-based crop management strategy can have significant impact on productivity." (Bansal, Klaij and Serafini, 1986).

There is no hint in the paper of the problems being experienced with the adoption of wheeled toolcarriers in India or that farmers at Taddanpally and Farhatabad did not continue to use the "successful" technology, after its "verification". Nor was there any indication that the "$ 500" Tropicultor had no implements and would actually cost four times this figure shipped with implements to a West African port.

4.4 Prospects for wheeled toolcarriers in India

4.4.1 Opinions based on general principles

Opinions as to the long-term importance of wheeled toolcarriers in India have varied. In his comprehensive study on farm machinery and energy research in India, Shanmugham (1982) commented favourably on the principle of the wheeled toolcarrier or "bullock tractor" but did not go on to put high priority on research into such implements. Rather he advocated research on more simple plows, commencing with a study of why the traditional wooden plow is still so popular in India. He cited figures on changing patterns of equipment use. While numbers of steel mouldboard plows in use increased steadily from one million in 1951 to five million in 1972, Shanmugham stressed that this should be seen in the context of a rise in the number of wooden plows from 32 million to 39 million from 1951 to 1972. While the number of traditional plows declined very slightly during the latter years of this data, the change to mouldboard plows still seemed slow. Shanmugham noted that the rapid rise in different forms of seed-drill or sowing devices (to four million in 1972) appeared more significant than changes in the types of plow in use.

The Director of the Central Institute of Agricultural Engineering (CIAE), Bhopal has also stressed the importance of low cost implements and simplicity of design, and while favouring the continuation of research and development on wheeled toolcarriers to allow faster and more timely cultivation, he has placed emphasis on a simple and low cost model (CIAE, 1985). The expensive and high quality Tropicultor has been tested on many research institutes in India and on some farms, and in general it has been found effective for both cultivation and transport. However a research centre in Pune observed that in the prevailing farming systems the Tropicultor had no special technical advantage over the various simpler (and much cheaper) implements used by local farmers (CIAE, 1985).

Brumby and Singh (1981) in a study for the World Bank reviewed information on the spread of implements in India and detailed many of the reasons suggested by farmers and professional agriculturalists for the observed low adoption rates of the steel mouldboard plow. These were often related to higher cost, heavier weight, small draft animals, the need for blacksmith training, difficult farm topography and sociological factors such as caste and systems of communal equipment use. In addition inadequate credit, weak research-manufacturing linkages and poor implement availability and back-up services were cited as factors that *might* have contributed to low adoption rates. However these authors questioned the adequacy of these arguments and preferred the explanation that technology that was available and not rapidly adopted was simply not cost-effective. They cited the rapid uptake of pumpsets and seed drills as examples of relatively expensive and complicated machines that were being rapidly adopted by Indian farmers, as these were perceived to be highly cost-effective.

Brumby and Singh went on to suggest that the wheeled toolcarrier represented an available and largely unused technology that had vast potential in India to increase the area of cultivated land and increase yields on existing lands. The options for actively promoting the toolcarriers included financing private contractors, credit provision, cooperative formation and the provision and demonstration of equipment to research and training farms. However, rather than advocate such immediate promotion, Brumby and Singh specifically recommended that ICRISAT, with World Bank support, carry out a study of the advantages, adaptability and constraints to the acceptance of the wheeled toolcarrier.

4.4.2 Opinions based on farmer surveys

In 1984 staff from ICRISAT and NIAE carried out a survey of farmers who had obtained wheeled toolcarriers and also of the various manufacturers of these implements to obtain an indication of future market demand (Fieldson, 1984; Kshirsagar, Fieldson, Mayande and Walker, 1984). The findings were clear: few machines had been sold without large subsidies of 50–80%; annual utilization had been low; hire markets had not developed; farmers did not perceive that the wheeled toolcarriers had overriding advantages over traditional implements and carts; farmers did not believe wheeled toolcarriers were indispensable to the ICRISAT improved Vertisol (black soil) technology package; most manufacturers had stopped making wheeled toolcarriers due to insufficient market demand. It was concluded that prospects for wheeled toolcarriers in dryland agriculture in India were "not bright".

Two separate ICRISAT consultancy missions in 1986 involved visits to villages and farms

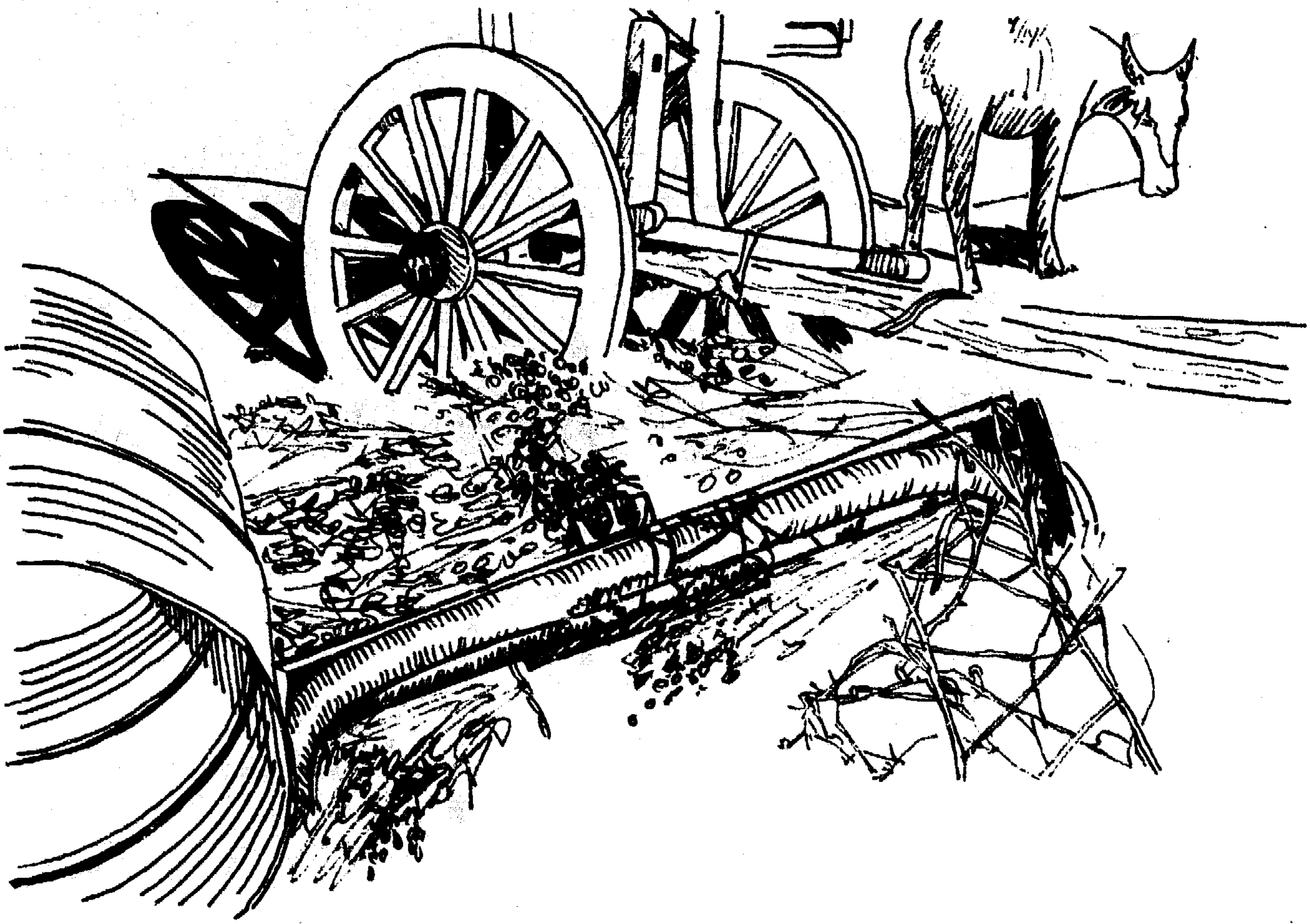


Fig. 4-18: Abandoned Tropicultor chassis in Maharashtra State, 1986. (Based on photo: P.H. Starkey).

to assess the impact of the ICRISAT wheeled toolcarrier technology in India and the observations of the 1984 survey concerning low utilization, lack of entrepreneurial hiring and lack of farmer enthusiasm were endorsed (Reddy, 1986; Starkey, 1987). At subsequent Resource Management Program seminars to discuss the consultants' work, the concensus of the ICRISAT scientists present was also clear: prospects were indeed not bright.

4.4.3 Opinions of manufacturers

One method of evaluating future prospects is to analyse patterns of manufacture and sales. There are difficulties in this as very few sales have been to farmers, traders or distributors but rather have been to development projects who have bought them through large contracts, and have subsequently allocated their stocks to farmers, usually charging only 20–50% of the ex-works price. Some stocks bought in 1982 remain in store. The pattern of production is illustrated in Table 4.1.

In the years 1979–1982 ICRISAT provided technical assistance to Mekins Agro Products (Hyderabad), Medak Agricultural Centre (Medak), Kale Krish Udyog (Pune) and Sri Lakshmi Enterprises (Bangalore) who all made wheeled toolcarrier prototypes and limited production runs. 1983 and 1984 were the years when large contracts were given by development organizations. Subsequent large contracts were few, and all the workshops except Mekins stopped toolcarrier production. The influential firm of Voltas which had initially acted as an agent for Nikart sales also abandoned the wheeled toolcarrier. The implication is that few (if any) workshops and commercial firms see

Table 4.1: Estimation of Wheeled Toolcarrier Production in India, 1979–1986

Toolcarrier	Numbers produced								
	1979	1980	1981	1982	1983	1984	1985	1986	Totals
Tropicultor[1]	27	35	30	53	516	385	140	165	1 351
Nikart		20	38	10	39	44	20	12	183
Agribar					2	5	15	10	32
Totals	27	55	68	63	557	434	175	187	1 566

[1] Figures include the Tropicultor-style toolcarrier marketed under the name Agricart.

(Figures relating to toolcarrier production and sales in India are not always consistent due to differences in calendar/financial years, manufacture dates/sale dates, local/export sales and differences in accounting for unsold stock and prototypes. While they indicate general trends in production, these figures should not be used to estimate the numbers of wheeled toolcarriers in use in India, since significant numbers have either never been used or were used and then abandoned.)

Sources: Agarwal, 1986; Awadhwal, Bansal and Takenaga, 1985; Fieldson, 1984.

any sales potential for wheeled toolcarriers in India.

For the past two years, the only manufacturer of wheeled toolcarriers in India has been Mekins Agro Products of Hyderabad. In 1982/83 and 1983/84 Mekins had been making over 300 toolcarriers a year. However, sales of wheeled toolcarriers in recent years have been only 140–190 per year, despite being the sole manufacturer and despite energetic promotion tours of India, Africa and the headquarters of major aid donors. The sales figure of 189 for 1986 had only been achieved through a negotiated order for 110 Tropicultors for Upper Krishna Project, Karnataka, and various small orders for various aid projects in Africa.

The Mekins Managing Director was very pessimistic about the prospects for the wheeled toolcarrier in India and the company had been diversifying into single purpose implements such as pole plows and ridgers. Wheeled toolcarriers were basically too expensive for the local farming systems. Even in the unlikely event of there being a major demand that would justify investment in additional tooling and presses, prices could only be reduced by about 25% (a figure that agrees with the estimates of Ghodake and Mayande, 1984). Mekins considers there are negligible prospects of direct sales of wheeled toolcarriers to farmers or traders, but there may well be a continued small demand of 100–200 per year from development projects in India and elsewhere.

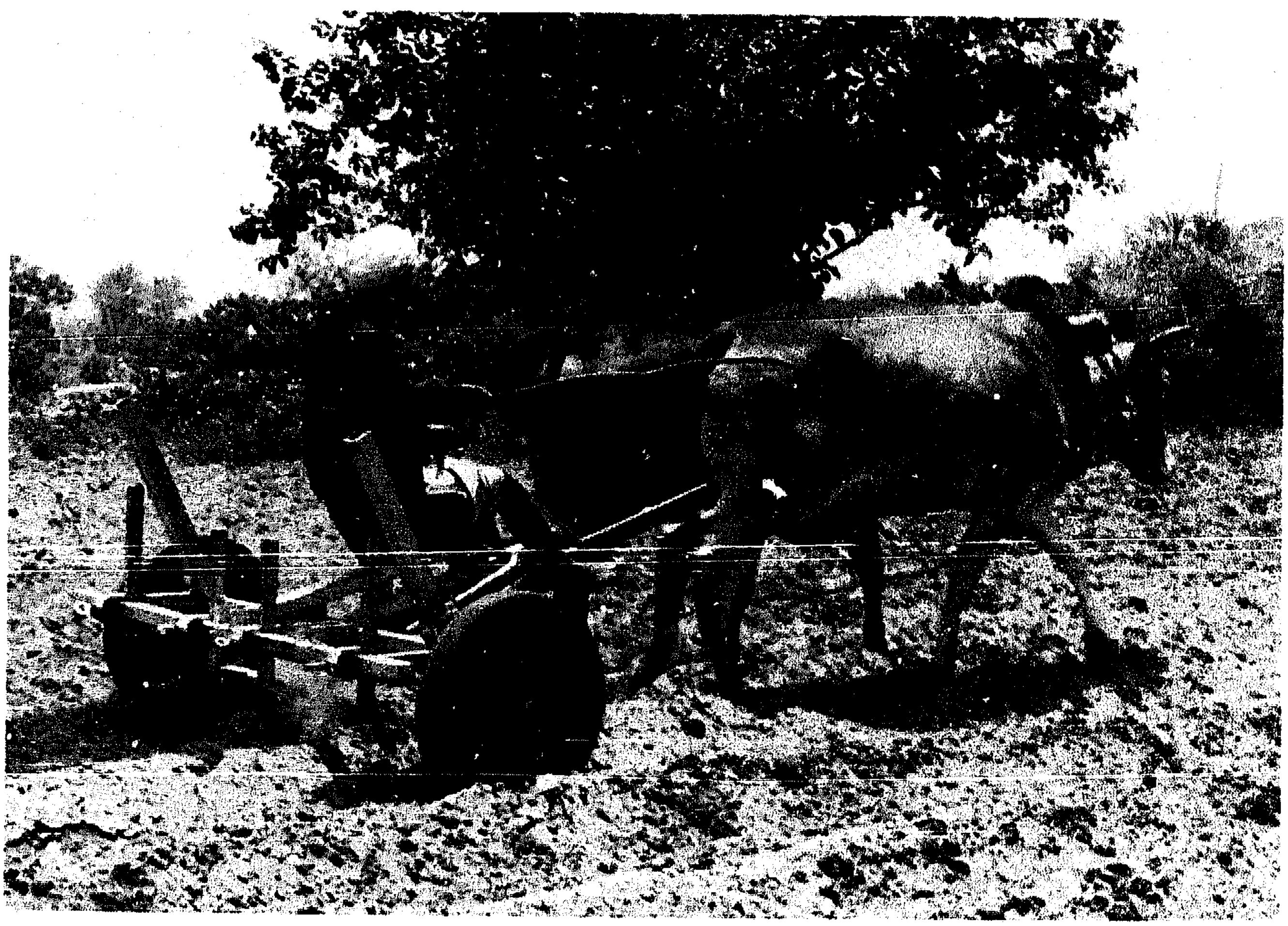
4.4.4 Conclusions on prospects for wheeled toolcarriers in India

It appears almost universally agreed that the present prospects for the high cost wheeled toolcarriers in India are minimal. Lower cost toolcarriers such as the Agribar and the CIAE toolcarrier have not yet been fully evaluated by farmers, but the evidence suggests that purchase price is not the only factor limiting the spread of wheeled toolcarriers. The existence of 50–80% subsidies has brought the Tropicultor package down to what might be a realistic price of the cheaper toolcarriers but has still not stimulated significant farmer interest. Furthermore, the fact that farmers who own high quality toolcarriers do not use them greatly (even though their marginal daily cost is now minimal) suggests that the problem is not simply economic. Thus suggestions that cheaper toolcarriers are "the solution" do not seem justified by the evidence. It is therefore concluded that *unless* a system of using wheeled toolcarriers is developed that is clearly economically, socially and technically appropriate to village conditions, there will be no significant demand for these implements in India.

4.5 Other wheeled toolcarrier initiatives in Asia

The work on wheeled toolcarriers in India has been the most significant in Asia in terms of the numbers of original designs produced, and the extent of promotion. In many other countries in Asia there have been small-scale evaluation trials, and some original designs have been produced in Pakistan and Thailand, although these have not passed the prototype stage. NIAE ADT toolcarriers have been tested in Pakistan, Yemen and Thailand, and Tropicultors have been used in Afghanistan, Pakistan and Yemen. In early 1987 small numbers of GOM Toolcarriers (Nikart type) were ordered for evaluation in Burma and the Philippines.

Fig. 4-19: NIAE wheeled toolcarrier being used for ridging in Yemen, 1973. (Photo: AFRC-Engineering archives).



5. Recent Initiatives in Africa: 1976—1986

5.1 International interest in wheeled toolcarriers in Africa

Having considered the experiences of India and of ICRISAT, it will be useful for us to return to Africa and review recent initiatives. It may be recalled that in the 1960s large-scale promotion of wheeled toolcarriers had occurred in Senegal and The Gambia with smaller-scale promotion in Uganda and Botswana. Evaluation trials of early Polyculteur and NIAE designs had been carried out in several African countries including Cameroon, Ethiopia, Kenya, Madagascar, Malawi, Nigeria, and Tanzania, generally with the direct involvement of British or French aid personnel.

In contrast to the period 1955–75, the last ten years have seen much more *international* involvement with wheeled toolcarrier programmes in Africa. The number of countries working with wheeled toolcarriers has increased greatly, and the internationalization of donor support can be illustrated by the fact that expatriate technical assistance staff working in this field in the last decade have included many funded by international centres and organizations such as ICRISAT, IDRC, ILCA, FAO, IFAD and the World Bank. In addition to the historical involvement of Britain and France, in the past ten years other bilateral programmes including those of Norway, Sweden, USA and West Germany have become involved in funding work in this field.

As will become apparent much of this renewed interest derives from ICRISAT's involvement in toolcarrier research, development and promotion. In West Africa some of the work with toolcarriers has actually been carried out under the auspices of ICRISAT in Mali and Niger. ILCA's evaluation of toolcarriers can be considered as having been derived from its CGIAR linkages with ICRISAT's. Workers in several countries have cited ICRISAT's encouraging work in this field as a major reason for their own involvement, and several programmes have requested technical drawings of toolcarriers from ICRISAT. However the phases of wheeled toolcarrier development being highlighted are merely an attempt at conveniently examining a continuum of numerous different activities. Thus, while the international "surge" of interest appears real, there has also been a consistent pattern of continued research, development and promotion by Jean Nolle in conjunction with French manufacturers and organizations. NIAE has also continued to be closely involved not only through its collaboration with ICRISAT in the development of the Nikart, but also through its links with British aid projects in several countries.

5.2 Recent initiatives in West Africa

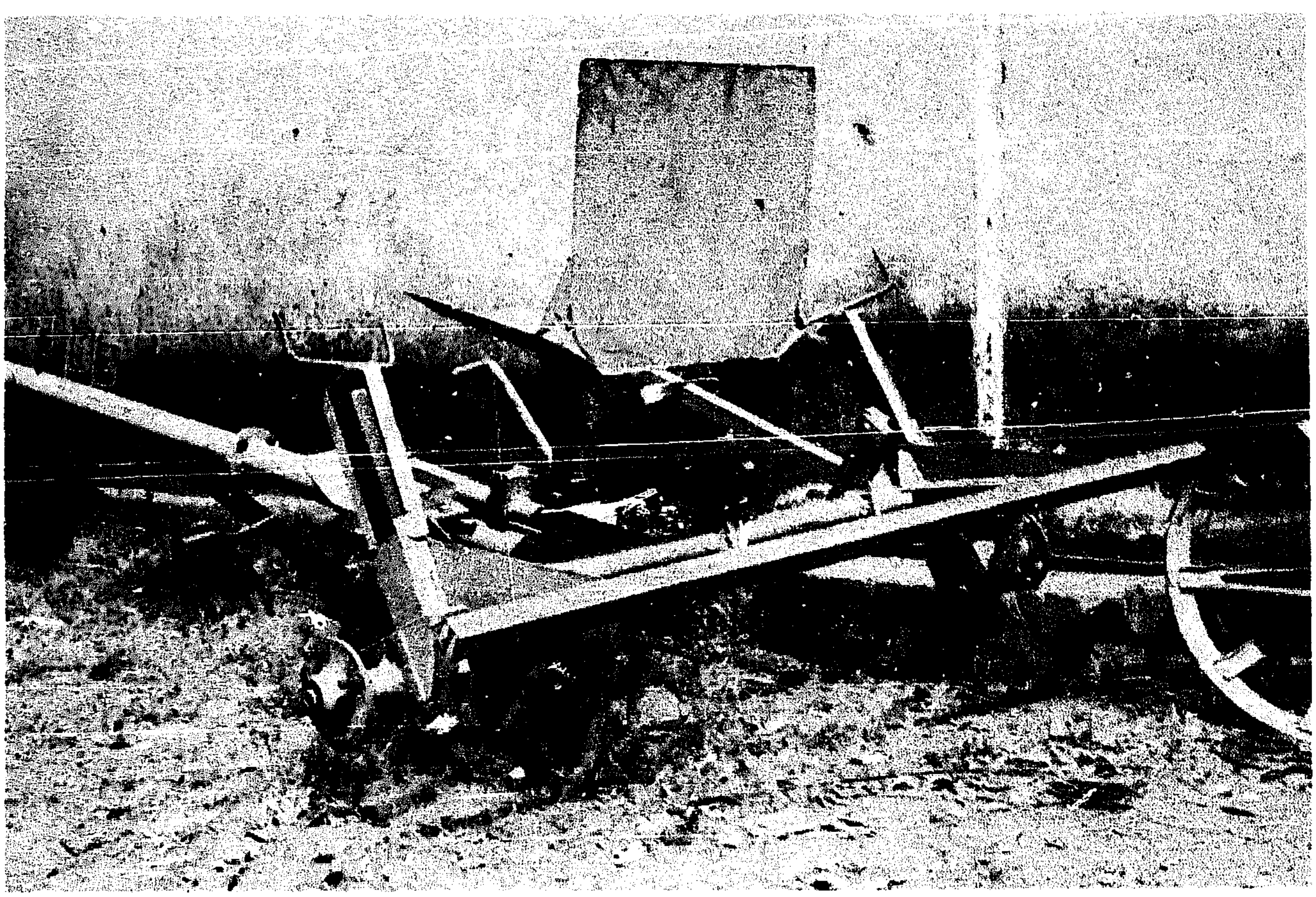
5.2.1 Mali

In Mali where animal traction is very well established and where there are about 150 000 plows and 70 000 simple toolbars in use, at least six designs of wheeled toolcarriers were evaluated on research stations between 1974

Fig. 5-1: SISCOMA Polyculteur from Sotuba Research Station awaiting repair at SMECMA factory, Mali, 1986. (Photo: P.H. Starkey).

and 1986. Test Report No. 48 of Division du Machinisme Agricole (DMA) provides results of on-station tests carried out in 1974 on a *Polyculteur* made by SISCOMA of Senegal (DMA, 1976). With a simple plow fitted the toolcarrier only worked well if it was adjusted to plow deeply, at which point the power requirement was excessive for the oxen. With more superficial plowing lateral stability was poor and it was concluded that it was less effective and less convenient than the simple mouldboard plows widely used in the country. In 1979 two *Tropisem* wheeled toolcarriers designed by SATEC (Société d'Aide Technique et de Coopération, France) were tested at Cinzana by OACV (Opération Arachide et Cultures Vivrières) and ICRISAT. The Tropisems had large metal wheels and a range of attachments including cultivating tines and were considered functionally equivalent to the Polyculteur (Shulman, 1979). After the tests on the Polyculteurs and Tropisems there was no

Fig. 5-2: Nikart prototype made at CEEMA in Mali but not used after initial trials. (Photo: P.H. Starkey).



follow-up importation, and all initial models were abandoned rather than used.

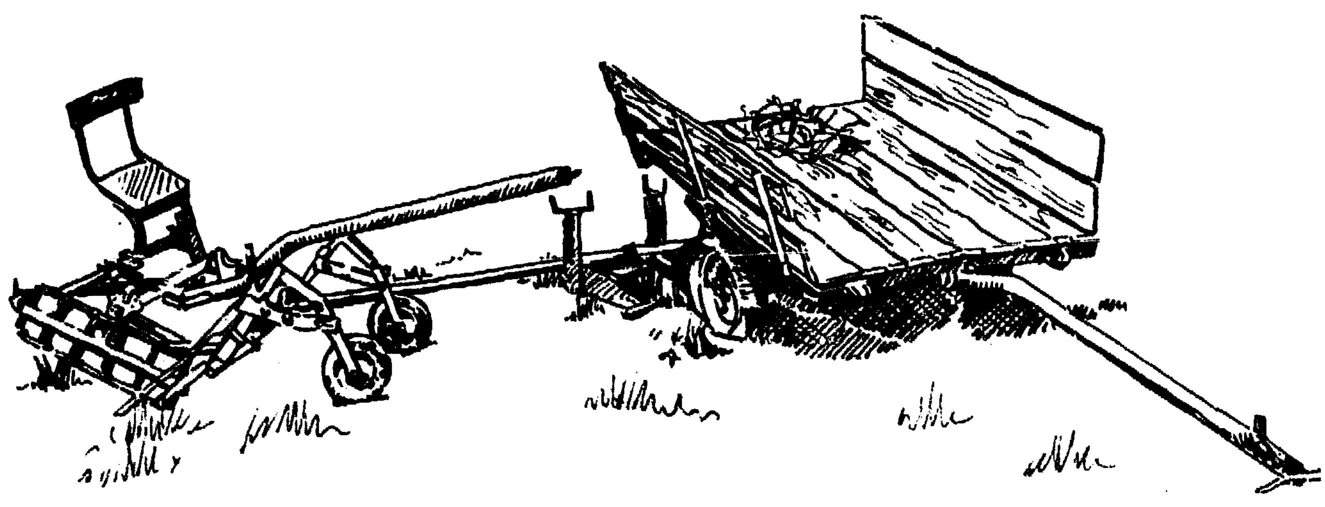
Ten *Tropicultors* made in India were successfully used on research stations at Sotuba and Cinzana in ICRISAT crop-breeding trials from 1980 to 1984, and at least one was passed on to a Centre d'Animation Rurale (at Cinzana). Because of the high draft requirement four oxen were used to pull the Tropicultor for plowing at Sotuba. By 1986 *none* of the Tropicultors remained in use at any of these stations or elsewhere in Mali. In 1981 five early prototypes of the Agribar were brought to Sotuba and Cinzana by ICRISAT. One was tested for a brief period, but all were abandoned after 1982, as the Nikart was found technically more efficient.

The first *Nikart* prototype was tested at Cinzana in 1982, and subsequently ten were supplied from India in 1983. In addition a Nikart was fabricated in Mali by Centre d'Expérimentation et d'Enseignement du Machinisme Agricole (CEEMA) in 1984, but after initial on-station tests it was never used. In 1986 six Nikarts were in regular use at Sotuba and Cinzana and ICRISAT scientists considered them valuable for on-station crop research programmes as a means of preparing uniform research plots for plant-breeding trials. However the ICRISAT Mali Programme had not carried out any research relating to toolcarrier use in local farming systems and research scientists did not consider the Nikart as suitable for the small farmers in the area due primarily to cost and complexity (S.V.R. Shetty, Principal Agronomist, ICRISAT Mali Programme, personal communication, 1985 and 1986).

Four of the ICRISAT-supplied Nikarts were distributed to smaller centres and in 1986 one Nikart was *loaned* to a farmer at the village of Kaniko for evaluation. This Nikart may have been the only one in use by a small farmer in Africa and so the on-farm trial was closely monitored by the Division de Recherches sur les Systèmes de Production Rurale (DRSPR). After one season of on-farm trials, the initial impression was very pessimistic about its applicability to village conditions in Mali on purely technical grounds (Piters, 1986), and economically it certainly could not be justified.

In 1986 a prototype toolcarrier designed by Lanark Highlands Technology of Canada was sent to Mali for evaluation by Centre Canadien d'Etudes et de Coopération Internationale (CECI), in cooperation with Division du Machinisme Agricole, Ministère de l'Agriculture. The development and testing of this prototype had been funded by the Interna-

Fig. 5-3: Equipment including one punctured Tropicultor cart, and the frames of a Polyculteur, a Nikart and an Agribar at ICRISAT's research farm at Sotuba, Mali, 1986. (Based on photo: P.H. Starkey).



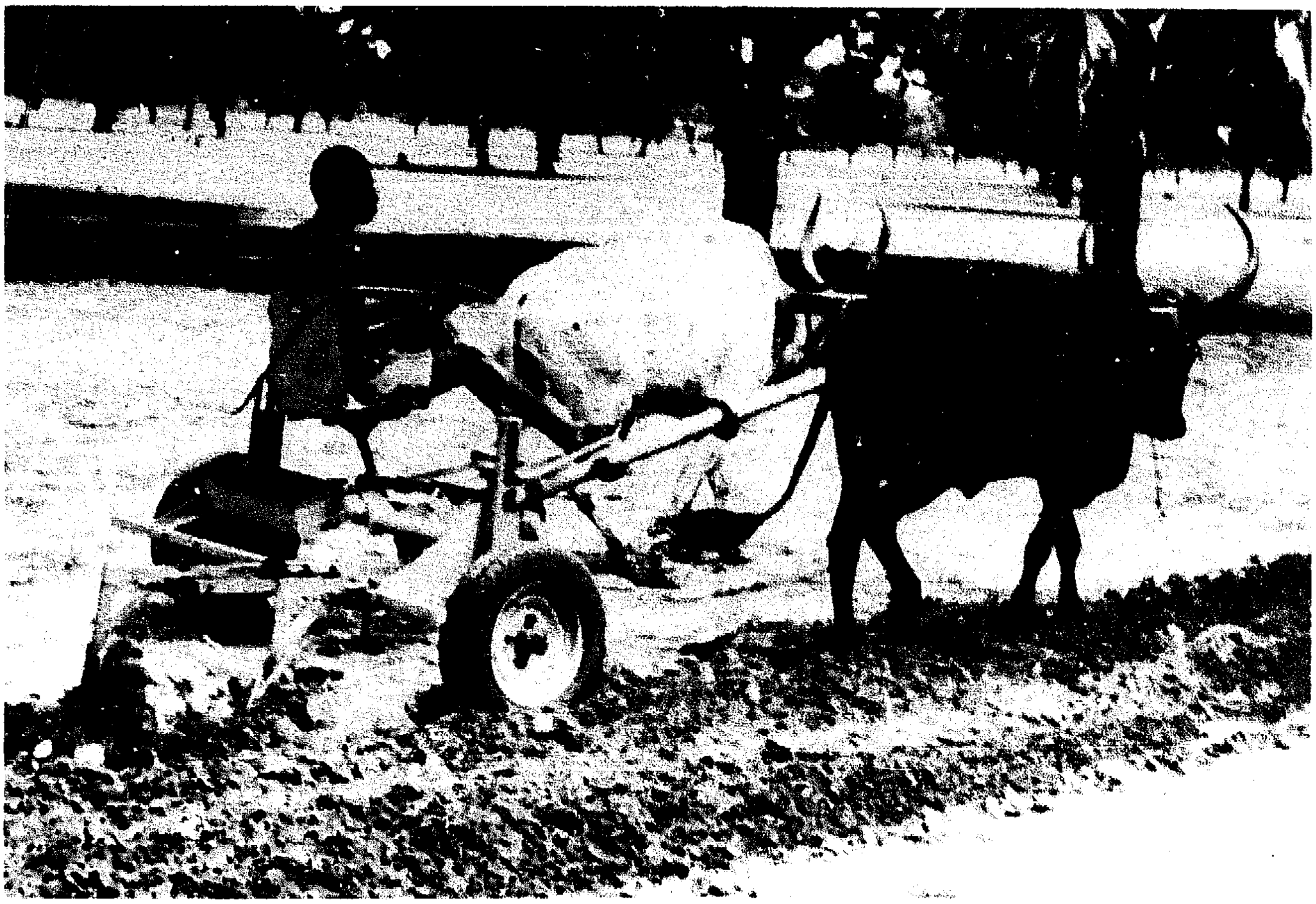
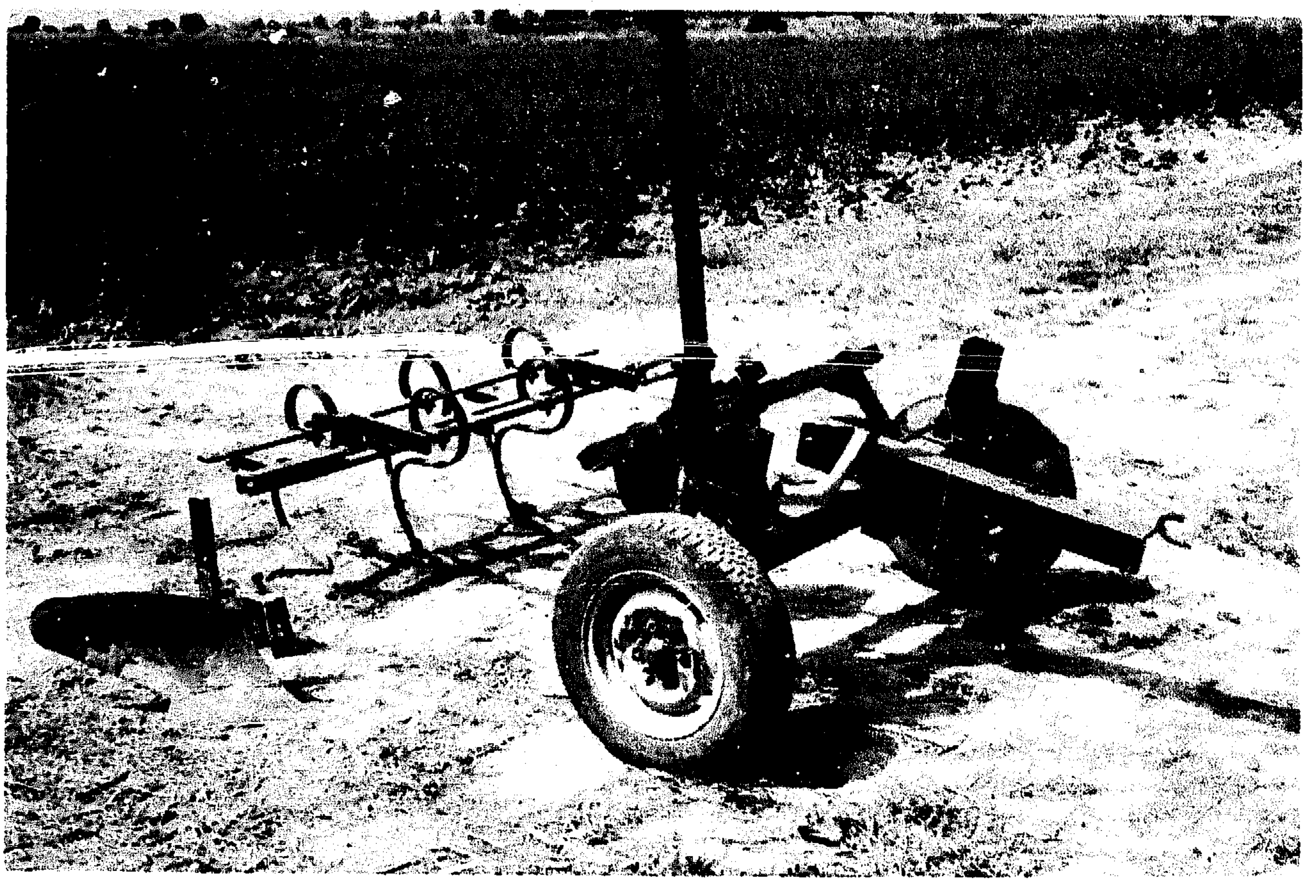


Fig. 5-4: Nikart with double mouldboard plow being assessed by farmer in Mali, 1986. (Photo: Bart de Steenhuysen Piters).

Fig. 5-5: Prototype Lanark/CECI toolcarrier tested in Mali in 1986. (Photo: P.H. Starkey).



tional Development Research Centre (IDRC) of Canada. Following a brief period of testing at CEEMA at Samanko, it was concluded that the prototype could only carry out the same cultivation functions as the locally available and much cheaper Ciwara Multiculteur, a derivative of the Houe Sine type of simple toolbar. A locally manufactured donkey cart and a Ciwara Multiculteur were together cheaper than the toolcarrier, and prospects for local manufacture of such a wheeled toolcarrier (at an economically viable cost) were negligible. It was concluded that the Lanark/CECI toolcarrier had no advantages over the Tropicultor or Nikart and more importantly there was no evidence that *any* wheeled toolcarrier could be cost-effective in the existing farming systems of Mali (Champigny, 1986; Starkey, 1986).

Thus several wheeled toolcarriers have been tested in Mali and both the Nikart and Tropicultor have been found technically effective on research stations, with the Nikart being preferred as it is lighter and easier to regulate in height. However there appears to be almost unanimous feeling within the Ministère de l'Agriculture, the Division du Machinisme Agricole and the DRSPR that the Nikart is not appropriate to present farming systems in Mali, being too heavy and too expensive and present emphasis is being placed on low cost implements that can be maintained by village blacksmiths (D. Zerbo, Chef, Division du Machinisme Agricole, Ministère de l'Agriculture, personal communication, 1985 and 1986).

5.2.2 Niger

Of the Sahelian countries, Niger is probably the one with the lowest proportion of farmers who use draft animal power. Nevertheless in the south of the country animal traction has been well established for many years, and the government, with the assistance of several aid donors, is actively promoting the use of cattle and donkeys for crop production.

During the last five years both Nikarts and Tropicultors have been used for on-station trial work at the ICRISAT Sahelian Centre, which lies 40 km southeast of Niamey. Using three Nikarts and two pairs of animals per unit per day, twenty-five hectares of scrubland were developed and cropped in one year. Ridging and weeding using Nikarts were carried out on a total of 120 ha, with each Nikart being used to accomplish the equivalent of one quarter of the work of a 40 kw tractor (Bansal, Klaij and Serafini, 1986). While the Tropicultor is stronger and heavier and well suited for transport, the Nikart is preferred to the Tropicultor for precision work, as the depth control is more sensitive and easier to adjust. Indeed for on-station crop research trials scientists have often preferred the Nikart to tractors for precise work such as inter-row weeding.

There have been some on-station trials using wheeled toolcarriers and, based on 1985 trials, ICRISAT reported that ridging with a Nikart led to 80% labour savings compared with manual scraping (ICRISAT, 1986). (Although not highlighted in the ICRISAT report, the data presented also suggest that similar savings were obtained with oxen pulling simpler implements.) To date there have been no on-farm evaluations or extension programmes relating to wheeled toolcarriers in Niger, but one ICRISAT officer feels that the Nikart represents a good technical option that might be able to overcome the major farm level constraint of inter-row weeding. He therefore felt that the Nikart technology should be presented to the farmers of Niger as one of the technical options available (P. Serafini, Farm Manager, ICRISAT Sahelian Centre, personal communication, 1986).

5.2.3 Nigeria

During the 1960s several NIAE-designed toolcarriers and also French-manufactured Polyculteurs had been tested in Nigeria. Much of the farming in the ox-using areas of northern Nigeria is based on ridge cultivation, and all the early toolcarriers had been designed for cultivation on the flat. The wheel tracks could not be adjusted to the recommended row-widths in Nigeria, and the low clearance made it difficult to weed on ridges. Thus the toolcarriers could only be used for primary cultivation and initial ridge formation. As a result in comparative trials with tractors, single purpose implements and hand labour, these early designs of toolcarriers had proved more expensive per hectare than single purpose ox-drawn implements, and almost as costly as tractor cultivation. This led to an early observation that it seemed strange that an institution that had presented a convincing case for tied ridging should design a wheeled toolcarrier that was apparently unsuitable for ridge-based cultivation (Stokes, 1963). Variations on the NIAE toolcarrier with adjustable track width, adjustable height and with a tied ridging device were all produced during the 1960s, but it is not clear to what extent these were tested in Nigeria. Kalkat and Kaul (1985) made reference to the report of Anibaloye (1970) relating to the testing of a Kenmore (NIAE-type) toolcarrier in Gasau area of Sokoto State in the late 1960s, but stated that in 1976 there were no wheeled toolcarriers available at Samaru to include these in a comparative trial of several simple toolbars. Thus early work with toolcarriers in Nigeria had been restricted to testing rather than promotion. Nevertheless in 1978 the Kenmore toolcarrier gained the unique distinction of being featured on the front cover of an agricultural textbook for secondary schools (Akubuilo, 1978).

As a result of the ICRISAT work on wheeled toolcarriers, and a sales promotion mission by the Managing Director of Mekins of Hyderabad, in 1984 five Nikarts and two Tropicultors were imported into northern Nigeria for evaluation. Staff of the Kano State Agricultural and Rural Development Authority (KNARDA) considered them unsuited to the requirements of local farmers. They were too costly and heavy, and had many parts that might go wrong; there were also some doubts as to their durability under field conditions.

5.2.4 Cameroon

Draft animals are only used in the north and northwest of Cameroon and much of the expansion in the numbers of working cattle has been attributable to the cotton promotion initiatives. In the early 1970s the Douala-based equipment-producing company "Tropic" acquired the rights to manufacture the Nolle range of equipment including Houe Sine, Ariana and Tropiculteur (Boyd, 1976). Sales were clearly disappointing as the firm subsequently dropped these ranges but in recent correspondence the company politely declined to release its actual manufacture and sales figures for wheeled toolcarriers.

A GTZ-supported component of the Wum Area Development Authority (WADA) programme in North-West Cameroon decided to start a pilot wheeled toolcarrier programme in 1980. Staff considered that the toolcarriers of the type produced by Tropic were too expensive, too heavy and that the steering potential of implements had not been adequately developed. In 1980 an Austrian (who had built some toolcarriers in Zambia while serving as a volunteer) assisted in the design and development of a wheeled toolcarrier based on an old car axle. The toolcarrier could be used for plowing, ridging and weeding and as a cart. During tests this worked well on the WADA farm, and ten

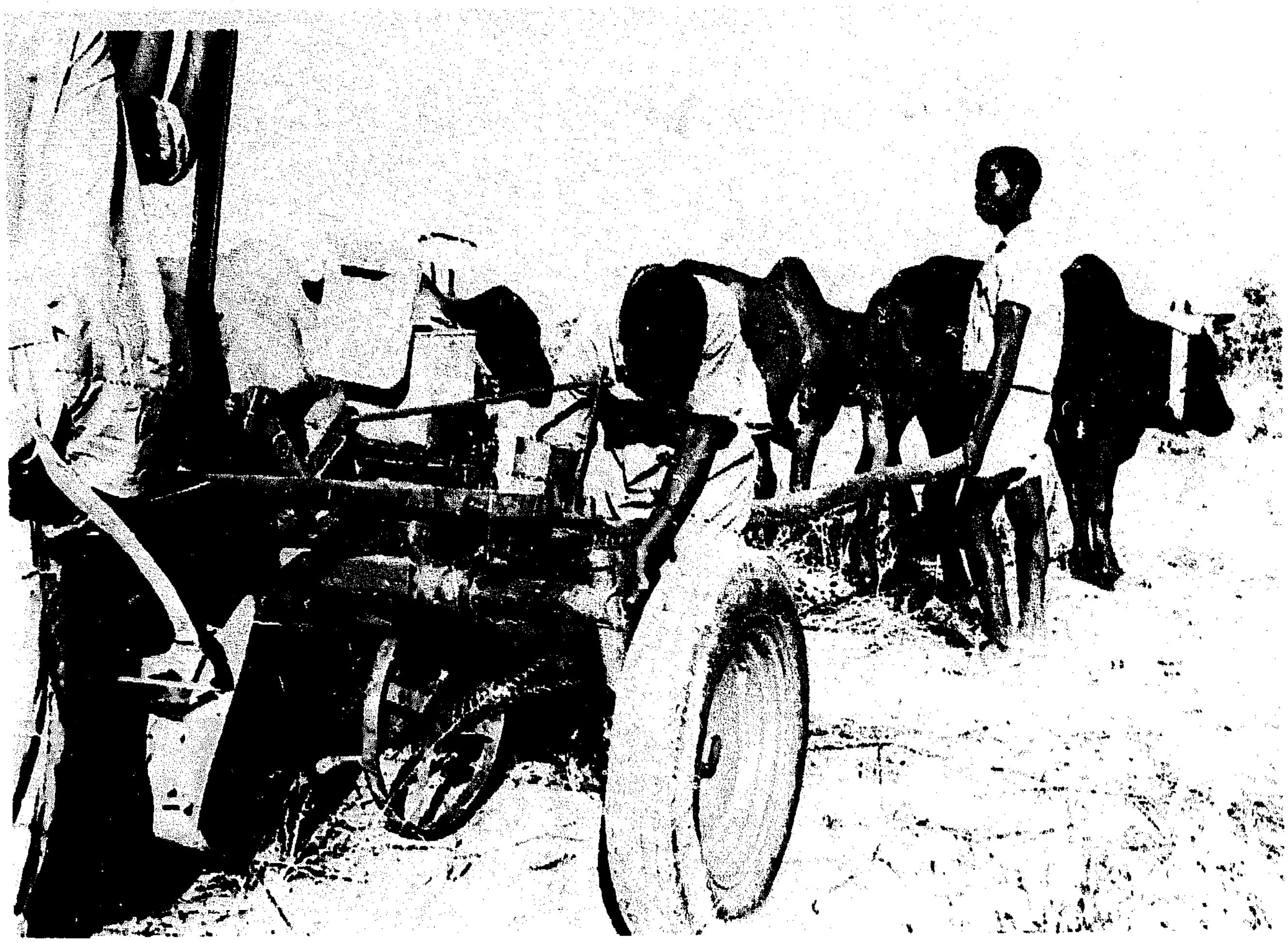


Fig. 5-6: The wheeled toolcarriers developed in Cameroon were based on this design from Zambia. (Photo: J. Rauch).

more were made and distributed to farmers. One Nikart was also purchased from India for evaluation. While a few farmers used their implements for two or three seasons, by 1986 none of the toolcarriers was in use for cultivation. The reasons for their abandonment were the inability of farmers to carry out simple repairs (such as punctures) and the complexity of changing between modes. Other factors militating against success were the hilly terrain and the fact that many farmers' fields were accessible only by paths too narrow for a wheeled toolcarrier. As a result the toolcarrier programme was abandoned, and the project is working on improvements of existing tools and an animal-drawn clearing implement (F. Rauch, personal communication, 1986).

5.2.5 Togo

Togo has a small but very active draft animal programme, with over thirty donor-supported projects promoting animal traction. The numbers of draft cattle in use had risen to about 8500 in 1986. The working animals are all small, belonging to a West African breed noted for its disease resistance. Two of the major constraints to draft animal power in the country are low farm profitablity and the existence of many stumps in the fields (Poats et al., 1985). In 1986 USAID ordered five Nikarts from India for evaluation, at a cost of over $ 2000 each. The justification for this importation had been the apparent success of these implements elsewhere. The consignment was due to arrive in early 1987.

5.3 Recent programmes in southern Africa

5.3.1 Mozambique

In recent years at least three development agencies have been supporting work related to wheeled toolcarriers in Mozambique, with a scale of importations not seen in Africa since those of Senegal and The Gambia in the 1960s. Some Mouzon Tropicultors were tested at the Namaachu Cooperative Development Centre in Maputo Province in the late 1970s but little systematic research on the technology appears to have been undertaken. In 1978 the French designer of the Tropicultor, Jean Nolle, undertook a consultancy assignment in Mozambique where he visited Namaachu, but apparently he himself did not advocate a major importation of wheeled toolcarriers.

The Tropicultors under evaluation were found to be technically effective and sixty more were imported in 1982, and at the same time four GOM Toolcarriers (Nikart-type) were purchased for evaluation. The wheeled toolcarrier importation was funded under Project CO-1 of MONAP, the Mozambique Nordic Agriculture Programme, a wide-ranging development project funded by several Scandinavian countries and administered by SIDA (Swedish International Development Authority).

Even before the 1982 toolcarriers had been fully distributed and evaluated, in the following year a further ninety Tropicultors were imported, plus the raw materials to manufacture 450 additional implements at the Agro-Alpha factory in Maputo and in Tete and Zambezia Provinces. To date the bulk of the materials to make Tropicultors has not been touched, and only a few trial implements have been manufactured within Mozambique.

The Tropicultors were heavily subsidized, being sold on long-term credit for the equivalent of about $ 600 including implements. It might be considered that there had been an additional hidden subsidy due to the fact that they were priced at the official rate of exchange at a time when many other goods and services in the country were based on a quite different, parallel (black-market) exchange rate. Some toolcarriers were supplied to cooperatives, but few of these were used. It is estimated that perhaps fifty of the total number of Tropicultors reached farmers in various parts of the country. Farmers experienced major problems with punctures and toolcarrier adjustments, and with limited extension or training services few attempted to use the weeders, ridgers or planters. In 1984 an evaluation of the use of Tropicultors in the Ilha Josina District 100 km north of Maputo found overall utilization had been very low, with some implements remaining unused, while those that were employed were mainly used as carts. There had been some technical problems relating to materials and manufacture, but lack of training and lack of interest in the implements had been more serious constraints. It was concluded that the high price of the Tropicultors was not justified considering the availability of single-purpose alternative implements (Robinson, 1984). By 1986 farmers owning Tropicultors were only using them as carts. However perhaps 15–20 toolcarriers were used for plowing and cultivation in rural schools and development centres in various parts of the country (G. Robinson, personal communication, 1986).

In 1983 an order was placed by Mozambique's Banco Popular de Desenvolvimento for fifty-one equipped wheeled toolcarriers to be delivered to the national importing agency Intermecano at Maputo, Beira and Necala. These were financed by a loan from the International Fund for Agricultural Development (IFAD), a United Nations Agency based in Rome. The tender was awarded to Sahall of U.K. which supplied a model

Fig. 5-7: Tropicultor being tested at Namaachu, Mozambique, during Jean Nolle's visit in 1978. (Photo: MONAP archives).

Fig. 5-8: Two Mouzon Tropicultors, one used as a cart, the other unused, in a village of Ilha Josina, Mozambique, 1984. (Photo: Gerald Robinson).

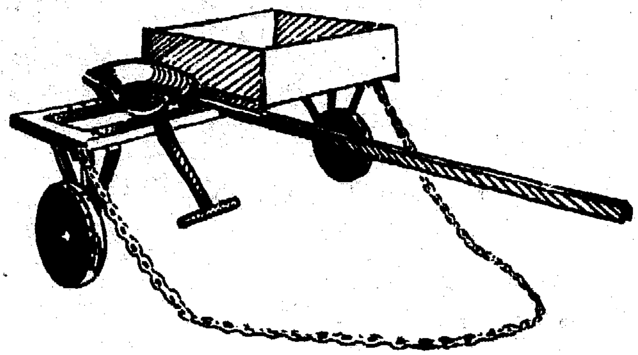


Fig. 5-9: Sahall wheeled toolcarrier with "500 kg cart" as supplied to Mozambique (From publicity brochure).

known as Lioness 3000. These had an adjustable wheel track, a drawbar made of rectangular hollow section steel and the small-diameter wheels could be either pressed steel with solid rubber tyres or spoked with bicycle-type tyres. Implements could be bolted to a raisable sub-frame, hinged to the chassis. These included plows and ridgers, disc and spiked tooth harrows, spring tine cultivators and twin-row seeders. An operator's seat was provided and a very small steel cart body could be bolted onto one side of the chassis. This cart had a theoretical capacity of 500 kg, but the small size of the cart effectively prevented the weight limit being reached if agricultural materials were transported. The manufacturers claimed that their toolcarrier was the first occasion that a three-point linkage had been applied to animal traction equipment (Sahall, 1984), although Jean Nolle had actually worked on this twenty years before. Apparently the Sahall toolcarriers had not been sold by 1986.

In 1985 the Faculty of Agronomy of the Eduardo Mondlane University in Maputo imported yet another Tropicultor, this time from Mekins in India, and also two Nikarts for evaluation. These were purchased through a research grant supplied by the International Development Research Centre (IDRC) of Canada. The wheeled toolcarriers were used for on-station research relating to groundnut production, and a technician was trained in India by ICRISAT in the use of the implements (K. Ramanaiah, personal communication, 1987).

The wheeled toolcarrier programme in Mozambique has been one of the biggest in Africa and was clearly expensive in terms of materials. To date it has had practically no impact other than providing expensive carts to a small number of farmers. However the programme is still potentially active as much equipment remains to be distributed. Among the reasons for the disappointing results seems to be a lack of clear strategy, for resources were widely distributed rather than geographically concentrated into the areas of greatest potential where farmers were well used to draft animals. The programme was also introduced without a clearly organized training programme. These problems had been exacerbated by the political/security situation in the country which made travel difficult in several areas. While it may be too early to draw firm conclusions on the prospects for the use of wheeled toolcarriers in Mozambique, there seems no reason for optimism for at present there is no evidence of the viability of the technology at farm level.

5.3.2 Angola

In 1985 the Swedish International Development Authority (SIDA) funded the provision of one hundred wheeled toolcarriers for the Government of Angola. The importation was not within the context of a specific development project supported by SIDA. Rather it was part of a programme of import funding, designed to meet immediate needs such as emergencies. Due to foreign exchange scarcities and the maintenance of high, fixed exchange rates there existed at this time a parallel ("black market") exchange rate that could be more than fifty times the official rate. This economic situation allowed expensive implements to be sold in local currency at what might seem to be a realistic price, judged by the official exchange rate. However, given the economic realities of Angola at this time, the use of official exchange rates resulted in extremely low prices when seen in the context of the prevailing unofficial rates on which much of the rural economy was actually based.

The Tropicultors, supplied by Mouzon of France, were each supplied with two plows, two seeders, a three-tine weeder and a transport platform. They were distributed in the southern province of Angola in 1985. The prices to farmers contained a high element of hidden subsidy (based on exchange rate maintenance) so that encouraging sales was not difficult. The distribution system appears to have been effective for most of the implements were in villages within the year.

By 1987 very few of the Tropicultors (perhaps 10–20) were being used for cultivation purposes. The large majority were being used only as single-purpose carts. A few farmers were attempting to use the toolcarriers for plowing but they indicated that the harrows supplied appeared to have been insufficiently robust for the conditions. There had been little use of the seeders and this may have been associated with limited training, or the difficulty of obtaining a suitable seedbed.

It is too soon to judge what the impact of this wheeled toolcarrier programme will be, but early reactions seem relevant. The general impression gained by the SIDA consultant who visited the area in early 1987 was that most of the Tropicultors would continue to be used only as carts, and that wheeled toolcarriers were unlikely to prove appropriate in the farming systems prevalent in southern Angola (Bartling, personal communication, 1987).

5.3.3 Botswana

It may be recalled from Chapter 3 that during the 1970s Botswana had developed two toolcarriers, the Mochudi toolcarrier (Makgonatsotlhe) and the Versatool. These had worked well on station and some 125 had been

Fig. 5-10: Early GOM Toolcarrier (Nikart) prototype, fitted with broadbed former, being tested with four oxen in Botswana, 1980. (Photo: AFRC-Engineering archives).

manufactured of which 72 had been purchased by governmental and NGO development agencies. However the programme of encouraging adoption had not succeeded as only twenty-four were actually purchased by farmers, despite active promotion, credit and subsidies. Promotion of toolcarriers was officially terminated in 1982 and government-owned toolcarriers were handed over to co-operating farmers without charge. Farmers subsequently used their toolcarriers only as carts.

Recent work with toolcarriers in Botswana has involved only small-scale on-station trials. One Mochudi toolcarrier was modified in 1980 to make broadbeds based on the ICRISAT system, but as the track could not be adjusted to the standard 1.5 metres results were not ideal (EFSAIP, 1980; 1981).

Examples of the British-manufactured GOM Toolcarrier of the NIAE/ICRISAT (Nikart) design and the French-manufactured Tropicultor were imported for evaluation. Results of the first season's trials were disappointing, with difficulties experienced in constructing and maintaining suitable broadbeds under Botswana conditions (EFSAIP, 1983). However subsequent tests showed the GOM Toolcarrier (Nikart) that had been specifically designed for broadbeds could be effective for on-station broadbed work. It was found to be easily adjustable for working depth and the mechanism for raising and lowering the implements was simple to operate from a ride-on position. Some structural weakness were detected. Four or six oxen were often used for plowing and cultivation with the GOM Toolcarrier (Nikart), and this reflected both soil conditions and the local traditions. The French-manufactured Tropicultor (at that time more expensive than the Nikart) was found to be stronger and preferable for general use, and had the advantage that it had adjustable wheel track. This made it effective for use with the elegant but expensive Mouzon reversible mouldboard plow. The standard Tropicultor mouldboard plow body was also preferred to that supplied with the GOM Toolcarrier. Although the raising and lowering mechanism was well counterbalanced, with a spring, it generally had to be operated by someone walking alongside the implement to ensure the catches engaged. The angle adjustment of the dissel boom was never used, and therefore seemed an unnecessary refinement. An intermediate toolframe, the Ariana, was also evaluated and found acceptable for on-station operations (EFSAIP, 1983; 1984).

After the initial evaluation trials, both the Tropicultor and GOM Toolcarrier (Nikart) continued to be found useful on the Sebele Research Station. In 1986 they were used for a variety of operations including plowing, broadbed formation and fertilizer spreading. In 1986 a prototype *Dammer Diker* was mounted on a toolcarrier for use after normal plowing. With the power of four to six large oxen the large paddle tines could rotate and punch or subsoil the ground, with the intention of increasing infiltration and reducing runoff.

The various trials did not lead to the identification of any applications for wheeled toolcarriers and broadbeds within the local farming systems, and there were no plans to promote a broadbed system in Botswana. From its experiences the Ministry of Agriculture has many reservations on the use of toolcarriers in general. Firstly, a toolcarrier, although able to undertake many functions during a season, can only perform one operation at a time. As both time and effort are required to change and store different implements, there is a strong tendency for farmers to leave it in just one of its operational modes, thus defeating its multipurpose objective. Secondly, the multipurpose implements should be capable of performing any operation at least as well as the single-purpose implements that they replace, and this has not generally been found to be the case with the

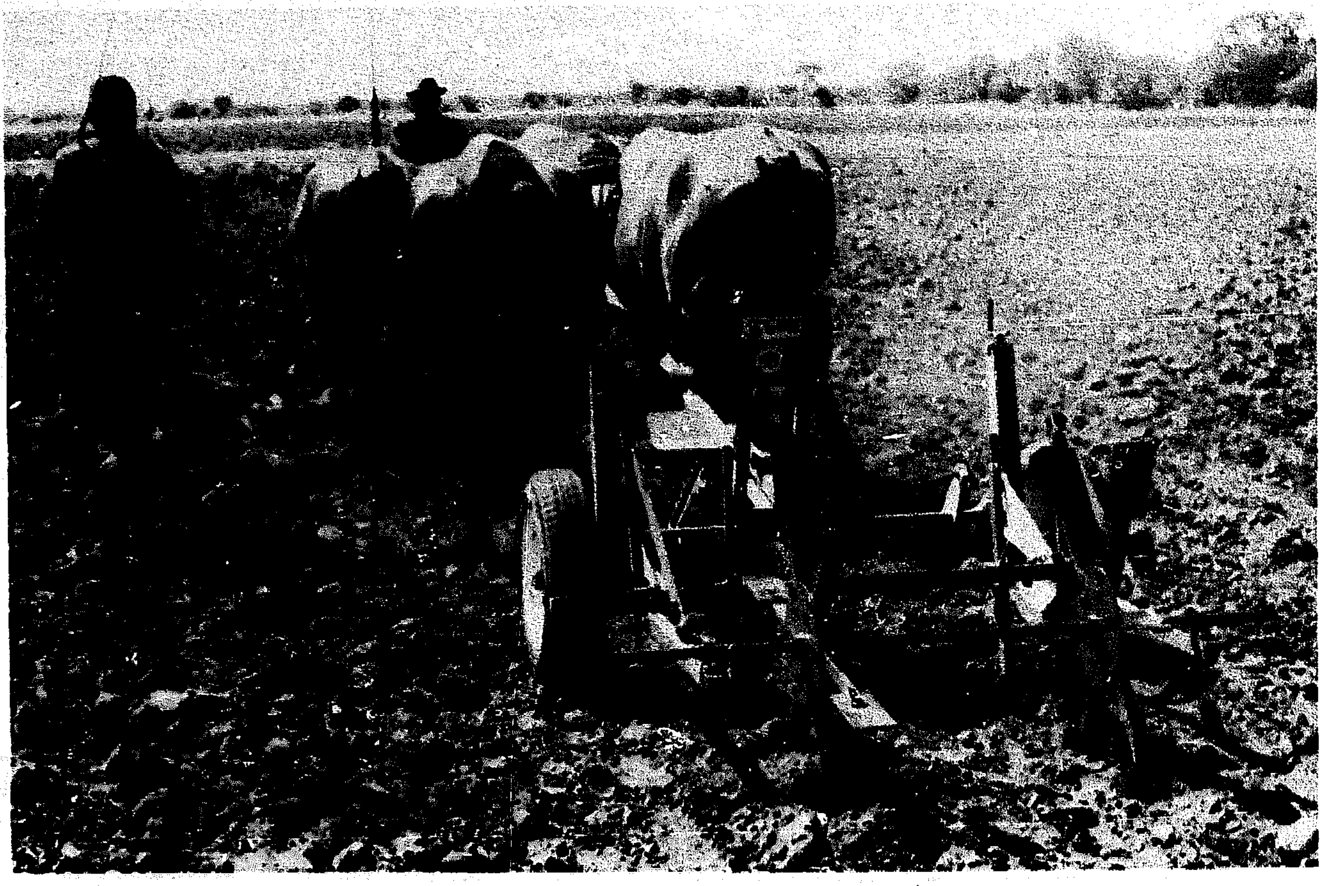


Fig. 5-11: GOM Toolcarrier (Nikart) with prototype "Dammer Diker" at Sebele Research Station, Botswana, 1986. (Photo: FMDU).

Fig. 5-12: Tropicultor with fertilizer distributer at Sebele Research Station, Botswana, 1986. (Photo: FMDU).

various wheeled toolcarriers evaluated in Botswana (EFSAIP, 1984).

There have been fifteen years of well-documented research and development on wheeled toolcarriers in Botswana, during which several different designs have been proven capable of working on station. However wheeled toolcarriers were conclusively rejected by the farmers themselves. The toolcarrier graveyards at Sebele Research Station and Mochudi are reminders of these experiences and it seems most unlikely that further wheeled toolcarrier promotion will be undertaken in the foreseeable future (D. Horspool, personal communication, 1987).

5.3.4 Lesotho

Two French-manufactured Tropicultors and twenty-seven Ariana intermediate toolframes were imported into Lesotho as part of a GTZ-supported programme of the Ministry of Agriculture in 1983. These were designed for testing and demonstration in district centres. Due to shipping delays and local constraints by early 1984 only the Ariana toolframes had been tested to any degree and early evaluations of these were favourable. Initial impressions suggested that the Tropicultors would be too expensive for most Lesotho farmers particularly if imported from France. It was suggested that one possible role for locally fabricated Tropicultors could be to replace the aging South-African-manufactured Safim two-row planters, some of which had been in use for up to 25 years. Such an investment would not be for small farmers but for entrepreneurs doing contract planting using their oxen or horses. It was therefore proposed that, while emphasis be given to the Ariana intermediate toolframes, a small number of Tropicultor toolcarriers be locally fabricated to give an indication of cost and feasibility and to provide sufficient samples to gauge farmer reaction (Munzinger, 1984). By 1986 wheeled toolcarriers had not been thoroughly evaluated or adopted in Lesotho, and apparently the authorities tended towards scepticism as to their relevance to small farm conditions.

5.3.5 Madagascar

In Madagascar, plows have been in use since 1850, and the simple mouldboard plow is still the most widely used piece of animal-drawn equipment. According to van Nhieu (1982), there has been some use of reversible plows and an even greater adoption of simple multipurpose toolbars, valued for their weeding tines. Several French designs of wheeled toolcarrier manufactured by Mouzon, Nolle and Ebra have been tested in Madagascar. However van Nhieu (1982) concluded "despite a great deal of publicity work these multipurpose units are seldom used on account of their high purchase price."

5.3.6 Malawi

In Malawi in the late 1960s wheeled toolcarriers based on the NIAE design had been tested at Chitedze Research Station but it had been decided not to promote these implements. In 1985 a single promotional example of the British-manufactured Sahall Lioness toolcarrier (as exported to Mozambique) was sent to Chitedze for evaluation, but first impressions were not encouraging (W. Kumwenda, personal communication, 1986).

5.3.7 Tanzania

Wheeled toolcarrier prototypes had been developed and tested in Tanzania by NIAE and TAMTU (Tanzania Agricultural Machi-

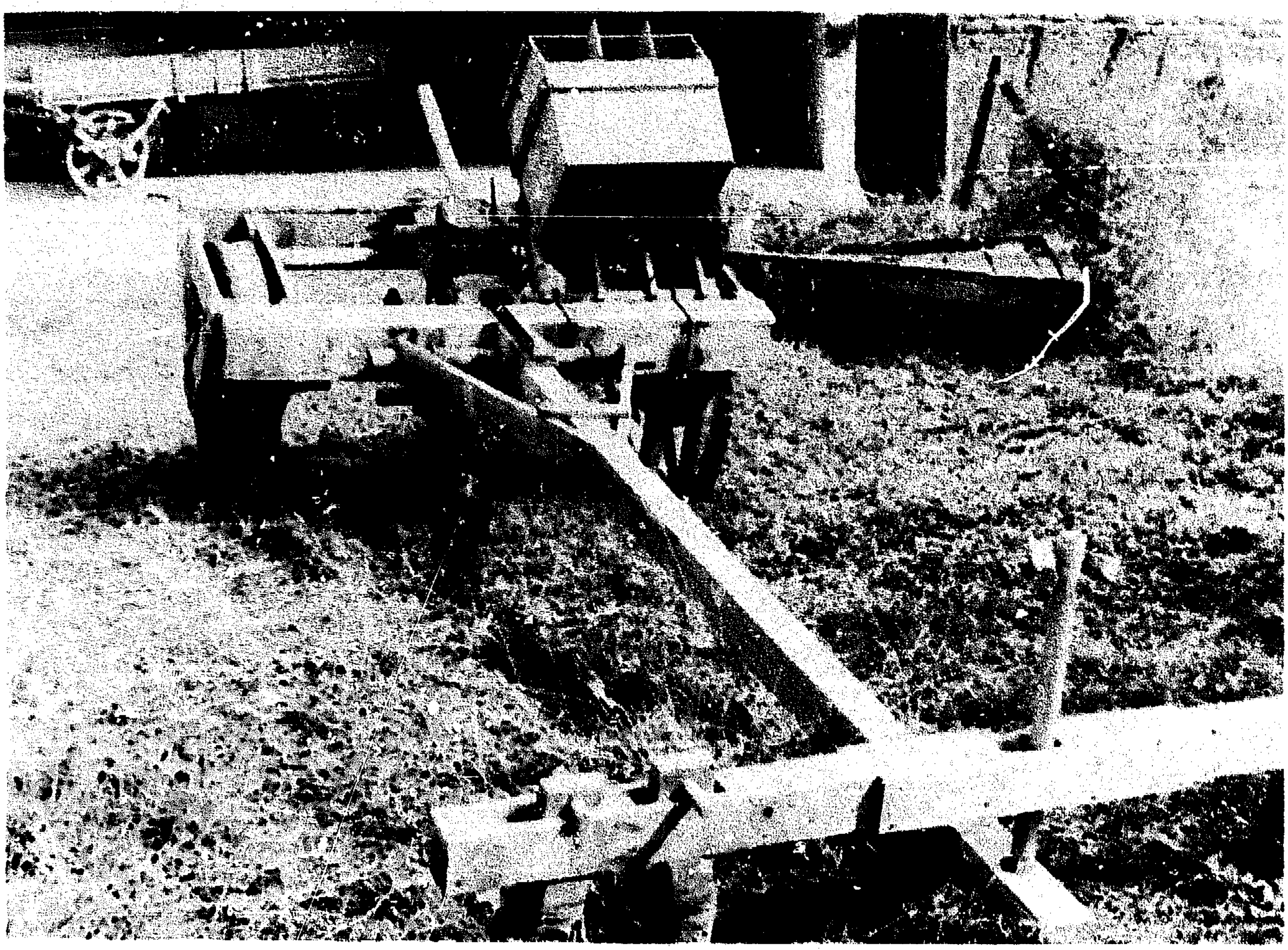


Fig. 5-13: Wooden-wheeled toolcarrier prototype developed at Uyole Agricultural Centre, Tanzania, 1984. (Photo: P.H. Starkey).

nery Testing Unit) in 1960 and 1961 but there had been no promotional follow-up to this. More recently in 1980 two large wooden toolcarriers were designed and built at the Uyole Agricultural Station, in the southwest of Tanzania (Kjaerby, 1983). These units had large wooden wheels giving high clearance, and wooden seeders and fertilizer hoppers. The shafts of the sweeps and tines were also constructed of wood, with steel being used only for the blades themselves. Although the construction in wood overcame some of the cost problems relating to imported steel, the toolcarriers were large, heavy and very cumbersome. While this was not too great a disadvantage when used with the large Friesian oxen on the smooth fields of the agricultural station, it would have been difficult for the smaller local East African Zebu animals to pull it over the uneven ground of local farms. Kjaerby (1983) considered that there might be the embryo of a useful implement within the prototype but warned that continued research under optimal conditions on the agricultural station would probably consume time, effort and scarce funds to produce only inapplicable results. Recent visits and reports suggest that on-farm research has not yet been undertaken with these wooden-wheeled toolcarriers. Thus this innovative technology has not yet passed the initial prototype stage, and it seems unlikely to be developed further.

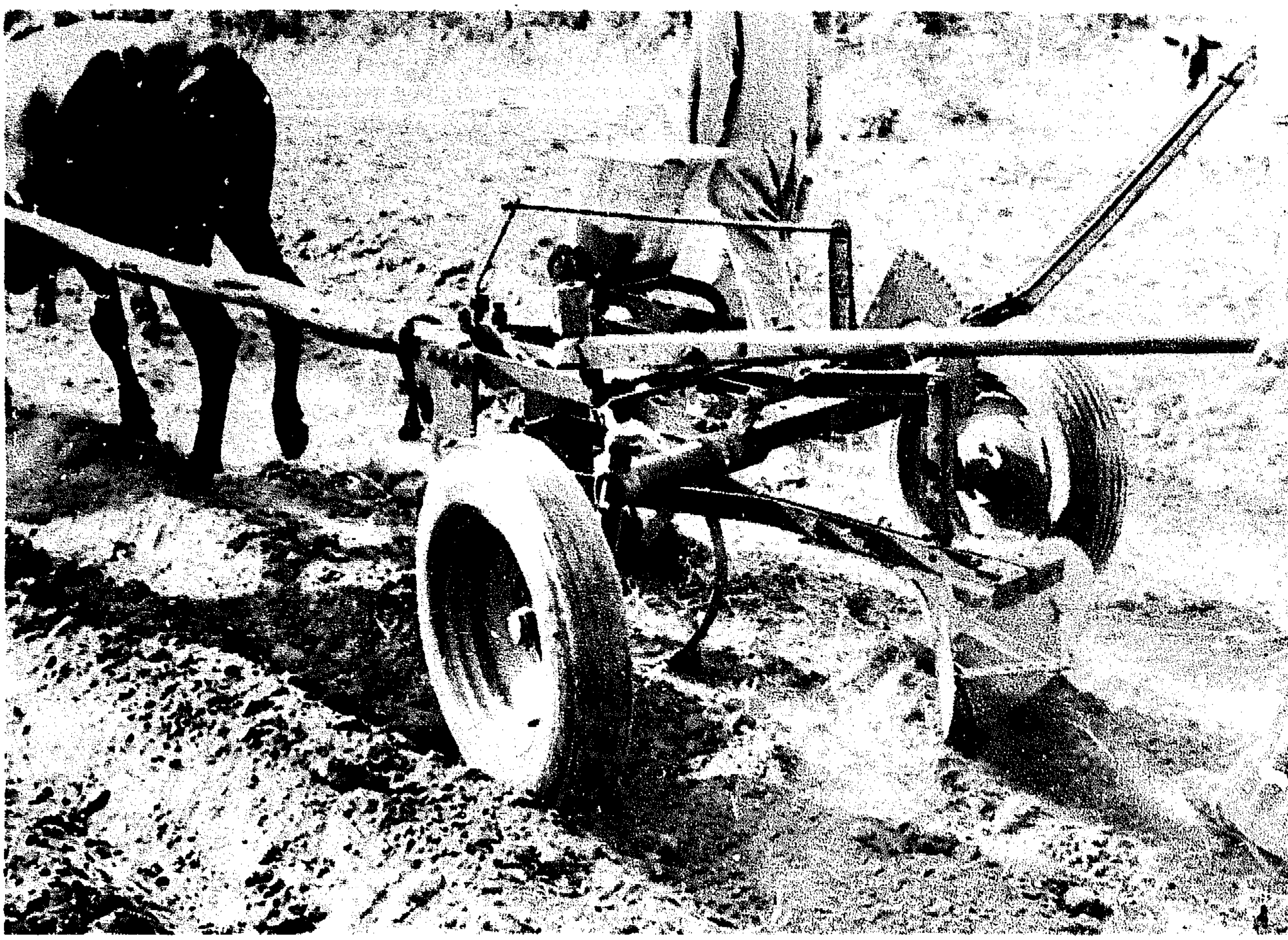


Fig. 5-14: Wheeled toolcarrier based on old front axles of a tractor, Zambia, 1985. (Photo: J. Rauch).

5.3.8 Zambia

In 1979 a small mission project involved in agriculture and artisan training developed an original design of wheeled toolcarrier using the front axles of scrap tractors. The implements were not designed for ride-on operations but were steerable from behind. The toolcarriers could be used with two or four oxen for plowing, ridging, seeding and weeding and were made available to groups of young people that had been trained by the project. The Austrian designer of the toolcarriers remained with the programme until 1987, at which time five of these wheeled toolcarriers were reported to be in use (F. Rauch, personal communication, 1987).

In 1985 the Technical and Vocational Teacher's College in Luanshya requested technical drawings of the Nikart from ICRISAT in India, and a similar request was received from Shamava Engineering Construction Company in Lusaka in 1986. It is possible that one or more prototypes were constructed using these drawings, but to date there has been no major initiative.

5.3.9 Zimbabwe

One Nikart was exported from the U.K. to the Institute of Agricultural Engineering of the Ministry of Agriculture in Borrowdale, Harare, Zimbabwe. It was tested on station, and one or two were fabricated locally from ICRISAT designs. Although detailed reports have not been obtained, apparently the wheeled toolcarriers did not arouse much enthusiasm, and by 1986 there had been no follow-up project.

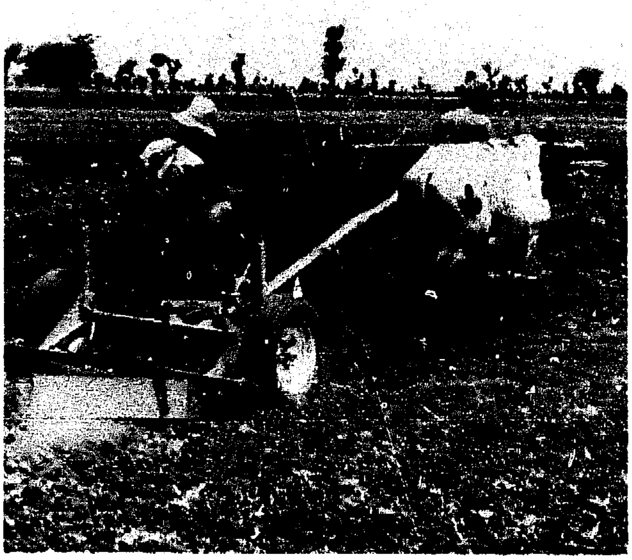
5.4 Eastern and northeastern Africa

5.4.1 Ethiopia

Ethiopia has the largest population of draft animals in Africa, with 6–7 million work oxen. The great majority of farmers use animal power and the traditional *maresha* ard plow for cultivation. Donkeys are widely employed for pack transport but the use of carts is not widespread. One reason for the scarcity of animal carts is their cost, for Ethiopian farmers' incomes are among the lowest in the world (Goe, 1987).

In 1969 and 1970 there had been some tests of NIAE-type Aplos wheeled toolcarriers by the Chilalo Agricultural Development Unit (CADU) but these were not followed by promotional schemes (CADU, 1970, cited by Goe, 1987). In 1982 the International Livestock Centre for Africa (ILCA) which is carrying out animal traction research in Ethiopia imported three Nikarts manufactured by Geest of the U.K. These were tested on ILCA's research stations between 1982 and 1984 where they proved to be technically competent when used with the large 500 kg Boran x Friesian crossbred oxen. The implement draft for plowing and broadbed formation was greater that that required for the traditional *maresha* implement and was considered excessive for the 300 kg indigenous Zebu oxen. The wheeled toolcarriers were relatively difficult to operate when the soil was wet, and their use would have implied major changes to the farming system with early cultivation and sowing and the development of early cultivars that were disease-resistant. ILCA also had reservations as to whether farmers, blacksmiths and traders in rural areas would have the tools, spare parts and mechanical knowledge to be able to maintain such implements and their pneumatic tyres (M. Goe, personal communication, 1987).

Fig. 5-15: GOM Toolcarrier (Nikart-type) being tested at the ILCA Debre Zeit Research Station near Addis Ababa in 1983. (Photo: ILCA Highlands Programme).



The overall evaluation of ILCA was "sobering". It was concluded that wheeled toolcarriers did not have much potential in the smallholder farming systems of Ethiopia unless their very high cost could be substantially reduced. This verdict was reached even after allowing for possible income generation through transport use (F. Anderson, personal communication, 1986). ILCA therefore did not progress to on-farm research relating to wheeled toolcarriers and since 1985 the wheeled toolcarriers owned by ILCA have been used only as single purpose carts.

Partly as a consequence of the evaluation of high cost wheeled toolcarriers, ILCA decided to work with modifications of the local *maresha* plow. In on-station and on-farm trials these modified implements, costing about 5% of the price of a wheeled toolcarrier, were found to be able to perform many of the broadbed cultivation operations for which the Nikart had been designed (Jutzi, Anderson and Astatke, 1986).

In 1982 a Norwegian Lutheran mission in Addis Ababa was sent plans for Nikart construction, but ICRISAT received no feedback on whether or not any prototypes were constructed. A private tractor firm Tetraco was reported to have imported in 1982 a limited number of wheeled toolcarriers for testing and marketing, but with the closure of this firm it was not known if any of these toolcarriers were sold (Goe, 1987). This private initiative may have been linked with the importation of thirty wheeled toolcarriers of the British-manufactured Sahall Lioness 3000 model in 1985. These were ordered for evaluation in Ministry of Agriculture centres in various parts of the country. More recently, in 1986 the Ethiopian Government requested tenders for another fifty wheeled toolcarriers with a particularly high technical specification of attachments. The implements ordered for these included fifty each of disc plows, reversible mouldboard plows, disc harrows, spike tooth harrows, spring tooth harrows, 6-row cereal planters, 2-row maize planter/fertilizer applicators, fertilizer spreaders, chemical sprayers, ridgers, levellers, ditchers, mower with diesel engines, tipping trailers and four-wheeled trailers. Such toolcarrier packages would probably cost about $ 3000–4000 each, making this one order of fifty very valuable.

5.4.2 Somalia

In 1985 and 1986 three separate requests were met from the Bay Region Agricultural Development Project in Somalia for the ICRISAT technical drawings of wheeled toolcarriers. One Nikart and one Agribar were purchased from Mekins of Hyderabad for evaluation as part of a consultancy input into the project, supported by the World Bank.

There were some initial problems encountered in assembling the Nikart, which may have been due to poor finishing of some parts and others being incorrectly supplied. During on-station tests there were breakages and damage to the tubes of the seeder-cum-fertilizer attachment due mainly to minor defects in the manufacturing and assembly processes. Sowing could be effective, but difficulties were experienced with the plates supplied in obtaining a plant population that was optimal for local conditions. The Nikart was demonstrated to village chiefs, farmers and extension workers, who were generally impressed, and significant local interest was stimulated in the possibilities of purchase or hire. However the consultant responsible for the evaluation expressed caution due to:

– the high cost of the toolcarriers,
– the need for at least two well-trained animals capable of maintaining straight rows,
– the heavy weight of the toolcarriers,
– the need for mechanical aptitude in setting up and using the relatively complicated implements correctly,
– the need for establishing and maintaining services for the repair and maintenance of toolcarriers and their pneumatic tyres. (Barton, 1986).

Evaluation of the Agribar was due to take place in early 1987. First impressions were that simple toolbars (such as the Pecotool or Houe Sine) might be more appropriate in the Bay Region of Somalia due to lower cost, simplicity and the potential for use with a single animal.

In 1985 ten Nikarts and five Agribars had been supplied to the Extension Service (AFMET) but for various reasons by early 1987 many of the implements were still unused. It seems too early to draw firm conclusions from the experience in Somalia, but early impressions of several people were that wheeled toolcarriers were too heavy, too complex and too expensive for use in the local farming systems. It seemed most unlikely that there will be any major attempts at promoting these implements (A. Seager, personal communication, 1987).

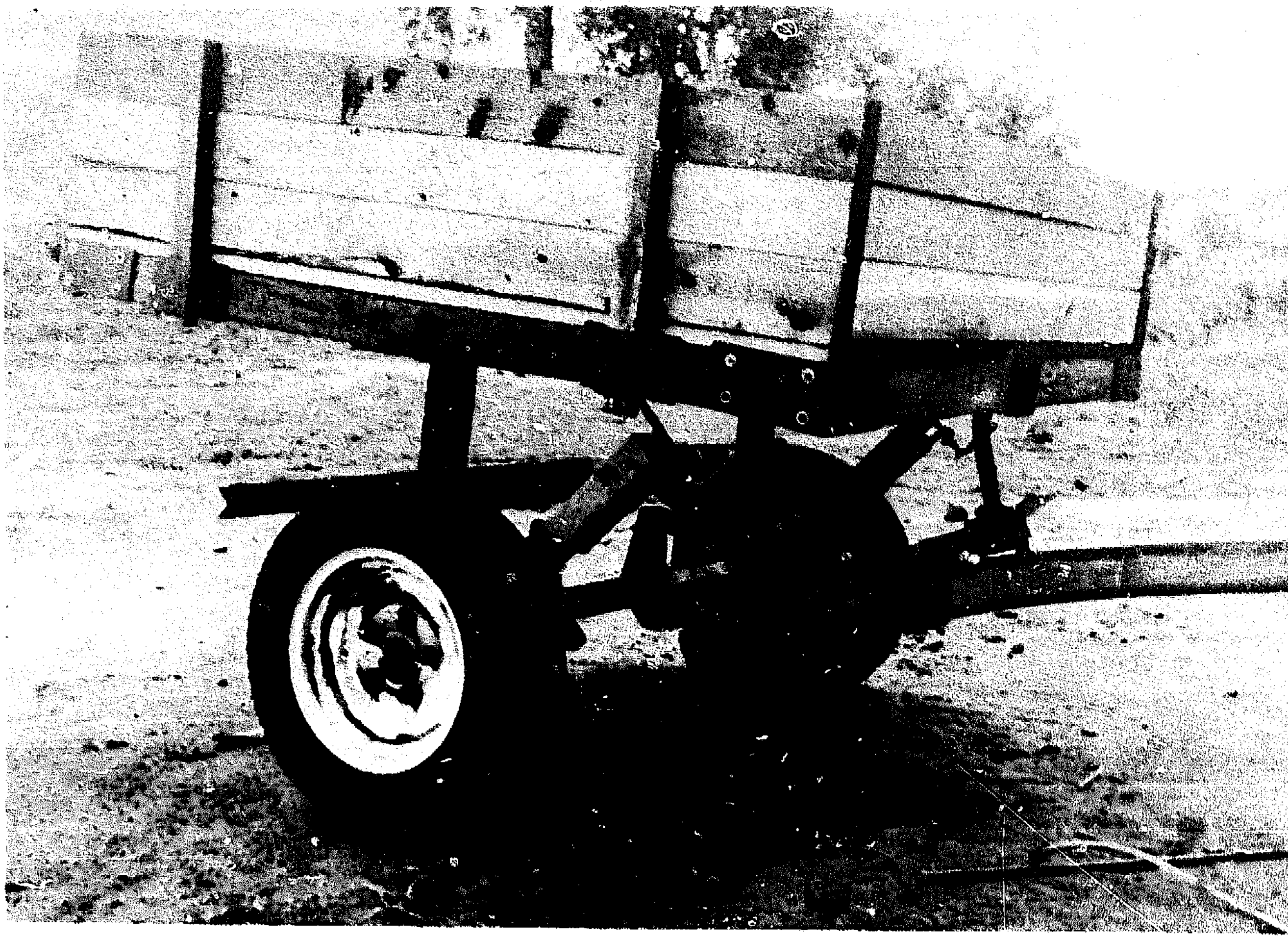


Fig. 5-16: GOM Toolcarrier (Nikart) fitted with cart body in Sudan, 1984. (Photo: Mike Ayre).

5.4.3 Sudan

In 1975 and 1976 the Atulba toolcarrier, based on the Versatool of Botswana, was developed in the Western Savannah Province of Sudan within the context of a development project supported by British technical cooperation (Gibbon et al., 1983). This did not pass the prototype stage. In 1983 a small number of GOM Toolcarriers of the Nikart design were imported for evaluation. These were considered to be of relatively poor quality construction. The loading platform was found to be uncomfortably high and could not be easily altered as the cart body had to be clear of the depth control mechanisms of the toolbar. The toolcarriers were not considered appropriate and were either abandoned or used as carts (M. Ayre, personal communication, 1987). In 1986 another development project in the Sudan ordered a few more GOM Toolcarriers for evaluation.

5.5 Summary of recent toolcarrier programmes in Africa

In the past ten years wheeled toolcarriers have been imported into at least fifteen African countries, and fabricated in at least eight countries. In most countries they have been found capable and competent in on-station trials. They have been found less suitable for use on small farms where there may be stumps, restricted access, smaller animals and fewer facilities for repairs and maintenance. In no country have wheeled toolcarriers been used regularly by farmers off station for a wide range of operations, and most toolcarriers have ended up merely as carts. In no country have sustained utilization rates by farmers ever approached those used in economic models to justify farmer investment and, to date, in no country has a farming system been identified in which the high capital cost of the equipment can be economically justified by the returns actually achieved by farmers using the equipment.

As more aid agencies have imported wheeled toolcarriers, graveyards of unused yet expensive implements and attachments, reminiscent of the tractor graveyards of the 1960s and 1970s, can be seen in several countries. Recent large contracts for countries such as Ethiopia, Mozambique and Angola show that aid agencies are continuing to fund the importation of wheeled toolcarriers. In addition, in budgetary terms the amount that has been, and is being, spent on financing expatriate technical cooperation personnel to evaluate this technology in many different countries in Africa may be greater than the cost of the equipment itself.

6. Experience in Latin America: 1979—19[illegible]

6.1 Experience in Brazil

In Brazil about 20% of farmers presently use animal traction. A total of about seven million draft animals are employed, one third of them oxen and the rest horses, mules and donkeys, and about 1.7 million simple plows are in use in the country (Reis and Baron, 1985).

During the period 1965–1975 there was at least one small research trial with NIAE-designed wheeled toolcarriers in Brazil, but this does not appear to have led to any promotional schemes. In recent years animal traction has become a more important area of research, with technical cooperation inputs from CEEMAT and the Inter-American Institute for Cooperation in Agriculture (IICA).

Prototype wheeled toolcarriers based on the ICRISAT version of the Tropicultor were developed in 1979 by Empresa Brasileira de

Fig. 6-1: Plowing with CPATSA Multicultor Mk I, Petrolina, Brazil. (Photo: Harbans Lal).

Pesquisa Agropecuaria (EMBRAPA) at its Centro de Pesquisa Agropecuaria do Tropico Semi-Arido (CPATSA). The prototype "Multicultor CPATSA I" seemed to catch the imagination of many, for following a national television programme, EMBRAPA received nearly 1000 enquiries from farmers, industrialists, institutes and traders requesting details (Lal, 1985). As a result of the apparent enthusiasm for wheeled toolcarriers, in 1981 two workshops started to produce toolcarriers based on the NIAE/ICRISAT (Nikart) design (ITDG, 1985) but few units were ever made in these short-lived initiatives.

CPATSA developed a second prototype "Multicultor CPATSA II" in 1981/82 which was an original design not based on either the Tropicultor or the Nikart models. However, early attempts to manufacture the CPATSA toolcarriers in cooperation with a local workshop were beset with technical and quality control problems, and the initial units did not stand up to rigorous field testing (Lal, 1985). As a result of these problems and the rapid progress of a parallel EMBRAPA/CEEMAT project, enthusiasm for the Multicultors CPATSA rapidly declined. CPATSA continued to work on designs of implements and cultivation systems to be used in conjunction with wheeled toolcarriers, but not on the toolcarriers themselves. Work was undertaken on a cultivation system intermediate between simple ridge cultivation and broadbeds. This was known as the W-form soil management system, and it made use of wheeled toolcarriers to carry grader-blades for the formation of wide, gently sloping ridges (Lal, 1986).

The EMBRAPA/CEEMAT scheme involving a major agricultural machinery manufacturer proved to be more successful in terms of achieved toolcarrier production. This initiative started in 1980 with the importation of eighteen sets of implements

Fig. 6-2: Plowing with CPATSA Multicultor Mk II, Petrolina, Brazil. (Photo: Harbans Lal).

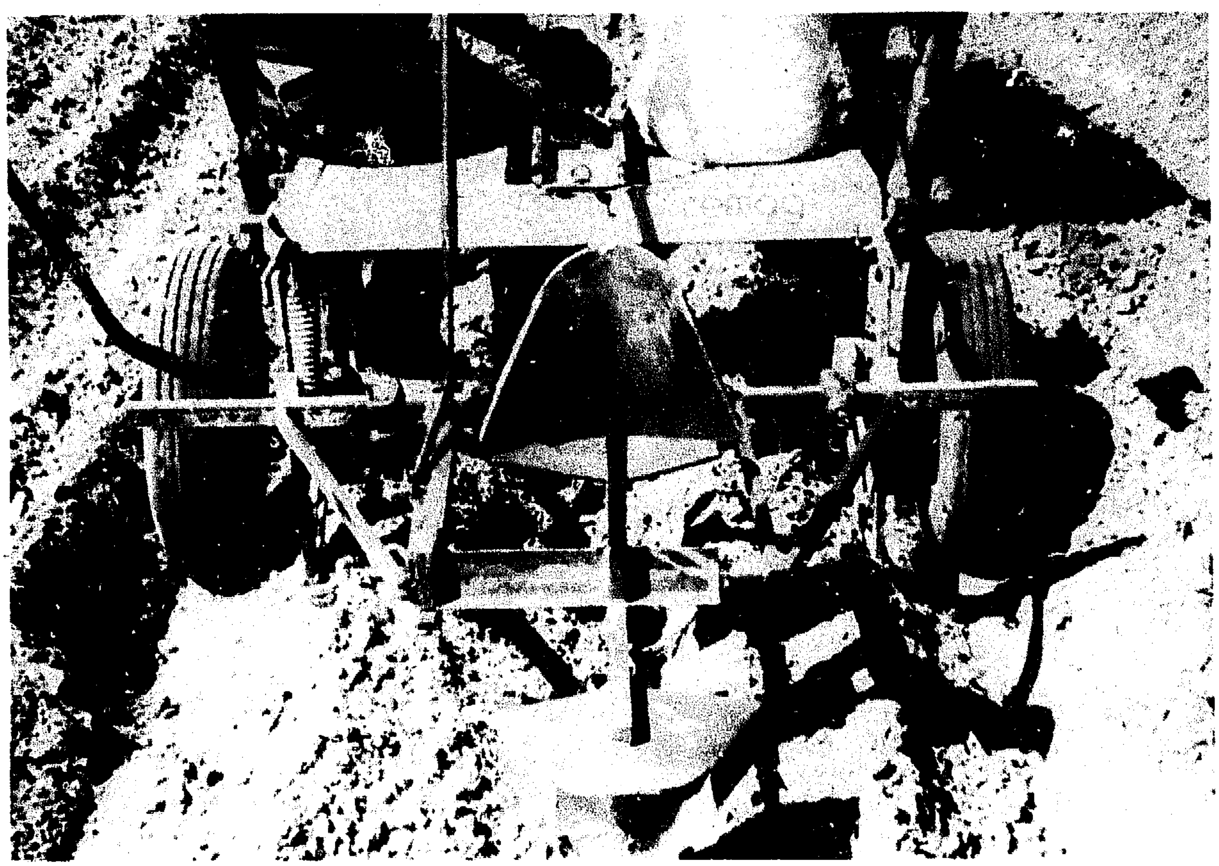
based on designs of Jean Nolle and manufactured by the French company Mouzon. These included six Tropicultors, three Arianas and two Houe Sine toolbars. Following a few months of on-station and on-farm trials in four states, twenty-four locally fabricated models were tested in nine states in 1981 (da Cunha Silva, 1982). By May 1982 a commercially manufactured range of three toolbars was launched under the name of *Policultor* (CEMAG, undated). The simplest, the Policultor 300, was based on the Houe Sine, the Policultor 600 was based on the Ariana while the wheeled toolcarrier, the Policultor 1500, was derived from the Tropicultor. In the first three years a total of seven hundred Policultor-1500 wheeled toolcarriers were reported to have been manufactured (Barbosa dos Anjos, 1985). In 1985 production of toolcarriers continued at the same level, 230 per year. The number manufactured in 1986 dropped to 147, and this rate of production continued into the first quarter of 1987 when thirty-four were made (CEMAG, personal communication, 1987).

Fig. 6-3: CEMAG Policultor 1500 toolcarrier with wheels inset with grader/leveller in Brazil, 1982. (Photo: CEEMAT archives).

The majority of wheeled toolcarriers were distributed to demonstration farms managed in cooperation with the extension services but physically based on the land of selected master farmers or community leaders (Reis and Baron, 1985).

The Policultor-1500 wheeled toolcarrier made by CEMAG is similar in versatility to the Tropicultor from which it is derived. It has a range of twenty implements that can be used including mouldboard and disc plows, ridgers, planters, and several different designs of tines, harrows and pulverizers. There is a range of equipment for distributing granular and liquid manures, and a hay rake option. Transport variations include carts and water tanks. The Policultor 1500 can be supplied with metal wheels and in addition to the version designed for use by a pair of oxen, the standard chassis can be

Fig. 6-4: CEMAG Policultor 1500 toolcarrier with prototype ridge-tying implement in Brazil, 1984. (Photo: Thierry Duret/CEEMAT archives).



attached to twin shafts for use with a single animal, or adapted for use by two donkeys or mules (CEMAG, undated).

It is too early to know how successful this wheeled toolcarrier programme will be in Brazil, for they have only been used by farmers for a few seasons and the initial manufacture and distribution of equipment have been subsidized. The general trend in production in the period 1984–1987 suggests a gradual decline rather than a strong acceleration.

Most workers involved in the wheeled toolcarrier programme seemed optimistic about their potential (Barbosa dos Anjos, 1985; Lal, 1985; Reis and Baron, 1985). The fact that farmers can sit on the wheeled toolcarriers is considered psychologically important in Brazil and attractive presentations of animal traction are an integral part of agricultural development policies in some states (Agricultura Parana, 1984).

However there has been at least one note of caution, for in a paper presented at a CEEMAT seminar on animal traction Bertaux (1985) counselled against the automatic assumption that multipurpose equipment is desirable in Brazil. He presented examples to show that, while the Policultor 1500 could perform all the operations required on an 8 ha farm, similar operations could be performed using simpler and cheaper implements. In addition the simpler implements might also favour mixed cropping and intensification. The wheeled toolcarriers might appear well suited to the perceived need to increase cropping areas, but research in different disciplines in Brazil had shown effective methods of increasing yields on land already cropped, and many farms in the 20–50 ha range had cultivation intensities of less than 50%. Bertaux argued for a farming system approach to agricultural equipment research and development, particularly in determining whether the farmers' objectives were to increase their area cultivated or intensify production on existing land.

Two factors that might favour the adoption of wheeled toolcarriers in Brazil include the fact that a quarter of the farms in the 20–50 ha range use animal traction, and the fact that in much of Brazil, oxen are large, weighing about 750 kg (Reis and Baron, 1985). However Bertaux (1985) gave examples of how, by combining the use of oxen, horses and donkeys with a simpler range of implements and a cart, similar benefits might be achieved. Bertaux also cited many of the constraints to the effective development of new equipment designs in Brazil, including lack of material standards, delays, inflation and great differences in blacksmith skills. Bertaux did not entirely reject the concept of the wheeled toolcarriers, but he argued strongly that one should learn from past mistakes and that given the existing infrastructure and farming systems in Brazil it might be better to deploy resources in developing solutions of more immediate relevance. Unfortunately the arguments and examples that Bertaux presented at the CEEMAT seminar were not included in the official proceedings, and only a summary of his contribution was published (Bertaux, 1985).

6.2 Experience in Mexico

In Mexico animal-drawn plows, ridgers and inter-row cultivators are widely used, and there are about 4.2 million draft animals, of which 2.8 million are draft cattle and the others are horses, mules and donkeys (Ramaswamy, 1981). In the early 1970s an NIAE-designed wheeled toolcarrier had been tested on a research station and a university had made an original prototype, but there had been no projects aimed at promoting these implements.

In 1980 the Instituto Nacional de Investigaciones Agricolas (INIA), with technical cooperation support from the British NIAE, started a project to evaluate animal traction equipment and assist the establishment of the commercial production of the prototypes found to be most suitable. Initial work included farm surveys, the testing of several implements including at least one Mouzon Tropicultor and visits by specialists such as Jean Nolle and Alan Stokes. Following these it was decided to complement the animal-drawn equipment already readily available with some new designs. The equipment selected for fabrication included a simple toolbar (the *Multibarra* based on the *Anglebar* design of the British agricultural engineer Alan Stokes), an adjustable ridger-cultivator, a disc harrow, a zero-tillage jab planter, and a Nikart-type wheeled toolcarrier that could be used for conventional tillage operations and also zero-tillage applications (Sims, 1984; Sims, Moreno and Albarran, 1984; Sims, 1985).

The Mexican version of the wheeled toolcarrier, the *Yunticultor* ("yunta" means a pair of oxen), was based on the ICRISAT/NIAE toolcarrier, commonly known as the Nikart. The specific advantages of the Yunticultor over traditional implements were cited as:

- the timesaving larger working width,
- the more efficient use of animal power,
- the multipurpose use (avoiding the necessity to buy many implements),
- the comfort of the seat to the operator (Sims, 1985).

Fig. 6-5: Wheeled toolcarrier developed at National University, Mexico, 1978. (Photo: AFRC-Engineering archives).

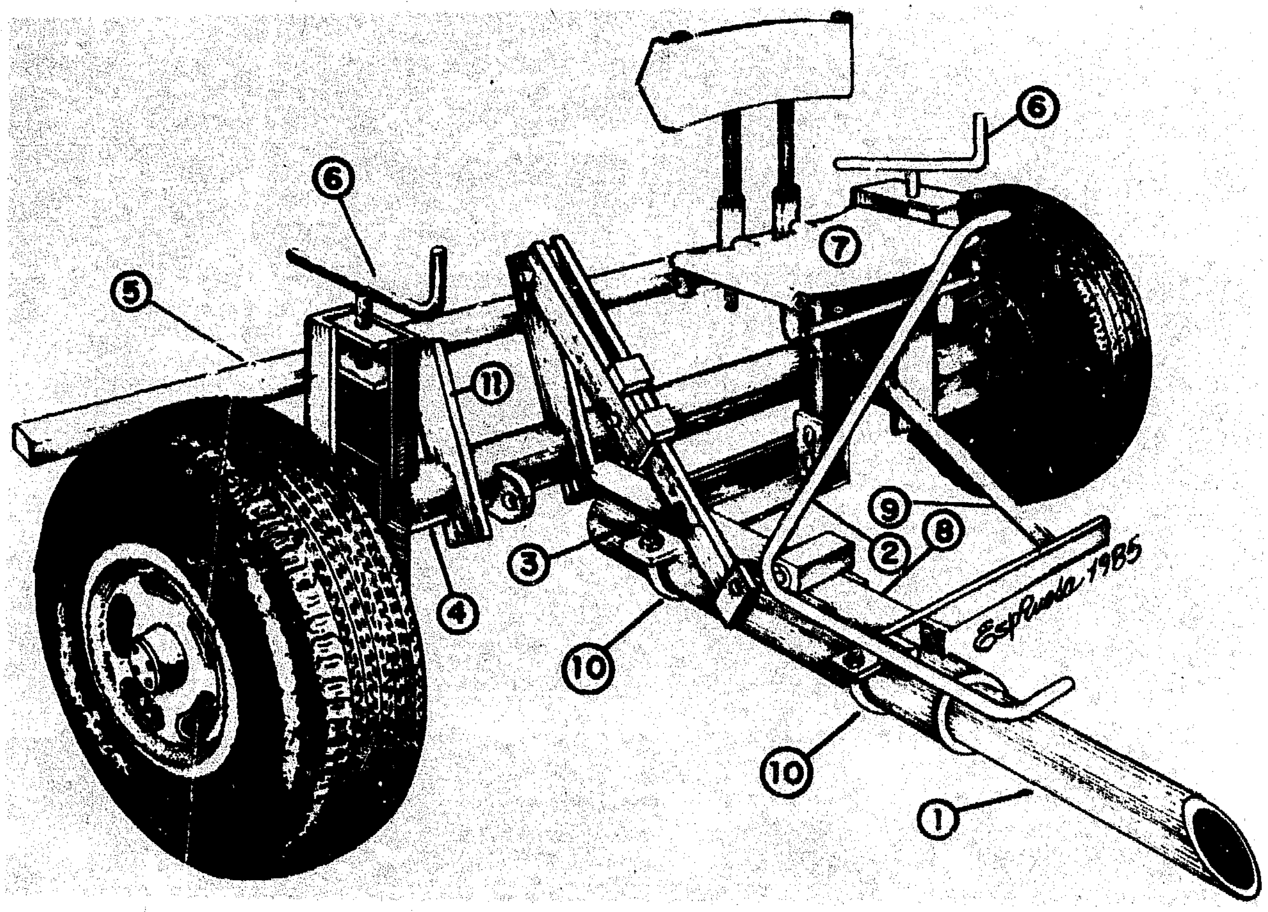


Fig. 6-6: Drawing of Yunticultor: 1. Drawbar. 2. Toolbar raising lever. 3. Adjustable stay for toolbar. 4. Main axle. 5. Toolbar. 6. Handle of height adjustment screws. 7. Seat. 8. Support shaft. 9. Lateral brace. 10. Clamps. 11. Offset position of drawbar. (Illustration: Sims, Moreno and Albarran, 1985).

However the great disadvantage was the price of over $ 1000 for the recommended package, compared with $ 200 for the simple toolbar with implements. As a result of the large price differences, the simple toolbar has been found to be more profitable for small farmers than either the wheeled toolcarrier or the traditional implements (Sims, 1985; Olmstead, Johnston and Sims, 1986). The simple toolbar is now being commercially manufactured by private workshops, with 1000 units being made by 1986.

The wheeled toolcarrier has been made in much smaller numbers. In the first instance two privately owned urban workshops were assisted to start production. One of these workshops subsequently closed when its owner died. The other made several units but experienced problems in obtaining the necessary raw materials and in ensuring quality control. It failed to establish a significant market for its toolcarriers and thus turned to more commercially attractive products. By 1986/87 the private workshop only made Yunticultors occasionally, when it received specific orders. The government-backed Servicios Ejidales (SESA) was persuaded to make fifty Yunticultors in 1985–1986 for the State of Oaxaca and so became the main toolcarrier manufacturer in Mexico. In 1986, SESA anticipated to continue production at a rate of at least fifty per year, subject entirely to specific state orders and finance.

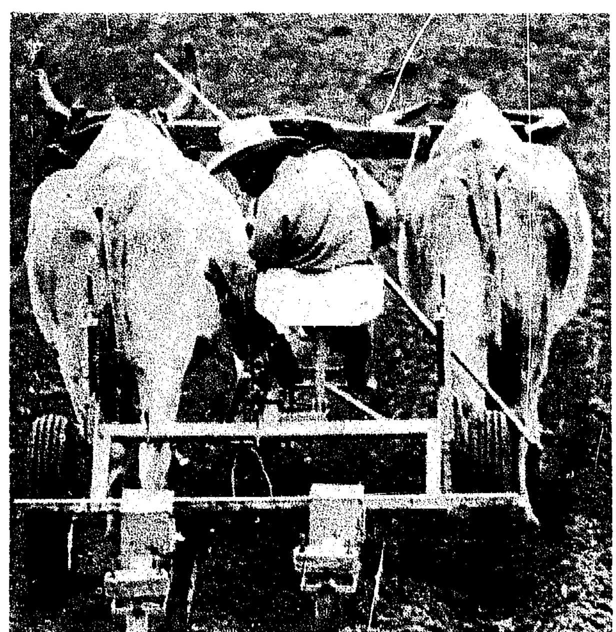
In early 1987 there were about one hundred Yunticultors in use in Mexico, with future production of another hundred being guaranteed by state funds. Some innovative

Fig. 6-7: Yunticultor with disc harrow in Mexico. (Photo: ICRISAT archives).

farmers who had heard of the implement had requested plans or models so they can try to make their own units (B. Sims, personal communication, 1986). Only a few of the units manufactured to date have been bought by farmers, as most have been owned by government agencies, projects and research stations. The wheeled toolcarriers are now being actively promoted by the government and ten Yunticultors have been given as prizes at state fairs. Officials have been happy to be photographed riding on the Yunticultor as a means of showing solidarity with the small farmers.

While promotional literature has emphasised the increased profitability of wheeled toolcarriers over traditional implements (Sims, Moreno and Albarran, 1985), the small size of many holdings makes it difficult to justify

Fig. 6-8: Yunticultor with unit planters in Mexico. (Photo: ICRISAT archives).



investment in such implements. Indeed the high cost of the wheeled toolcarrier meant that its use was described as *more* capital-intensive than tractor-based systems of production (Olmstead et al., 1986). This apparent anomaly is based on the investment costs of equipment per unit area, and the ease of hiring tractors allows their capital costs to be spread over a wide area. In theory the overhead capital costs of the toolcarrier could also be spread more widely through hiring or through sharing within families or villages. However such systems have not developed and Mexican farmers have given very negative reactions to the suggestion that Yunticultors could be shared (Olmstead et al., 1986).

More recent economic studies carried out by staff of NIAE have suggested that the use of the wheeled toolcarrier could be economically viable in Mexico, but that capital availability would be the major constraint. This problem will be overcome for an initial fifty farmers in Oaxaca State which is planning to provide interest-free credit.

With the present programmes of subsidies and promotion, numbers of toolcarriers in use in Mexico will certainly increase in the short term. However it is too early to assess whether or not there will be any sustained adoption by the farmers in the longer term, but the apparent increasing popularity and significantly higher profitability of the simpler toolbar may be a sign of the possible trends.

6.3 Experience in Nicaragua

In Nicaragua animal traction is widespread, and based on traditional ard-type wooden plows and wooden carts with large wheels in the more isolated areas. Steel equipment imported from the USA is more common in the areas around towns. Since 1982 CEEMAT has been closely involved in the development of animal traction equipment through its associations with the National Appropriate Technology Research Centre (CITA) and an EEC-supported project with an animal traction component. In 1982 the French equipment designer Jean Nolle visited Nicaragua to establish the production of a small number (10–25) of toolbars and before leaving he had fabricated one Tropicultor wheeled toolcarrier, and one Ariana intermediate toolframe.

One of the CEEMAT workers involved with the project appeared to be highly pessimistic about the future of toolcarrier production (Bordet, 1985). On the production side there were problems relating to cost of production, insufficient trained manpower, a lack of raw materials of suitable quality, and the limited resources and skills of village blacksmiths. More importantly perhaps, there were also serious doubts as to whether multipurpose equipment was actually desirable.

Most cooperatives in Nicaragua have several pairs of animals, and if single purpose implements are used, different pairs can be plowing, harrowing and transporting at the same time. However, should they be equipped with one wheeled toolcarrier, it could only perform one operation at a time. The wheeled toolcarriers thus have the disadvantage of being less flexible than a comparable range of single purpose implements and did not appear to have any compensating technical advantages in performance over the simpler implements. The heavier weight and restricted manoeuvrability of the wheeled toolcarriers make them unsuitable for use in the mountainous areas. Finally for the price of a Tropicultor wheeled toolcarrier in Nicaragua it would be possible to buy a whole range of simpler implements, including a cart made of imported steel (Bordet, 1985). Thus the early impressions suggest that there is unlikely to be a genuine market demand for wheeled toolcarriers in Nicaragua in the near future.

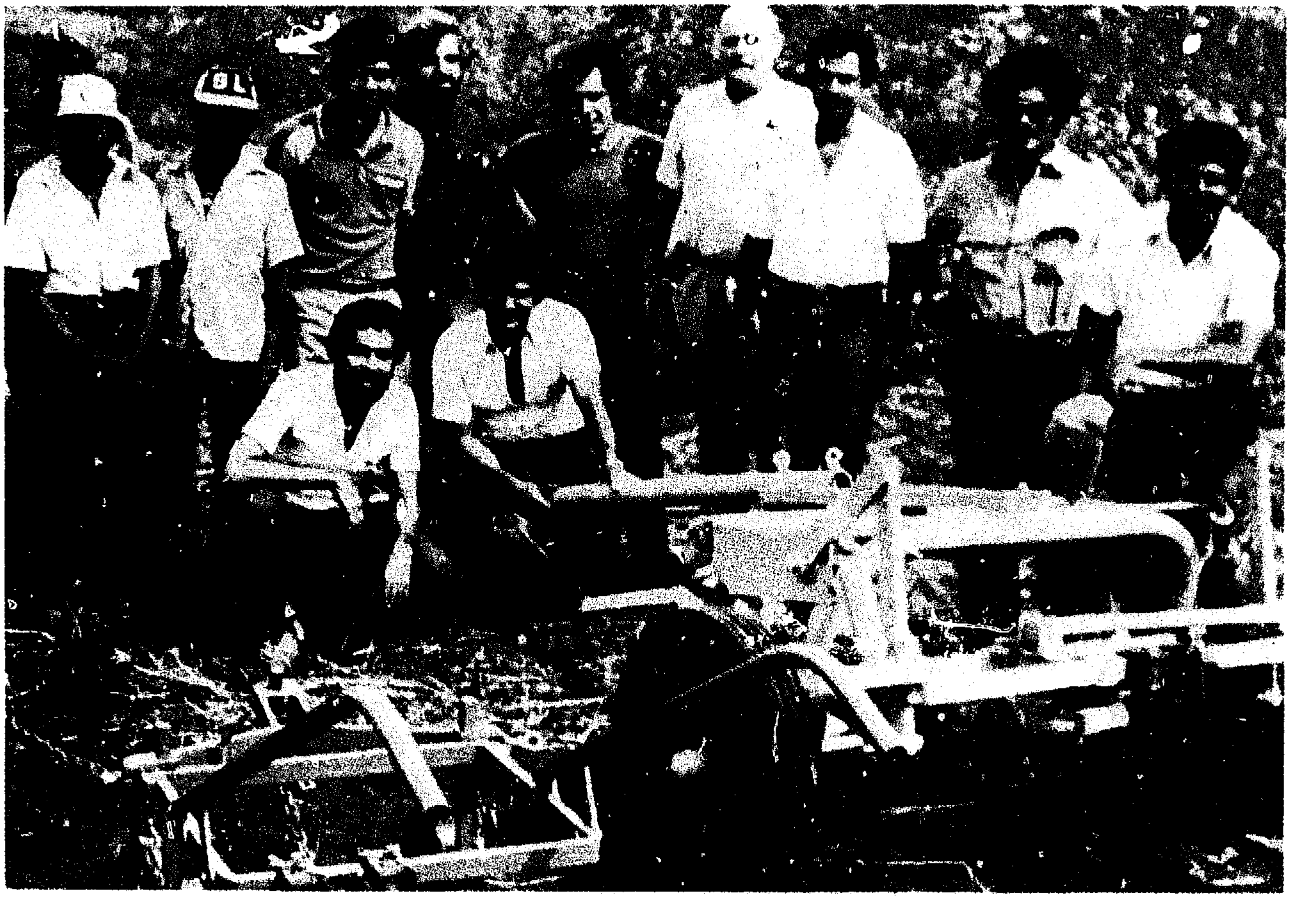


Fig. 6-9: Jean Nolle (back centre) with Tropicultor made in Nicaragua, 1982. (Nolle, 1986).

Fig. 6-10: Demonstration of Tropicultor and Ariana in Nicaragua, 1982. (Photo: Mouzon).

6.4 Experience in Honduras

In Honduras pairs of oxen are widely used to pull traditional wooden plows and wooden carts. Jean Nolle carried out a consultancy involving the local fabrication of Tropicultor toolcarriers in 1972. This programme appears to have been small and short-lived, for an agricultural engineer involved in toolcarrier development in Honduras from 1985 to 1987 had not come across any Tropicultors in the course of his work (D. Tinker, personal communication, 1987).

Between 1982 and 1985 the Unidad de Desarrollo y Adaptacion (UDA) of the Natural Resources Ministry with technical cooperation from ODA and USAID made about fifteen wheeled toolcarriers. These were based on the Yunticultor of Mexico, a derivative of the ICRISAT/NIAE Nikart design. All of these were lent to farmers for evaluation and an indication of their acceptability. The general acceptability of the Yunticultors was low. This was mainly due to the large change in the farming system implied by Yunticultor use and the high investment cost of about US $ 2000. Even if it were intrinsically profitable, such an investment would represent a large risk for a small farmer.

The low farmer acceptability combined with the high cost and problems of local manufacture meant that the programme was nearly terminated in 1985. However the toolcarrier was considered by the UDA as prestigious, for it could give an impressive performance at field demonstrations, where it was shown as a high quality "ox-tractor" for ride-on plowing, disc-harrowing, ridging and cultivating. It was therefore decided to undertake a major redesign of the Yunticultor with the objective of reducing the cost and increasing the ease of manufacture. The initial model of Yunticultor/Nikart used several components that had to be cut with gas from thick steel plate. It also had wheel hubs based on the Ambassador car widely used in India, but unavailable in Central America. Work on a Mark II Yunticultor started in 1985, and was designed to be made only from locally available materials such as angle-iron, and to have all cutting based on hacksaws. The main chassis frame member originally made of galvanized pipe was replaced with a box section made from two angle-irons. This was considered stronger and the straight edges facilitated jig construction and use (Tinker, 1986).

By 1987 UDA had built four Mk II Yunticultors and through the various design modifications the anticipated "commercial" cost of the Mk II had been reduced to about US $ 1500. This price did not include any seeder, as the only implements available were plows, ridgers, tines and a cart body. It is accepted that the Yunticultor Mk II is still likely to be too expensive for use by peasant farmers. Therefore any promotion will be aimed at either groups of farmers or entrepreneurs interested in developing hire services with toolcarriers. It was planned that the Mk II toolcarrier would be initially promoted on a very small scale by two NGO charities. One NGO workshop was to make five toolcarriers in 1987 for use with peasant groups, while a second charity was intending to buy two in order to encourage contract hiring.

There appears to be little optimism relating to short-term prospects for wheeled toolcarriers in Honduras. It is generally accepted the design changes will not have significantly altered the reasons for the present low acceptability of the implements in existing farming systems. Nevertheless it has been argued that continued work on wheeled toolcarriers may be justified by possible future applications within new farming systems. These include deep beds for vegetable production and broadbed contour farming for soil and water conservation. Thus in 1988/89 research trials may be undertaken involving the use of wheeled toolcarriers for vegetable production (D. Tinker, personal communication, 1987).

Wheeled toolcarriers have proved technically competent in Honduras, but they have not been found economically appropriate in existing farming systems. Honduras is therefore searching for a possible application for these implements, and this is likely to be a long-term task. Thus there is, at present, no evidence to suggest that wheeled toolcarriers will be adopted by farmers in Honduras.

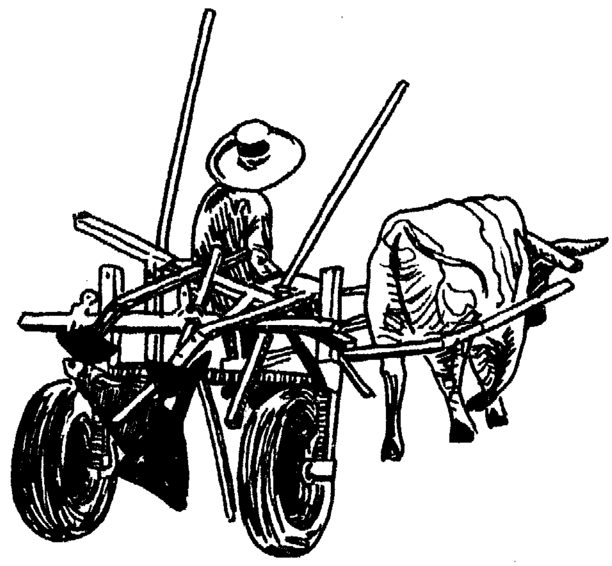


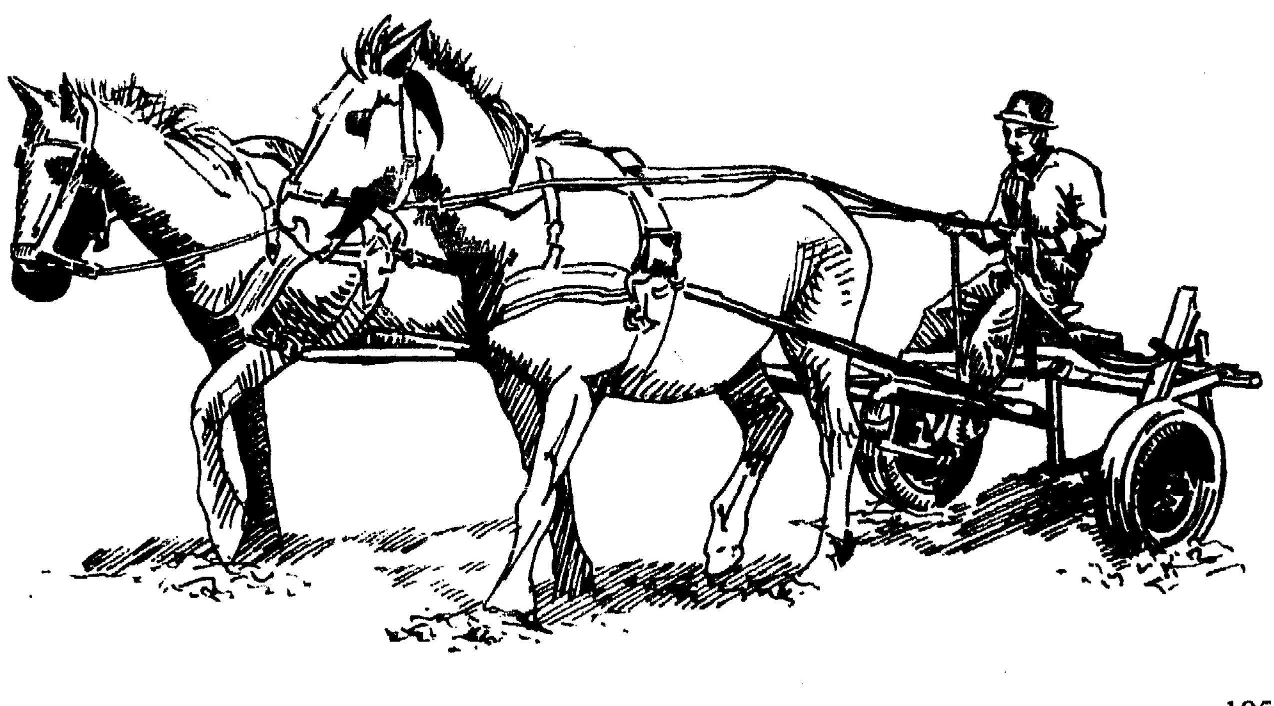
Fig. 6-12: NIAE toolcarrier with single ox in Costa Rica. (Based on photo: AFRC-Engineering archives).

6.5 Other Latin American initiatives

In Chile, Jean Nolle adapted his Tropicultor design for the use of horses in 1969 and some NIAE toolcarriers were tested in the early 1970s. In 1985, a single Sahall wheeled toolcarrier was sent to the University of Conception for evaluation. This University continued its research interest in wheeled toolcarriers and in 1986 was working to develop a horse-drawn toolcarrier suitable for use in Chile.

Jean Nolle visited Paraguay in 1977. Following successful demonstrations of a Tropicultor in use, a coordinating committee to introduce wheeled toolcarriers in Paraguay was formed in conjunction with the United Nations Development Programme (UNDP) (Development Forum, 1978). It was envisaged that ten Tropicultors would be manufactured and tested in different parts of the country, with the technical support of Mouzon and finance from the French Govern-

Fig. 6-11: NIAE toolcarrier pulled by horses weeding tomatoes in Chile. (Based on photo: AFRC-Engineering archives).



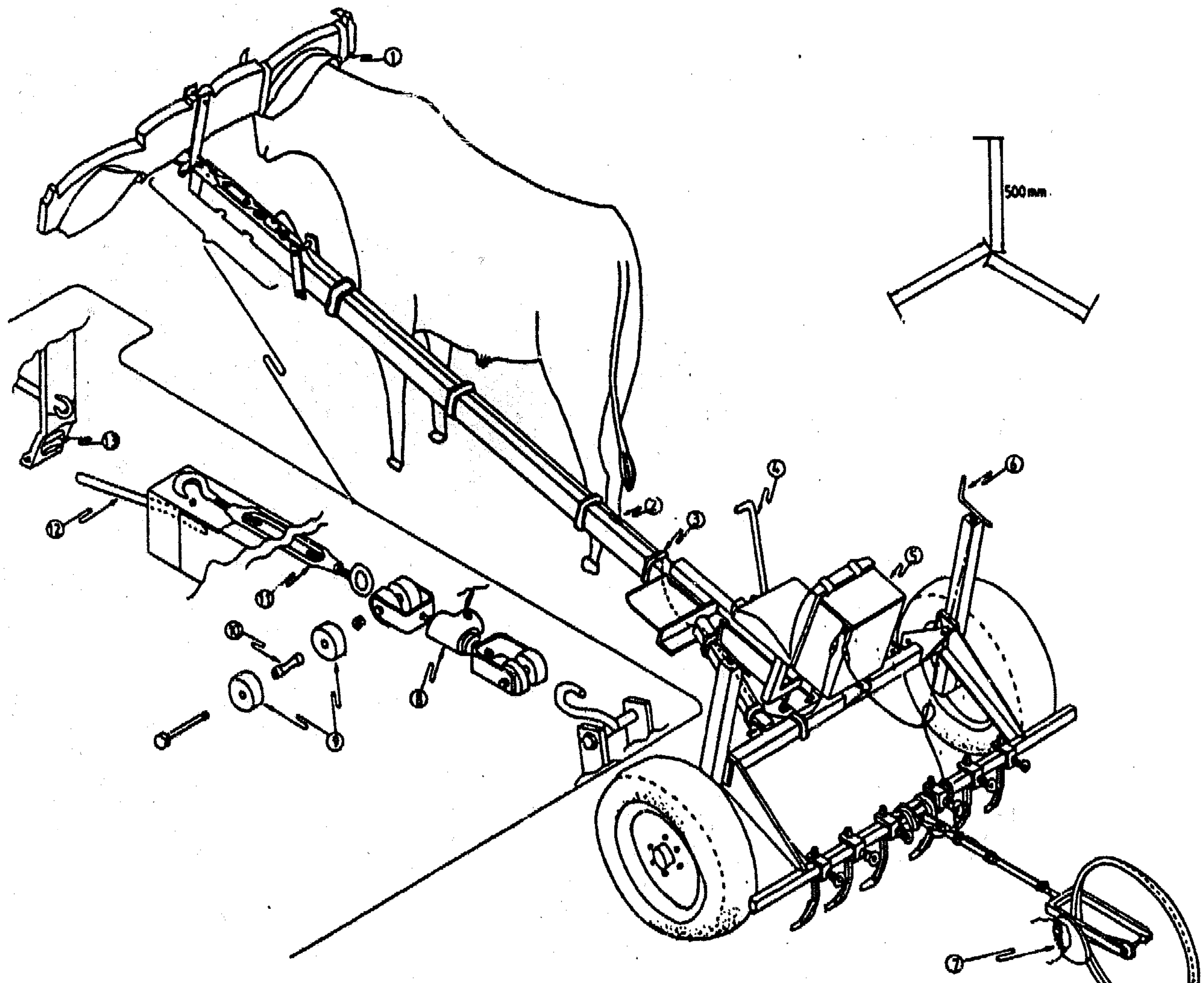


Fig. 6-13: GOM Toolcarrier (Nikart) adapted for research on draft power in Costa Rica (Drawing: Peter Lawrence).

ment. It was considered that the Tropicultor would be ideal for increasing cotton and other agricultural production in the east of the country, as well as for developing the western semi-arid plain, the Chacao (Development Forum, 1978). Details how this scheme developed appear difficult to come by, but there seems no indication that it was markedly successful.

A small number of Mouzon Tropicultors were tested in El Salvador between 1977 and 1980 (Mouzon, 1978). Jean Nolle also visited Argentina, Colombia, Ecuador, Guatemala, Panama, Peru and Venezuela.

Fig. 6-14: Mouzon Tropicultor seeding maize between ridges in El Salvador, 1980. (Photo: Mouzon).

Some NIAE-type wheeled toolcarriers were tested in Colombia and in Costa Rica during the 1970s, but this did not lead to any promotion. A small number of Nikart toolcarriers were imported into Costa Rica for on-station evaluation. One of these was adapted as a research implement for measuring the work output of draft animals during transport and cultivation operations (Lawrence and Pearson, 1985).

In 1984 the ICRISAT technical drawings of the Nikart were sent to Instituto Superior de Agricola in Santiago in the Dominican Republic and also to an individual in Bolivia, but by 1986 there had been no feedback from either country.

6.6 Conclusions based on Latin American experience

While the lessons from Africa and India appear clear, there is much less positive or negative evidence from Latin America. There have been small numbers of wheeled toolcarriers in several South and Central American countries for many years, but few projects have progressed beyond the on-station evaluation stage. This may itself be highly significant, but without major attempts at encouraging adoption there have been neither notable successes nor failures where it matters most – at farm level.

At present there seem to be two major promotional initiatives under way that may provide useful evidence – in Brazil and in Mexico. Both have been supported by external technical assistance and both have the somewhat dubious advantage of a relatively high profile of political support. In some respects the stage reached is similar to that of Gambia and Senegal in the 1960s, Botswana in the 1970s or India in the 1980s. In such cases a euphoric combination of encouraging on-station research, official support for the new technical "solution" and subsidized production, promotion and credit were leading to (temporary) farmer adoption. The question in Mexico and Brazil is whether the adoption curve will crash, as in Africa and India, or whether it will continue to rise in the ideal exponential curve, as has always been hoped for by toolcarrier protagonists.

Compared with Africa and Asia there are two factors that may favour adoption: high ratios of land to labour and large animals. Some people might suggest that the apparent great importance attached to a farmer's "image" should also assist adoption.

On the cautionary side it should be noted that both Mexican and Brazilian initiatives were beset by early problems in producing high quality implements at a reasonable price. In both countries some professionals actually involved in implementing the externally financed projects have expressed serious doubts about the economic viability and technical desirability of the wheeled toolcarrier programmes. In both Mexico and Brazil it has been demonstrated that all the operations performed by a toolcarrier can be performed easily, and more cheaply using simpler implements.

Time will tell, but while those strongly advocating the use of toolcarriers are now having to turn from Africa and Asia to Latin America in search of a possible practical use for their technology, the prospects are by no means full of promise. It is interesting to note that in both Mexico and Brazil the projects are spreading their risks (and those of the farmers) by promoting *ranges* of equipment that include simple toolbars. This seems a very sensible approach from all points of view. The farmers can opt for what they perceive as most appropriate (under much less pressure than when one technology is being heavily promoted) and the projects themselves may rightly be able to claim "success" even if the wheeled toolcarrier option is rejected by the farmers.

7. Observations on Wheeled Toolcarrier Programmes and Reports

7.1 Observations on technical designs

7.1.1 Specifications and compromise

Most of the forty-five designs listed in Table 7.1 have been proven capable of performing agricultural operations on research stations, and thus have been technically competent from the engineering point of view. Indeed it might be argued that one major problem with the majority of toolcarriers is that they were built on the basis of excellence of engineering rather than adaptability to the farming systems. Design considerations have been discussed by Kemp (1980), Bansal and Thierstein (1982) and Garg and Devnani (1983) and emphasis here will be placed on principles rather than specific comparisons. By way of example some of the specifications and prices of three toolcarriers made by one manufacturer are given in Tables 7.2 (p. 110) and 7.3 (p. 111). In Table 7.4 (p. 112) examples are given of the costs of toolcarriers from all current manufacturers who maintained export price lists in 1986/1987.

In general all aspects of wheeled toolcarrier design have to be based on compromises between the need for high versatility and the needs for low cost and simplicity. As a result no toolcarrier can ever be "perfect". The most successful model in recent years has been the Tropicultor and its derivatives. This is very strong and very versatile, but as a consequence it is often considered too heavy and too expensive. One good feature is its high clearance for inter-row cultivation, yet this is offset by a poor feature, for the Tropicultor's height means that the cart option can be unstable when laden, and liable to tip over in deep ruts. Towards the other extreme is the Agribar, which is much lighter and cheaper, yet these benefits have been achieved at a cost of reduced convenience of operation and fewer options.

Many toolcarriers (including early Polyculteurs and the Nikart) had a fixed wheel track. This reduced manufacturing expense and the number of adjustments necessary. However this also meant that plowing with a single mouldboard plow could be complicated for, if one ox walked in the furrow, the

Table 7.1: List of some toolcarrier designs and numbers manufactured

DATE[1]	NAME[2]	COUNTRY[3]	DERIVATION[4]	NUMBERS[5]
1955	Polyculteur (Léger)	Senegal	Jean Nolle	4 (m)
1956	Polyculteur (Lourd)	Senegal/France	Jean Nolle	300 (m)
1957	Polyculteur M–N	France	Jean Nolle	1 200 (m)
1960	NIAE ADT	U.K.	Original	30 (e)
1961	Tracteur Hippo	France	Jean Nolle	25 (m)
1962	Otto Frame	India	Original	100 (e)
1962	Nair Toolcarrier	India	Original	100 (e)
1962	Tropiculteur Mouzon	France	Jean Nolle	1 650 (m)
1962	AVTRAC	France	Tracteur Hippo	35 (m)

Table 7.1 continued

DATE[1]	NAME[2]	COUNTRY[3]	DERIVATION[4]	NUMBERS[5]
1963	TAMTU toolbar	Tanzania	NIAE ADT	<10 (e)
1963	Aplos	U.K.	NIAE ADT	600 (e)
1965	Baol polyculteur	Senegal	Polyculteur	800 (e)
1965	Uniwersalny Kinny	Poland	Original	100 (e)
1965	Xplos	U.K.	NIAE ADT	400 (e)
1967	Balwan toolcarrier	India	Original	50 (e)
1968	Kenmore	U.K.	NIAE ADT	300 (m)
1971	Makgonatsotlhe	Botswana	Original	125 (m)
1971	Versatool	Botswana	Prototype	15 (m)
1972	Makerere Toolbar	Uganda	Prototype	<10 (e)
1973	Tropic Polyculteur	Cameroon	Tropiculteur	50 (e)
1975	ICRISAT Tropicultor	India/France	Tropiculteur	1 400 (m)
1976	UEA Toolcarrier	U.K.	Versatool	<10 (m)
1978	Nolbar/Agribar	India/France	Jean Nolle	40 (m)
1978	Akola Cart TC	India	Prototype	<10 (m)
1978	Agricart	India	Tropicultor	70 (m)
1978	Tropisem	France	Original	50 (e)
1978	Paraguay Tropicultor	Paraguay	Tropicultor	30 (e)
1979	Nikart	India/U.K.	Original	200 (m)
1979	Multicultor CPATSA I	Brazil	Tropicultor	50 (e)
1979	Bultrac	India	Original	<10 (e)
1980	GOM Toolcarrier	U.K.	Nikart	120 (m)
1980	Malviya MFM	India	Original	50 (e)
1980	Udaipur toolcarrier	India	Prototype	<10 (e)
1980	Shivaji MFM	India	Original	50 (e)
1980	Akola toolcarrier	India	Prototype	<10 (e)
1980	TNAU toolcarrier	India	Prototype	<10 (e)
1980	Uyole toolcarrier	Tanzania	Prototype	<10 (m)
1980	Polynol	France	Tropicultor	30 (m)
1981	Sahall Lioness	U.K.	Original	150 (e)
1981	Multicultor CPATSA II	Brazil	Prototype	<10 (e)
1981	Mozambique Tropicultor	Mozambique	Tropicultor	50[6]
1981	Yunticultor	Mexico	Nikart	120 (m)
1982	Polycultor 1500	Brazil	Tropiculteur	1 100 (m)
1982	CIAE toolframe	India	Prototype	30 (m)
1982	WADA toolcarrier	Cameroon	Prototype	11 (m)
1984	ATSOU	France	Prototype	<10 (e)
1985	Yunticultor Mk II	Honduras	Yunticultor	<10 (m)
1986	Lanark/CECI	Canada	Prototype	<10 (m)
		TOTAL (*very* approximate)		10 000

1 Approximate date of first prototype.
2 Name commonly used to describe implement (some are trade names).
3 Principal country of development and/or manufacture.
4 Derivation of toolcarrier or source of inspiration (where known).
5 Although many are based on manufacturers' figures (m) some numbers on this table are only estimates (e) of numbers of wheeled toolcarriers made since the design was first developed. They serve only as a general guide and do not relate to numbers sold to farmers or used in the field.
6 Figure of Mozambique based on number that may have been manufactured; the materials and components for the fabrication of several hundred toolcarriers were purchased, but since by 1986/87 they still had not been used they are not included in this list.

Table 7.2: Comparative specifications of some wheeled toolcarriers

Specification	Tropicultor	Nikart	Agribar
Weight (kg)	200	170	135
Wheel type	Pneumatic	Pneumatic	Solid rubber
Wheel diameter (mm)	720	640	300
Wheel bearings	Ball bearing	Ball bearing	Mild steel bush
Transport capacity (kg)	1000	1000	Nil
Pitch adjustment	Gradual/screw	Steps/pin	Steps/pin
Depth adjustment	Steps/pins	Gradual/screw	Steps/bolts
Wheel track adjustment	Yes	No	Yes
Crop clearance	High	Low	Low
Average draft[1] (kN)			
Plowing (rainy season)	1.81	1.77	1.81
First weeding	1.13	0.98	1.13

[1] Draft-measurements taken on station at ICRISAT Centre, Patancheru, India, using similar implements on all three toolbars.

Sources: Mayande, Bansal and Sangle, 1985; ICRISAT, 1985; Mekins, undated.

plow body had to be very offset to the line of draft. On the Nikart this was partially overcome by giving the draw-pole, or "dissel boom", a second offset position. Some workers have said that this has compromised convenience in favour of improvements in draft alignment, although the designers have argued that there is no loss of convenience in

Fig. 7-1: The lever for raising and lowering an implement on a GOM Toolcarrier (Nikart); this is easy to use from the operator's seat. (Photo: FMDU, Botswana).

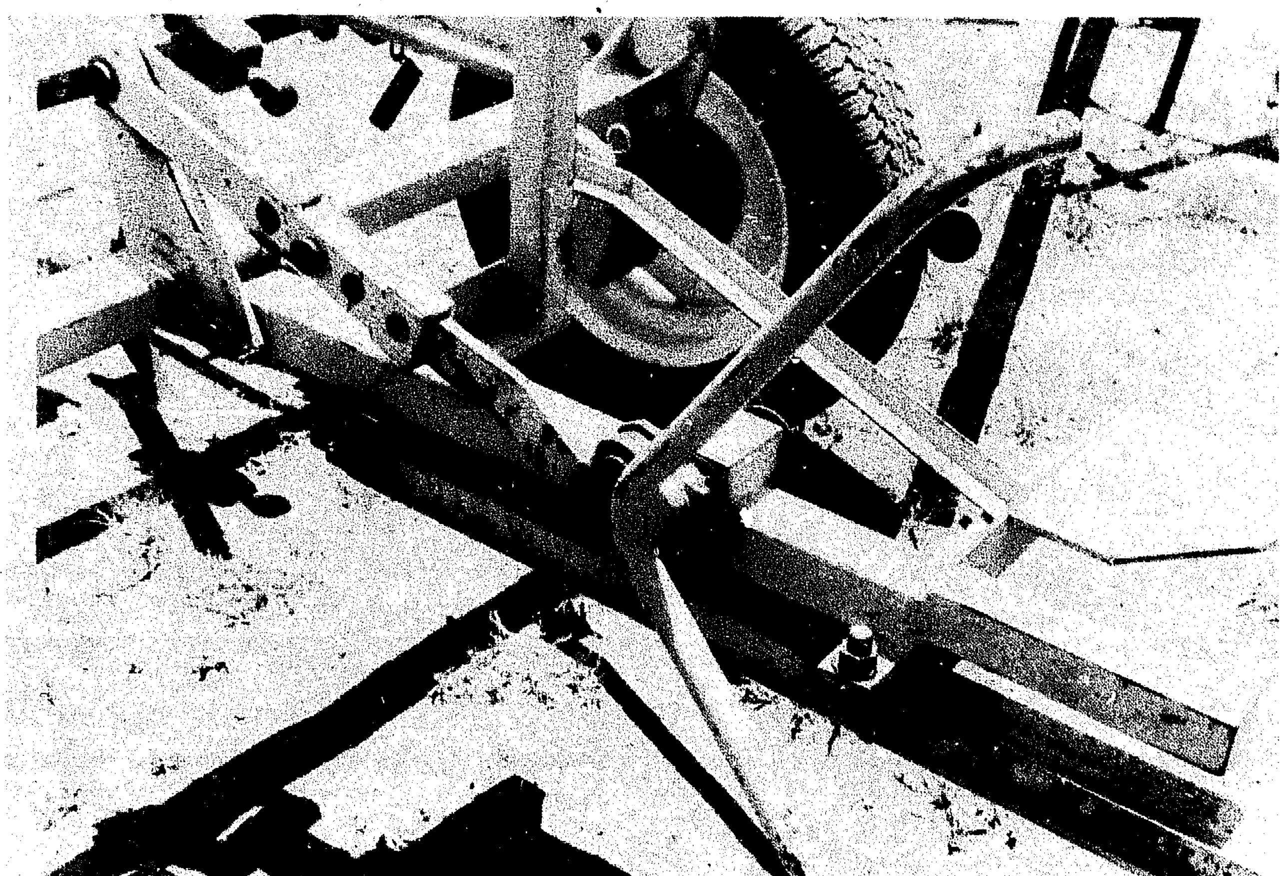


Table 7.3: Sample prices of three toolcarriers from one manufacturer[1]

Equipment	Tropicultor US $	Nikart US $	Agribar US-$
Basic chassis	600	550	200
Cart frame (without wood)	100	100	n/a
Plows (one left-hand, one RH)	52	52	52
Ridgers (two)	46	46	46
Clamps (ten) and toolkit	50	50	50
Tines (five spring, five rigid)	60	60	60
Wide blade harrow (120 cm)	30	30	30
Inter-row weeding blades (five)	56	56	56
Steerable toolbar	40	40	40
Angle blade scraper	75	75	75
Peg tooth harrow	50	50	50
Disc harrow	100	100	n/a
Planter/fertilizer applicator[2]	615	450	125
Basic ex-works price	1874	1659	784
F.O.B. charges[3]	200	200	200
C.I.F. charges[4] to seaport	580	580	290
Total cost (African) seaport	2654	2439	1274

1 Figures are based on December 1986 export prices of Mekins Agro Products of Hyderabad, India. These figures are intended only as a general guide and interested customers should contact this firm and/or other firms for current prices and specifications (see Table 7.4).

2 For the Nikart the planter/fertilizer applicator is a (complicated) attachment to the toolcarrier chassis. For the Tropicultor it is actually a single purpose implement with its own transport wheels derived from the Nikart planter/applicator. For the Agribar it is a very simple unit in which seeds are fed into the tubes by hand.

3 Standard charges for packing and local transport to docks at Bombay or Madras. (Domestic orders are liable for lower standard charges which cover local taxes, surcharges and local delivery).

4 Carriage, insurance and freight to overseas port. Based on charges of US $ 2900 per container from Bombay to a West African port (charges elsewhere in the world may be similar). Standard packing is five units per container for Nikart and Tropicultor (with seeders) or ten Agribar units. Orders over fifty units would be completely knocked down and reassembled locally, with economies of scale in freight charges.

Sources: Agarwal, personal communication, 1986.

this case. Fixed wheel spacing made the inter-row cultivation of crops with different row spacings inconvenient or impossible.

Some toolcarriers (such as the Tropicultor) have had a high, arched chassis, while others (such as the Nikart) have had a low, straight chassis. A low chassis and low centre of gravity gave good stability but late weeding of crops and ridge cultivation were made difficult by the relatively low ground clearance.

Toolcarriers have to be sufficiently strong to stand up to quite severe shock-loads (for example a cultivating implement hitting a root) and may also (depending on specifica-

Table 7.4: Sample prices of toolcarriers from different manufacturers[1]

Toolcarrier	Basic chassis US $	Chassis with basic implements US $	Chassis, implements and seeder US $
SISMAR Polyculteur[2]	n/a	1500	2000
GOM Toolcarrier[3]	n/a	1250	2000
Mekins Nikart[4]	550	950	1400
Mouzon Tropicultor[5]	950	1450	2250
Mekins Tropicultor[4]	600	1000	1600
CEMAG Policultor 1500[6]	800	1250	1650
Mouzon Polynol[5]	1000	1500	2300

1 These figures are based on details supplied by the various manufacturers during the period December 1986 and April 1987. Each manufacturer has different pricing policies and the figures are not directly comparable between manufacturers. In addition to these prices local taxes of up to 19% may be payable in some cases, and the cost of packing a crate or container and transporting to a port may add over $ 250 per toolcarrier. Shipping costs will vary but can be in the order of $ 300–500 per toolcarrier. These figures are intended only as a general guide and interested customers should contact the various firms for current prices, specifications and conditions.

Addresses:

CEMAG – Ceara Maquinas Agricolas S/A
Av. Gaudioso de Carvalho, 217 – Bairro Jardim Iracema,
C.P. D 79 CEP 60000, Fortaleza, CE, Brazil.
Telex: (085) 1533 CMGL BR Tel.: (085) 228 2377

Geest Overseas Mechanisation Ltd. (GOM)
White House Chambers, Spalding, Lincs. PE11 2AL, U.K.
Telex: 32494 GSTGOM Tel.: (0775) 61111

Mekins Agro Products Pvt Ltd.
6-3-866/A Begumpet, Greenlands,
Hyderabad AP 500 016, India.
Telex: 155-6372 Cable: MEKINS Tel.: 227 198

SISMAR (Société Industrielle Sahélienne de Mécaniques, des Matériels Agricoles et de Représentations), B.P. 3214, Dakar, Senegal.
Telex: 7781 SISMAR SG Tel.: 51.10.96 (Pout), 21.24.30 (Dakar)

Société Nouvelle Mouzon
B.P. 26, 60250 Mouy (Oise), France.
Telex: 150990 F Tel.: 44.56.56.18

2 Figures based on ex works (Pout, Senegal) quotation of April 1987 for chassis with plow, ridger, groundnut lifter, steerable weeding tines, and cart body. Seeder comprises three units.

3 Figures are for crated toolcarriers FOB U.K. seaport and are based on April 1987 quotation for GOM Toolcarrier (Nikart-type) set including ridger, plow, weeding tines and cart body. Seeder comprises three independent precision units (add $ 600 extra for three fertilizer units).

4 Figures based on December 1986 ex-works (Hyderabad, India) export prices. For the Nikart the planter/fertilizer applicator is an attachment to the toolcarrier chassis. For the Tropicultor it is a single purpose implement with its own transport wheels derived from the Nikart planter/applicator.

5 Figures based on March 1987 prices at the workshop in France and do not include packing costs nor local taxes. The equipment package here comprises steerable weeder, plow, ridger and cart body. Seeder comprises three independent units.

6 Figures based on April 1987 ex-works prices at Taboao da Serra, Brazil. The equipment package includes steerable weeder, plow, ridger and cart body. Seeder is based on three independent planter units.

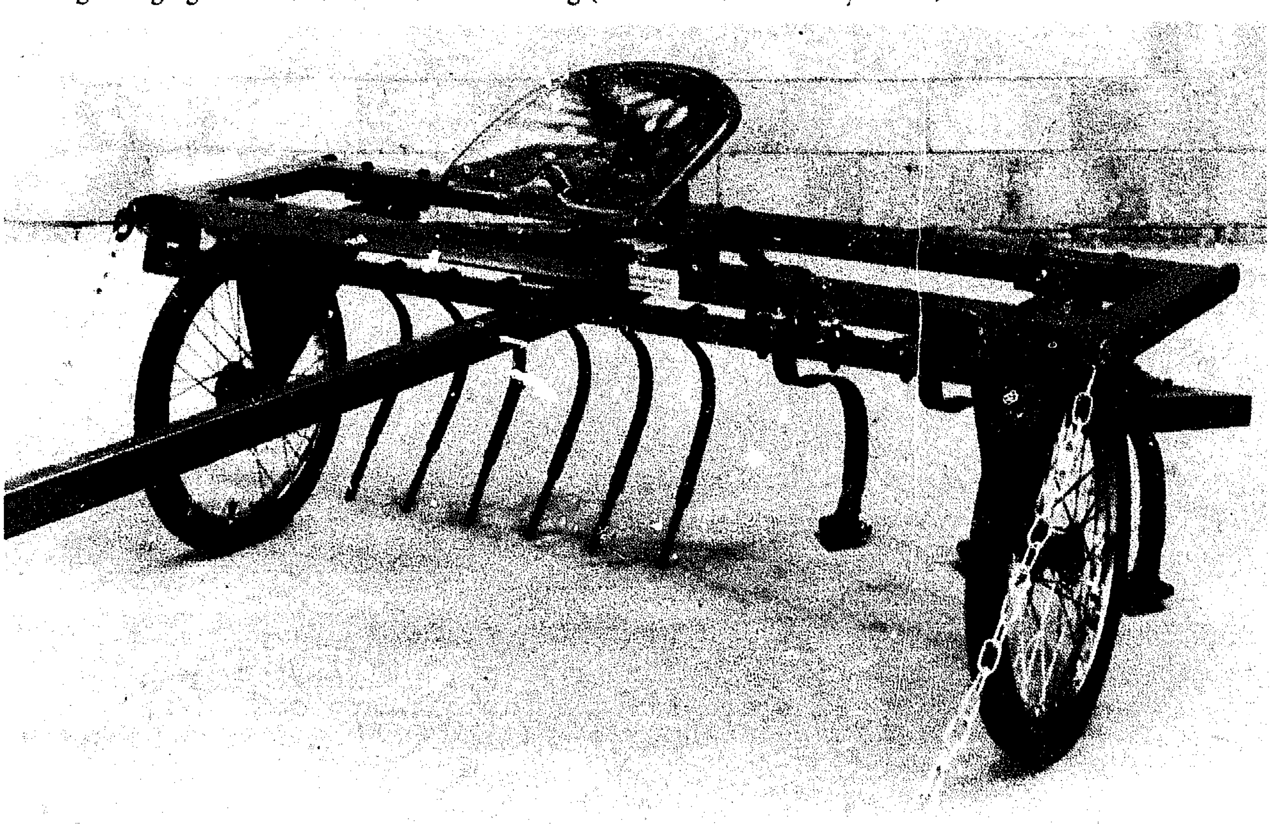
Sources: CEMAG, GOM, Mekins, Mouzon, SISMAR; personal communications, 1986/87

Fig. 7-2: The lever for raising and lowering an implement on a Tropicultor; this is well balanced but is easily operated from the driver's seat. (Photo: FMDU, Botswana).

tion) have to be able to carry the weight of driver and payload. Yet strength implies expense in steel or bracing structures and also weight, and one of the most common criticisms voiced by farmers is that toolcarriers have been "too heavy".

Ease of adjustment is most important, for it has been noted time and time again that if an adjustment is difficult, farmers often will not bother with it. They may complain about the implement and even abandon it completely rather than struggle with an inconvenient procedure. On several toolcarrier prototypes, and even production models, there have been adjustments requiring two spanners and two or even three pairs of hands to release a fitting, support the implement, move and retighten. For example, the Sahall Lioness 3000 cultivating tines were attached to the toolbar by twelve nuts and twelve bolts. In such circumstances it is perhaps not surprising that farmers have tended to leave their implements at one setting. Re-

Fig. 7-3: Sahall Lioness 3000 toolcarrier. Each tine is fixed to the toolbar with one or two nuts and bolts, making changing between modes time-consuming (Photo: Sahall Soil and Water).



ports on disappointing toolcarrier adoption that have blamed "inadequate farmer training" have often been referring to implements of great inconvenience rather than great complexity.

Almost all wheeled toolcarriers have had pneumatic tyres, and attempts to save money through use of second-hand tyres have been short-lived. Punctures have been frequently cited as being a major problem. Steel wheels have been used on Tropisem prototypes and are a current option on the CEMAG Policultor (Tropicultor-type) in Brazil. Solid rubber tyres have been fitted to Sahall Lioness toolcarriers and Agribars, but farmer reaction has yet to be gauged. Again it is a question of compromise; simple steel transport wheels are likely to be cheaper and less of a problem than pneumatic tyres but are less effective for road transport.

Ease of raising and lowering implements at the end of rows or for transport to the field is important for overall convenience but by itself is unlikely to be a principal reason for the acceptance or rejection of a design. Accurate depth control is particularly important for seeding and weeding operations and a mechanism that allows on-the-move adjustment (as the Nikart) provides great precison. However such accuracy is not needed in the plowing and transport modes. It can be argued that it is unrealistic to combine on the same implement the precision required for seeding and weeding with the ruggedness and strength required for plowing and transport.

7.1.2 Desirable specifications

From this brief discussion it is clear that it will be impossible to draw conclusions as to ideal toolcarrier specifications, for these will depend on those specific compromises that are most appropriate to the farming systems in which they are to be used. For example, the relative profitability of the crops and the costs and availability of labour will determine how important toolcarrier price may be. Social considerations will decide whether the provision of a seat is essential. Thus, while each case will be site-specific, perhaps the relative advantages of the different features may be considered here to assist in decision-making. (In doing so it must be remembered that in practice a farming systems approach is being advocated in which individuals or multidisciplinary teams work with the farmers themselves to determine the optimum equipment specification.)

It has been almost universally observed that farmers have not changed between transport and cultivation modes, and so if one is designing an agricultural implement transport characteristics should not strongly influence design. (This assumes, of course, that a defeatist position is not being adopted as most toolcarriers have actually ended up as simple carts!) Nevertheless it may be noted that the simple platform built into the Tropicultor chassis (not the cart body attachment) has been considered useful for minor transport operations.

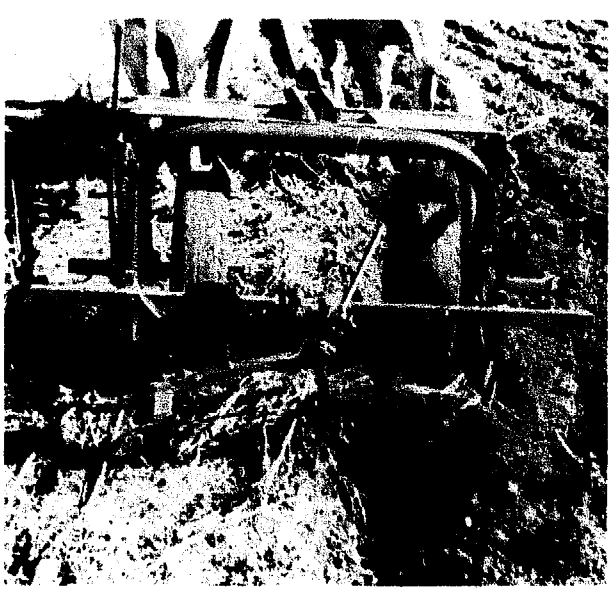
Conventional mouldboard plowing is one of the operations in which toolcarriers cannot be expected to excel, for the wheels and chassis tend to mean the plow body is offset to the draft forces (even with a Tropicultor that has the wheel position changed) and as the wheels rise and fall over uneven surfaces the depth of work varies in no relation to the immediate soil characteristics or the animals' behaviour. By comparison a simple mouldboard plow can line up well with the draft forces and the operator can regulate depth constantly (in response to the animals or soil conditions) by simple hand pressure.

High strength in a toolcarrier is mainly required for plowing and transport, yet, as noted above, these are two operations in which toolcarriers do not have particular

Fig. 7-4: A GOM Toolcarrier (Nikart) plowing; to improve alignment with the fixed wheeltrack the beam is offset and a cranked plow used. (Photo: FMDU, Botswana).

comparative advantage over conventional implements. This might suggest that less strong, lower weight (cheaper) implements designed mainly for planting and weeding would be more suitable.

Fig. 7-5: A Tropicultor plowing; to improve alignment with a variable wheeltrack the wheels are inset. (Photo: FMDU, Botswana).

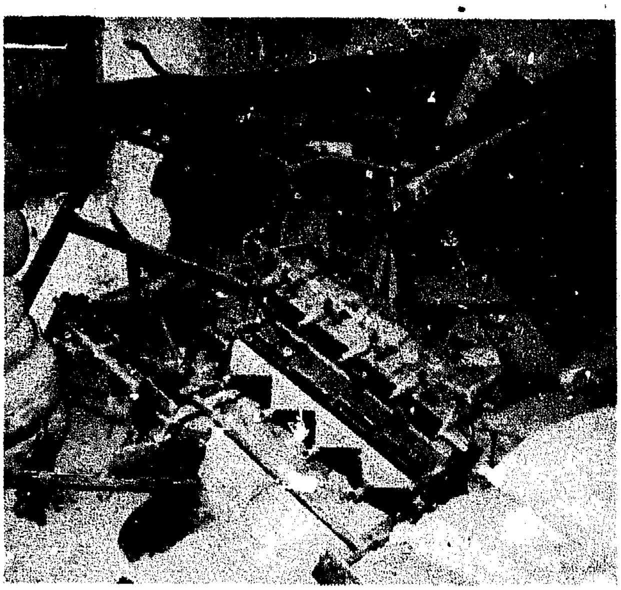


Multi-row weeding is fraught with problems if the rows are not completely parallel, and there are sad stories of farmers unintentionally ripping up some of their crops with a wheeled toolcarrier that cannot be as rapidly lifted or steered as single row cultivators. Thus multi-row weeding requires very accurate multi-row seeding. For such seeding wheeled toolcarriers do have some advantages (but also some disadvantages, for in traditional fields with stones or clods a wheel rising over an obstruction can disrupt seed flow). However, precision seeders, such as those designed for the Nikart, are relatively inconvenient and complicated to set up, and there is thus a very strong temptation either not to use them or to leave them permanently in position. (It should be mentioned that the Nikart designers claim that the seeder is *not* inconvenient to set up, as the seeder frame is held by a single clamp, and once this is secured, all that remains is to loop a chain round a sprocket and clamp the coulters. Nevertheless, despite elegant design features, when a relatively heavy and complicated seeder body has been for some months in a farmer's crowded storeroom, the energy required to overcome inertia in order to remount and reset it is considerable.)

ICRISAT was aware of the problems of using seeders on wheeled toolcarriers and saw a need for a single purpose seeder, initially intended for use in conjunction with the Tropicultor. It has therefore recently developed the planter-cum-fertilizer applicator that had originally been designed for use on the Nikart into a single purpose implement. Thus in India the seeder in the full Tropicultor package is now actually a separate single purpose implement. (Although this is an important change in direction, it is somewhat academic as Tropicultor sales have virtually ceased.)

From these various observations on toolcarrier specifications, there seem to be strong and logical reasons for minimizing the importance of transport, plowing and seeding functions, and concentrating on the tine-cultivation operations. It might even be worthwhile to study the characteristics of many well-proven wheeled cultivators developed in Europe and North America in the late nineteenth and early twentieth century. Nevertheless, while such implements may be effective for tine cultivation, their use for multi-row weeding would be dependent on accurate row planting. If accurate row planting is not performed, it is likely that simple weeding implements such as the Houe Sine of Senegal, the Triangle of Burkina Faso, or the traditional narrow blade harrow from India may be more accurate, efficient and much cheaper.

Fig. 7-6: A Nikart seeder in village storeroom in India, illustrating the inertia to be overcome before setting it up again. (Photo: P.H. Starkey).



Thus there are quite strong arguments to the effect that the optimal toolcarrier is actually just a tine cultivator, used in conjunction with a single purpose plow, seeder and a cart. In most countries where toolcarriers have been provided, farmers have simply used them as carts and bought other simpler equipment (one exception appears to be Senegal where quite a number were used as single purpose multi-row seeders). Thus, if one can consider farmer reaction to past schemes as an indication of market demand, one would have to conclude that farmers want simple implements and carts.

One final important specification related to both cost and reliability is the ease of manufacture. During recent correspondence, many sources have cited problems relating to quality control. In particular, although the Nikart was designed for ease of local manufacture, the final output of all manufacturers, whether from India, Mexico or the U.K., has been criticized on grounds of manufacturing quality. As few manufacturers have made more than one type of toolcarrier at a time, it is difficult to distinguish the effects attributable to the workshop from any due to the design. Correspondents have not identified such widespread problems with the manufacture of Tropicultors and derivatives, and this may be attributable to its very much longer history of development and manufacture.

No wheeled toolcarrier can be said to have been proven by farmer purchases. The high cost, high quality Tropicultor (and derivatives) is the present world market leader, but this is largely a function of aid donor choice rather than end-user market forces. The low cost toolcarriers without transport options such as the Agribar or the CIAE toolcarrier have never been promoted or widely tested by farmers. Thus there is very little evidence of consumer preference between toolcarriers as very few farmers have ever had a choice of designs. In one of the few cases where a choice was available, farmers in India opted for Tropicultors in favour of Nikarts, but finally returned to traditional implements!

7.2 Observations on private sector involvement

Jean Nolle (1985) suggested that the lack of adoption of multipurpose implements was not caused by the small farmers rejecting the technology, but was because producers were refusing to make and sell such implements. He suggested that producers have had no incentive to make multipurpose implements for they have been able to make more money selling a larger number of single purpose implements. He also suggested that the lack of success of his Hippomobile in France was related to a boycott by dealers. It therefore seems useful briefly to review the involvement of the private sector in different regions.

In France the Mouzon company started manufacturing Nolle's Polyculteurs in the late 1950s and has continued (with various company restructuring) to manufacture and market Nolle's designs until the present time. In the past thirty years Mouzon has sold 3000 wheeled toolcarriers, 12000 intermediate toolframes (Arianas) and 53000 simple toolbars (Houe Sine). Other French firms, including Bélin International marketed Nolle's toolcarriers for a time but pulled out of the market in the early 1980s when sales proved inadequate.

In the U.K. the NIAE toolcarrier was manufactured mainly by John Derbyshire and by Kenmore Engineering, both of which adapted the design slightly and attempted to identify local agents to market their products in several countries. Both firms were disappointed with their achieved sales (totalling 1400 units) and eventually abandoned manufacturing such products. More recently Geest Overseas Mechanisation manufactured about 120 GOM Toolcarriers (similar to the Nikart). Geest subsequently sold its U.K. manufacturing subsidiary but continued to meet specific orders at a rate of about thirty per year by subcontracting the work. In 1986 Geest saw little market potential for the GOM Toolcarrier, mainly because it was prohibitively expensive for peasant farmers. As a result Geest did not actively market its toolcarriers or maintain stocks of implements or spare parts, but it did continue to meet specific orders in the interests of good public relations (GOM, 1986). The firm of Sahall designed its own toolcarrier in the early 1980s. It gained one large contract for Mozambique and then undertook some exploratory sales missions to Malawi, Kenya and Ethiopia but follow-up sales were not sufficient and in 1985 the firm went out of business.

In Senegal the SISCOMA factory manufactured and marketed wheeled toolcarriers from the 1960s until it ceased business in the early 1980s. Its successor at the premises, SISMAR, initially maintained wheeled toolcarriers as part of its standard range but due to lack of market demand subsequently made these implements only to order. During the period 1983–1986, sales averaged less than ten per year. In Cameroon the Tropic factory started to make and sell wheeled

Fig. 7-7: Publicity brochure for Policultor-1500 toolcarrier. (CEMAG, undated).

toolcarriers in the 1970s but ceased these lines due to lack of sales. In Botswana the Mochudi Farmers Brigade was assisted with aid funds to start production of the Makgonatsotlhe and for eight years attempted to market it. Sales were disappointing and the debts incurred through the toolcarrier programme made it difficult for the Brigade to change to new products.

In India the large manufacturer Voltas attempted to market its Universal Otto Frame in the 1960s and Escorts tried to sell its Balwan toolcarrier. These and other entrepreneurial initiatives appear to have failed through lack of market demand rather than lack of promotion. Following the ICRISAT work on toolcarriers, in the early 1980s several workshops were assisted to start to fabricate wheeled toolcarriers based on Tropicultor or Nikart designs. At least eight firms attempted to market them, but by 1985 there was only a single manufacturer left. This one producer admitted the only real market outlet within India was the rapidly dwindling number of government promotion schemes and so the Director had undertaken sales missions to Africa, North America and Europe to try to obtain orders for donor-assisted aid projects elsewhere in the world.

In Brazil several small workshops were encouraged by the work of CPATSA and reports of the ICRISAT successes to start making wheeled toolcarriers, but most ceased within one year. The one major producer still making toolcarriers in Brazil is actively marketing its Policultor range, but sales are not increasing. Elsewhere in Latin America, there have been several schemes to establish wheeled toolcarrier production, but for a variety of reasons (some unconnected with the toolcarriers) most have been of limited duration.

Thus the private sector has been involved in wheeled toolcarrier fabrication for many years. Some firms have had complementary ranges of single purpose implements while others have only manufactured multipurpose implements. While some companies have ceased manufacturing or trading altogether this cannot be directly blamed on toolcarrier manufacture. In the 1960s firms tried to use private trading companies to market their products, but this did not work as there was no sustained demand from the farmers themselves. By the 1980s the public and aid sector dominated the distribution of agricultural implements in many Third World countries, and this had distorted commercial trading patterns. This distortion, combined with the inability of small farmers to afford wheeled toolcarriers, meant that few companies in the world regarded it as commercially viable to target their manufacturing or marketing towards the end-users. Thus most wheeled toolcarrier-manufacturers that continued in production did so by concentrating on large contracts from governments, aid agencies and development projects.

In 1987 Intermediate Technology Publications released the booklet *Multi-purpose Toolbars* (ITP, 1987). This derived from the more general publication *Tools for Agriculture* and attempted to be a brief illustrated catalogue of toolbars and their possible suppliers worldwide. It listed the names and addresses of nineteen manufacturers of wheeled toolcarriers: eight in India, six in Latin America, four in Europe, and one in Africa. The information for these entries had been collected in good faith from the manufacturers during the early 1980s, but by the date of the publication of this booklet thirteen of the nineteen firms listed were no longer actually manufacturing wheeled toolcarriers. Thirteen manufacturers of Nikart-type toolcarriers were listed, while in practice in early 1987 there was only one workshop (in Mexico) producing this design on a regular basis. One other workshop in India was still actively trying to market this product, and one British manufacturer made small numbers occasionally in response to specific orders. All the other manufacturers listed had ceased active involvement or interest in such equipment, although some would have still been prepared to quote for large orders. The IT Publication booklet also listed eight manufacturers of Tropicultor-type wheeled toolcarriers, of which only three were still actively involved in manufacturing these implements in 1987. Some other designs listed such as the Sahall and the CPATSA toolcarriers had been completely abandoned. The information on which the publication had been based had been correct when it had been obtained. This illustrates the rapid loss of interest of the private sector as the lack of any real market for these products became clear.

In Tables 7.3 and 7.4 (p. 111/112) sample prices are given for the basic toolcarrier packages offered by those manufacturers that were actively involved in wheeled toolcarrier production and export in 1986/87.

There seems to be little or no evidence to support Nolle's suggestion that farmers have been deprived of multipurpose implements due to the vested interests of manufacturers. On the contrary the evidence suggests that many manufacturers and distributors would have benefited from developing markets for their products and actively tried to do so. They have on many occasions tried to market wheeled toolcarriers directly, but lack of sales has suggested that there was no genuine market demand from the end-user. As a result some have abandoned their investments in wheeled toolcarriers, while others have concentrated on the irregular but potentially lucrative market for aid donor and development project contracts.

7.3 Observations on terminology

The author has held discussions relating to toolcarriers with a very wide range of research and development workers of many institutions in developed and developing countries. From these it is apparent that the vast majority have understood (incorrectly) that wheeled toolcarriers had been highly successful in some parts of the world. While much of this is due to the optimism of reporting, there has also been considerable misunderstanding relating to terminology, particularly the definition of simple toolbars and more complicated wheeled toolcarriers.

In order to distinguish clearly between different types of multipurpose ("polyvalent") implements, CEEMAT proposed a standardization on the term "multiculteur" for a simple toolbar pulled by a chain and "polyculteur" for wheeled toolcarriers that could be used as carts (CEEMAT, 1971). Unfortunately, in the influential English edition of this major work, this important point of definition was missed out, and neither the French words nor English alternatives were specifically proposed (FAO/CEEMAT, 1972). Nevertheless in this work and the book of Munzinger (1982) the words *polycultivator* and *multicultivator* were often used as the English equivalents of the French definitions. The present author would have liked to have recommended the continued use of these words in the English language, perhaps simplified to *polycultor* and *multicultor*. However the term *wheeled toolcarrier* has already become commonly used and understood, while the distinction between polycultor and multicultor is becoming less clear as some manufacturers have used *polyculteur* (or similar word) to describe simple toolbars (Tropic in Cameroon; CEMAG in Brazil).

There has been a general (but by no means universal) tendency for English-language writers to use the term *toolbar* for the simple multiculteur implements and the word *toolcarrier* for polyculteurs. For this reason the author has proposed standardization on *simple toolbar, intermediate toolframe* and *wheeled toolcarrier.* This series of definitions is not ideal, being verbose and with the use of the "value" terms *simple* and *intermediate*. However standard terms that convey the required concepts are urgently required, and these definitions each with their descriptive adjective should not create further confusion.

However for the past twenty years there have been no standard definitions and thus in the otherwise useful review by Bansal and Thierstein (1982) entitled "Animal-drawn multi-purpose tool carriers" the words toolcarrier, toolbar and toolframes were considered synonymous, and simple multiculteur toolbars such as the Houe Sine of Senegal were described as toolcarriers. Without precise words to distinguish simple toolbars and wheeled toolcarriers, there has been a tendency in English publications to confuse the technologies. Translation of the terms multiculteur and polyculteur has been clearly difficult, particularly as some authors using the English language have been unaware that in French "multiculteur" has been clearly defined as a simple toolbar.

One important example of confusion started as a minor inaccuracy in a translation of a paper by Le Moigne, published in the proceedings of the ICRISAT seminar on socio-economic constraints to development (ICRISAT, 1980). At the end of the proceedings the original French version of the paper is given and in this Le Moigne clearly differentiated between the simple toolbars as "multiculteurs" and the wheeled toolcarriers as "polyculteurs" (Le Moigne, 1980a). Le Moigne also clearly stated that the various designs of wheeled toolcarriers (polyculteurs) including the Nolle Polyculteur, the Tropiculteur, and the Bambey "polyculteur à grand rendement" were *not* well known and had *not* been widely adopted in West Africa. For this reason, he explained he had not included their insignificant numbers in his otherwise comprehensive tables of animal traction equipment in use in various West African countries. However in the English version of Le Moigne's paper, which was given prominence in the proceedings, both "multiculteur" and "polyculteur" were translated as "tool carrier" (Le Moigne, 1980b). Thus in the English version of the table of animal-drawn equipment in West Africa one category of equipment is labelled "Toolcarriers". Although this heading was annotated with the word "multiculteurs" in parentheses, the use of the word toolcarrier has apparently given the false impression to some English-language readers that thousands of *wheeled toolcarriers* were in use in the various West African countries, when the original table referred to the "Houe Sine" type of simple toolbar.

The potential for confusion was compounded in two more widely circulated publications of the Intermediate Technology Development Group, in which Gibbon (1985; 1987) reprinted the English translation of the table of Le Moigne. In these publications Le Moigne's table is preceded by two others specifically related to wheeled toolcarriers and also by two illustrations of wheeled toolcarriers. Thus readers without detailed knowledge of West Africa and French definitions would almost inevitably be given the impression that the thousands of "toolcarriers" in use in West Africa were wheeled toolcarriers. Indeed this had been the understanding of several British development workers including some members of staff of ITDG, NIAE, ODA and UEA.

A similar example of imprecise terminology and potential for misunderstanding is seen in the book of Ahmed and Kinsey (1984) in which Le Moigne's ICRISAT paper (English version) is also cited. These editors concluded that "toolbars" (in this context they were referring to wheeled toolcarriers as promoted in Uganda) had not been successful anywhere in East and Central Africa. However, the authors continued, such implements were widely used in West Africa (Ahmed and Kinsey, 1984).

As a result of lack of clear definitions in the English language, there is still much misunderstanding in the interpretation of the literature in this field. It is therefore necessary for authors to define clearly their terms and for readers to take particular care to ensure they understand precisely to what technology reports refer.

7.4 Observations on the literature relating to wheeled toolcarriers

7.4.1 Optimism

One characteristic of all the wheeled toolcarrier programmes reviewed has been the optimism regarding the technical competence of the implements, the economics of equipment use and the advantages of newly devised farming systems. With the rather unfair advantage of hindsight it is now clear that much of this optimism was unrealistic, although at the time it may have seemed justified. To quote specific publications here might imply an unacceptable degree of selectivity since there have also been some more moderate statements. However the object of this discussion is to learn from the past and a few specific examples appear necessary to justify some of the conclusions. It must be stressed that the following examples are not cited for the sake of ridicule (for the authors were generally making some very valid points), but merely to illustrate how the very strong *impression* of success has developed.

In descriptions of equipment the word "perfected" has been used in connection with

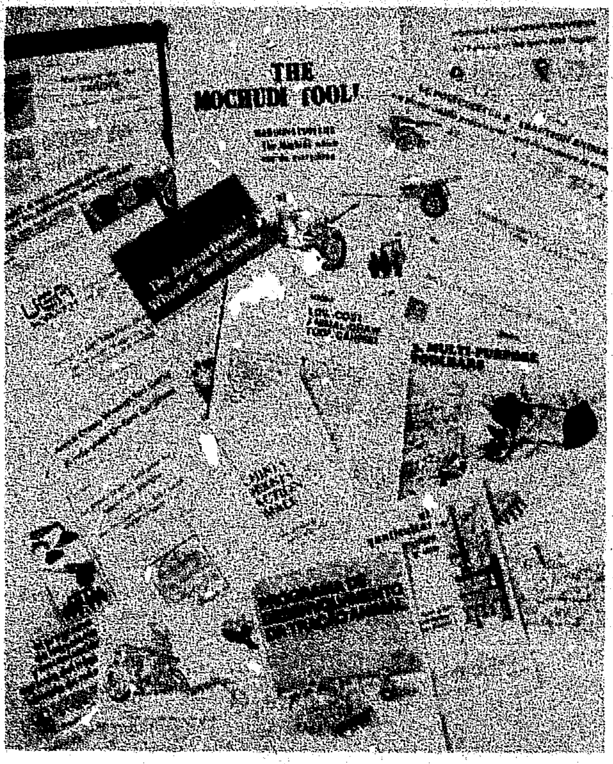


Fig. 7-8: Some optimistic publications. (Photo: P.H. Starkey).

the Mochudi (Makgonatsotlhe) toolcarrier in Botswana (Eshleman, 1975) and the Yunticultor in Mexico (Olmstead et al., 1986). Many claims have been made for the various farming systems packages developed on station around wheeled toolcarriers. These range from relatively modest claims that by using the Mochudi toolcarrier and tine cultivation system in Botswana erosion would be reduced and weeds would be better controlled (Eshleman, 1975) to the great aspirations for the ICRISAT toolcarrier systems. These latter are illustrated by Brumby and Singh (1981) who concluded: "The total yield potential this [wheeled toolcarrier] equipment package promises is so large and so important to India's foodgrain output that a major effort to propagate its use is warranted."

While it has been the agricultural engineers who have developed technically efficient implements and agronomists who have been largely responsible for the associated cropping systems, it has been the economists who have justified their use, with optimistic models and assumptions. Early economic models developed at Bambey Research Station in Senegal illustrated how the wheeled toolcarriers would allow cultivated surfaces to double, relative to alternative equipment, while at the same time allowing returns to both area and labour to increase (Monnier, 1967 and 1971). Hunt (1975) based her economic costings of toolcarriers in Uganda on a low hourly rate derived from the very optimistic assumption that Tropiculteurs would work 1600 hours a year (say 320 five-hour days). Binswanger et al. (1980) developed economic costings for wheeled toolcarrier use in which the practicalities of ownership on small farmers were elegantly avoided by suggesting hypothetical hire costs that an optimizing entrepreneur might charge. ICRISAT economists used such assumptions for several years and claimed that wheeled toolcarriers could be paid for from the additional profits of the new farming system in just one year, if used on at least four hectares (Ryan and Sarin, 1981; Ghodake, 1985). While few reports have given details of prices, some authors, having described the large number of operations a wheeled toolcarrier can perform, go on to cite the price of a toolcarrier chassis and wheels, but without cart or implements (Bansal et al., 1986). This naturally gives a very favourable impression because even the basic implement set (without seeder) generally doubles the price of the toolcarrier.

Optimistic forecasts have been made of toolcarrier production. For example, referring to the project to transfer the Nikart design to accurate production in Indian workshops using jigs and fixtures, Kemp (1983) stated, "This exercise has been eminently successful. Of the two organizations assisted, one had produced and sold over 200 Nikarts by early 1983." The figure of 200 had apparently been quoted by the manufacturer in question. In fact total production of Nikarts in India at that time was still below 100

(Fieldson, 1984) and even by 1986 total sales of Nikarts from all Indian manufacturers had not reached 200.

ICRISAT reports have generally maintained a high degree of optimism and several of the more noteworthy ones were cited in Chapter 3. To take a seemingly innocuous example, the publication *ICRISAT in Africa* simply stated, "The ten toolcarriers used in the Mali research program have been so successful that the possibility of having them fabricated locally is under investigation." (ICRISAT, 1986). The *impression* given by such a factual statement was clearly one of considerable potential, which was unrealistc since both ICRISAT staff in Mali and the Malian authorities seriously doubted the applicability of wheeled toolcarriers off the research station.

7.4.2 Failure to follow optimistic reports

There have been very few attempts to update reports of experience after the initial optimistic results. As a result the only records available for a conventional literature review are the reports of successes. For example early work in East Africa was reported in the East Africa Agricultural and Forestry Journal and the Journal of Agricultural Engineering Research. Early work in Botswana was reported in World Crops. Early work on the Nikart was reported in *Appropriate Technology*, *Ceres* and *Machinisme Agricole Tropical.* Encouraging work in India has been published in *Agricultural Mechanization in Asia, Africa and Latin America.* The author is unaware of anyone who has written optimistically about

Fig. 7-9: UEA toolcarrier, based on the Versatool of Botswana and the Atulba of Sudan, at University of East Anglia, England, 1985. (Photo: David Gibbon).

wheeled toolcarriers in these journals following up early work with a discussion of the actual problems encountered or of farmer dissatisfaction with the equipment.

7.4.3 Discounting disadvantages

Any technology has disadvantages as well as advantages, and objective publications are likely to cite examples of both and draw conclusions based on the relative balance of technical, social and economic benefits and costs. It is quite possible for a publication to be strongly in favour of wheeled toolcarriers, while mentioning some of the problems associated with this technology. Thus Bansal and Thierstein reviewed several drawbacks of wheeled toolcarriers (cost, need for training and back-up services, and requirement to link them to comprehensive technology packages) while still being highly positive. Kemp (1983) while extremely optimistic on the future of the Nikart noted that while it had been specifically designed for easy interchange between cart and cultivation modes, farmers tended to use only one of these options.

However a few publications have neglected the discussion of disadvantages. The 1981 edition of the ICRISAT wheeled toolcarrier bulletin failed to mention any possible problems relating to the adoption of wheeled toolcarriers. This had to be corrected in the 1983 edition that does have a heading "Drawbacks of the tool carrier" which notes some of the problems associated with cost and maintenance. An article in the French agricultural development journal *Inter Tropiques Agricultures* also illustrates the promotion of the toolcarrier without any reference to possible disadvantages. The illustrated article describes a wide range of possible operations, stressing the timesaving role of the toolcarrier, and concludes with a summary of the advantages: consistency of agricultural operations achieved with less effort of the animals and multipurpose use throughout the year. No mention was made of any possible disadvantages (Inter Tropiques, 1986). While professional agriculturalists might be cautious if they were to read such positive promotion in the pamphlets of manufacturers, the existence of such articles in the literature of national aid agencies and international research centres has tended to reinforce the impression that the wheeled toolcarrier is a well-proven and successful technology.

7.4.4 Some expressed disquiet

While it is clear that many of the published reports emanating from the wheeled toolcarrier programmes have been excessively optimistic or unbalanced, this has by no means been universal. Nevertheless most examples of disquiet were in reports of restricted circulation. As early as 1964 an internal CEEMAT document noted some of the problems of wheeled toolcarriers (CEEMAT, 1964). These included the restricted manoeuvrability during field operations and the fact that their high initial cost made it more difficult for farmers gradually to build up a range of equipment than if they started by using the most important single purpose implements (e.g. a seeder in Senegal or a plow in Mali). In 1985, in an international journal, a senior officer at Bambey Research Centre in Senegal noted that the wheeled toolcarriers had significant disadvantages as well as advantages, notably their high cost and their complexity. He doubted that the toolcarrier would spread rapidly among small farmers as the toolcarrier was twice the price of a complete set of single purpose implements. His calculations excluded the provision of simple ox carts as these were apparently unavailable in Senegal at the time (Nourrissat, 1965). Some evaluations have admitted major problems in The Gambia (Mettrick, 1978), Botswana (EFSAIP, 1984) and India (Fieldson, 1984; Kshirsagar et al., 1984) although, in contrast to the optimistic reports, pessimistic papers have seldom been published in international journals. More recently workers engaged in programmes promoting wheeled toolcarriers in Brazil and Nicaragua have expressed strong reservations about the desirability of such technology (Bordet, 1985; Bertaux, 1985).

7.4.5 The attitude of reference publications

In contrast to many reports produced by the programmes themselves, reference publications have generally taken a relatively cautious approach to wheeled toolcarriers. It is noteworthy that, although CEEMAT has been closely involved in wheeled toolcarrier development, its major animal traction reference work, which was published in English by FAO, is very objective on the subject of toolcarriers. Toolcarriers are presented among very many other animal traction equipment options and no attempt is made to promote them over any other technology. Toolcarriers are described as a potentially important step forward, but it is also noted that they require well cleared, flat land, a comprehensive and profitable cropping system to justify their expense, and an advanced infrastructure and extension service to promote them (CEEMAT, 1971; FAO/CEEMAT, 1972). In another reference work on animal traction based on an extension manual for Niger, CEEMAT did not dwell at all on wheeled toolcarriers and merely sets out some of their advantages and disadvantages (CEEMAT, 1974).

In his work on animal traction in Africa, Munzinger only briefly mentioned toolcarriers. He noted that in a few (unspecified) countries toolcarriers were of importance and that there was a good chance for their further promotion and utilization, citing as his reference the ICRISAT Information Bulletin (Munzinger, 1982; ICRISAT, 1981). However in the same volume Viebig was more cautious, and while giving descriptions of the technical advantages and disadvantages he concluded that: "Promotion of these implements is advisable only in special cases, following detailed examination of the conditions under which they are to be used. In some cases it has been discovered that the technically attractive but also elaborate and expensive polycultivators are simply used as carts after a while." (Viebig, 1982).

7.4.6 The citation of other countries

In the general publication "ICRISAT and the Commonwealth" that was produced at the time of the meeting in India of the Heads of the Commonwealth and the visit to ICRISAT of Queen Elizabeth II there is a section entitled "A multipurpose wheeled tool carrier" (ICRISAT, 1983). This includes a photograph of farmers using a wheeled toolcarrier, and superimposed on the photograph are the names of twenty-two countries: Botswana, Brazil, Burma, Cameroon, Dominican Republic, Ethiopia, France, India, Indonesia, Kenya, Mali, Mexico, Mozambique, Pakistan, Paraguay, Senegal, South Africa, Sri Lanka, Tanzania, U.K., Upper Volta (Burkina Faso) and Zimbabwe. The text explains that this is a list of countries in which wheeled toolcarriers have been used or are currently in use, to which they have been supplied, or in which they are manufactured. The information was factually correct, and by these criteria the list could have been expanded. Through such a list an *impression* is given that links the technology with a large number of countries in the mind of the readers.

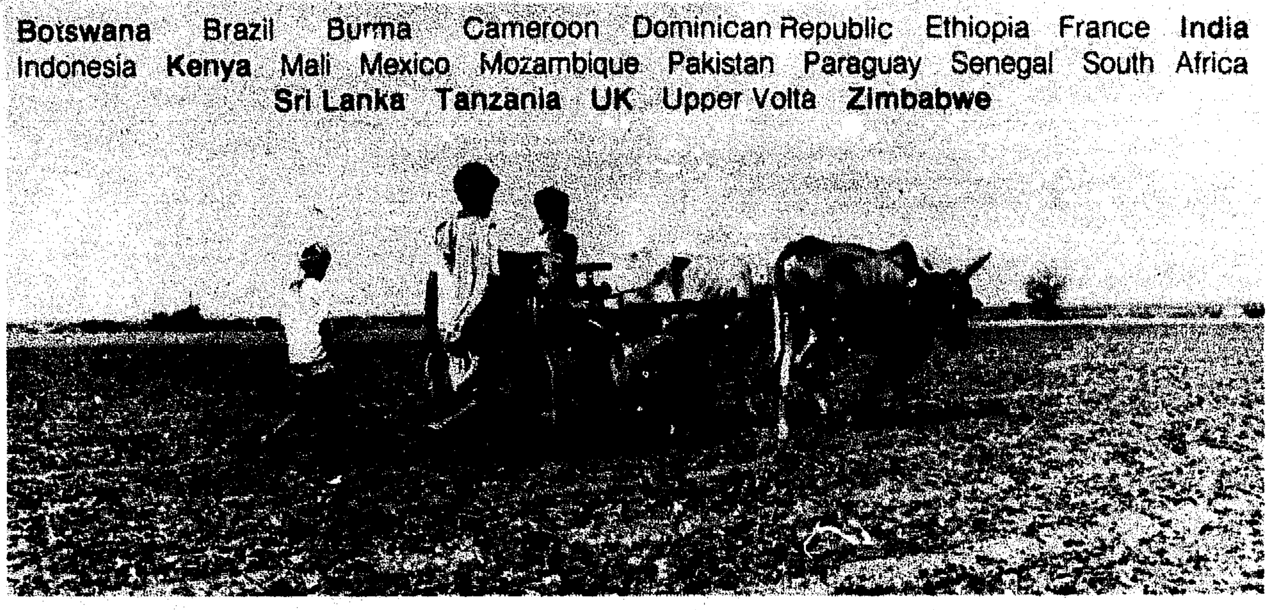


Fig. 7-10: Example of country citation: an illustration from the booklet "ICRISAT and the Commonwealth" (ICRISAT, 1983).

Kemp (1983) quite correctly and factually stated that the Nikart was being evaluated in Botswana, Mali, Zimbabwe and Mexico and several publications have illustrations of toolcarrier use in a variety of different countries. For example, the ICRISAT information bulletin on wheeled toolcarriers has photographs taken in India, Brazil, Mozambique, Botswana and Mexico (ICRISAT, 1983), and Nolle (1986) provided illustrations of his toolcarriers from Senegal, France, Madagascar, Mexico and Nicaragua.

The Intermediate Technology Publications booklet on toolbars (ITP, 1987) provided thirteen illustrations of wheeled toolcarriers and the names and addresses of nineteen toolcarrier manufacturers worldwide. This resource publication is likely to be referred to and circulated for several years to come and yet, as noted in Section 7.2, even at the time of publication the large majority of manufacturers listed (fourteen out of nineteen) had actually stopped any active involvement with wheeled toolcarriers. Someone contacting the various manufacturers would naturally find this out. Nevertheless the general *impression* left with anyone looking at this publication would inevitably be that in 1987 wheeled toolcarriers were being quite widely manufactured on four continents.

In all these examples the citations of countries were valid, and there was no suggestion of "name-dropping" merely for effect or any attempt to provide an unrealistic impression. Nevertheless most citations of countries have been made in the context of very positive articles and it appears that one consequence of such passing references to countries has been that many development workers have gained a strong impression that wheeled toolcarrier technology has been widely accepted in such countries. In fact in some countries cited fewer than ten wheeled toolcarriers have been in use, and these have only been evaluated on research stations.

7.4.7. Multiplication and legitimization of "success" stories

Articles in professional journals are unlikely to reach decision-makers, but these people are often influenced by formal and informal media channels that like to promote apparently successful innovations. In Africa a large number of English-speaking Africans (and expatriates) listen to the BBC, and several have reported hearing of wheeled toolcarriers from "The Farming World" agricultural programme. Many aid agencies sponsor publications such as "Overseas Development", "Inter Tropiques Agricultures" and "Exchange" that have included brief illustrated articles on wheeled toolcarriers. The fact that wheeled toolcarriers seem photogenic means that magazine editors may use such photographs to illustrate general articles. For example, in a general discussion on animal traction published in the widely circulated *Afrique Agriculture*, Yves Bigot did not mention wheeled toolcarriers, yet two out of the three untitled photographs used to illustrate the article were of wheeled toolcarriers in use in Africa (Bigot, 1985). Many voluntary agencies disseminate news snippets or whole publications. For example, animal traction projects in Africa requesting information on possible equipment from Volunteers in Technical Assistance (VITA) received copies of the optimistic publication "The Mochudi Toolbar: Makgonatsotlhe, the machine which can do everything". These are all examples of excellent information dissemination channels that are doing a great deal of valuable work in stirring up existing knowledge. However they can only pass on information flowing into them, and if all the reports they receive on a topic are optimistic, they will naturally disseminate this impression.

To take another example, until recently the introductory slide show of the International Livestock Centre for Africa (ILCA) contained a picture of a "farmer" (perhaps a research station employee) sitting on a Nikart wheeled toolcarrier in Ethiopia as the

Fig. 7-11: Nikart on test at an ILCA research station in Ethiopia: this image was used to explain that farmers will adopt good innovations. (Photo: ILCA Highlands Programme).

commentary explained that African farmers will adopt innovations that are shown to be suitable. Although ILCA scientists themselves have had reservations about the suitability of wheeled toolcarriers, the slide show (prepared by information experts rather than research scientists) clearly gave a psychological "stamp of approval" to the wheeled toolcarrier technology. The use of this seemingly innocuous slide by ILCA was traced after some African researchers had told the author that they thought that ILCA had carried out successful research on wheeled toolcarriers and was advocating their use. Thus ILCA had (apparently unintentionally) been promoting wheeled toolcarriers to many influential visitors from all over Africa.

As a final example, an agricultural textbook designed for secondary schools in Nigeria and English-speaking West Africa had a wheeled toolcarrier on its front cover. The text stated that these implements were becoming more widely used in many areas (Akubuilo, 1978).

These secondary "media" channels have three important effects. Firstly they greatly multiply the audience, secondly they simpli-

Fig. 7-12: An impression of success: a selection of ICRISAT publications. (Photo: P.H. Starkey).

fy the information to fit the time or space available and thus tend to make optimistic reports even more positive, and thirdly they have the effect of "legitimizing" the information. To have heard of a success story on international radio, through an aid agency publication, from an NGO resource centre, through a textbook or from an international research centre gives the information more credibility and status than a technical research report. Most aid agency publications have disclaimers in small print at the front to say that the organization does not necessarily endorse the views contained in the articles. This is a legal safeguard, but, as advertising experts know, the important thing is that the product has become linked in a persons's mind with the reputation of the sponsoring organization.

There is no suggestion whatsoever that any fault or blame should be attached to such media channels, for they are doing excellent work in spreading information. In the case of wheeled toolcarriers they have achieved a remarkable accomplishment by making agricultural planners and decision-makers throughout the world aware of the technology and its "success". The problem has been that no organization appears to have fed into the system any of the disadvantages of the implements, or the problems experienced by farmers. Thus the initial success stories of research scientists have multiplied and achieved legitimacy.

7.4.8 Effects of the literature and media

In the period 1985 to 1987 the results of the optimistic reports, the concentration on advantages, the passing citation of countries, and the multiplication and legitimization processes were very clear. The great majority of research and development workers in this field, together with staff of aid agencies, were under a strong impression that the wheeled toolcarriers had been successfully used and adopted in many parts of the world. This statement is not just speculation, for between 1983 and 1987 the author visited animal traction programmes in twenty countries and discussed the role of wheeled toolcarriers with research and development workers. Through seminars, professional meetings and correspondence the author has had contact with another twenty countries, and a clear pattern has emerged. Workers are under the very strong impression that wheeled toolcarrier technology is very successful – *somewhere else.* Researchers have often admitted problems in their own country or region but have also cited assumed successes elsewhere.

For example, in East Africa many people are under the impression that wheeled toolcarriers are widely used in West Africa (Ahmed and Kinsey, 1984). Authors in Britain (Gibbon, 1985), France (Poussett, 1982) and India (Bansal and Thierstein, 1982) have given similar impressions relating to widespread diffusion in West Africa. In West Africa, people have cited successes in southern Africa (derived from reports from Botswana) and in India (derived from reports from ICRISAT), while those in southern Africa have pointed to the success of wheeled toolcarriers in Asia. Workers in Bangladesh reported the success of the ICRISAT technology in India (Sarker and Farouk, 1983) and in 1986 even some staff of ICRISAT Headquarters in India were under the impression wheeled toolcarriers had proven successful in India itself. However, as already noted, others in India have cited their successful introduction within West Africa. Meanwhile in Latin America reference is made to the achievements in both Africa and India.

In the course of the background research for this present publication, the author has visited many of the countries cited by colleagues as "successes" in the use of this technology and has been repeatedly surprised to find that the actual situation involved far fewer toolcarriers and much less extensive testing than he had been led to believe from professional discussions and the literature. For example, until 1985 the author himself was under the *impression* that wheeled toolcarriers were actually being used by farmers in Mali. It is only after he had visited Mali and established that this was not the case that he has been able to realise the full extent of the overall optimism. For since ascertaining the real situation he has been told by several influential and distinguished workers in the field that Mali has been a clear success story. Had it not been for his field visits he would naturally have believed this.

Until December 1986 the author himself also believed the apparent success of wheeled toolcarriers in India. As recently as May 1986 he submitted an article to the journal "Appropriate Technology" stating that, while lessons from Africa were clear, India was apparently still going through the stage of *accelerating increase*, and it was too early to judge whether this increase would continue. Although he had reviewed a large number of articles, he had not come across a single one that had counteracted the false impression of success he had been given from the literature. At this time he was also engaged in correspondence and professional discussion concerning wheeled toolcarriers with several organizations, including ICRISAT and NIAE. Yet no organization volunteered any information that might counteract the effect of the optimistic literature. It was only during a professional visit to ICRISAT in December 1986 that he learnt that the peak in India had actually been passed in 1984, two years before. Many of the problems had been documented in 1984 by ICRISAT and NIAE in internal reports, but these had not been disseminated. Fortunately it was still possible to update the text of the article in question (Starkey, 1987) or it too would have unintentionally contributed to the general impression of "success somewhere else".

This example is not intended to imply there was any conspiracy of silence, for it merely demonstrates an obvious point: individuals and organizations are much more likely to provide information on their successes than their disappointments. However it does illustrate one very important point: if an individual actively searching for information in both published and unpublished form is given, and passes on, an impression of optimism and success, then under present circumstances those obtaining information through standard, public channels have very little hope of obtaining a realistic picture.

This is worrying and for this very reason the author is slightly concerned lest his very open verdict on present evidence from Latin America of "not proven either way" turns out to be a third example of optimism. There may well have been cases of clear farmer rejection of which he is unaware. It would be ironical if unjustified optimism in this publication were to stimulate continued investment in toolcarriers in situations comparable to those in which they have already been found inappropriate.

8. Implications, Lessons and Conclusions

8.1 Summary of experiences

The review of wheeled toolcarrier projects over the past thirty years reveals the following points in common:

- All initiatives have been characterized by much early enthusiasm for the design.
- All designs have been subsequently modified and refined.
- All modified designs have been proven capable of work on station.
- Designs with a high degree of versatility have been found complex by farmers and expensive and/or difficult to manufacture accurately, and there has been a tendency to simplify designs with time.
- All designs have been described by farmers as being heavy for the animals to pull, and they had therefore been used with fewer than expected implements, or with multiple pairs of animals.
- Despite the potential for conversion from toolcarrier to cart, farmers have generally kept to one mode, and after one to three seasons as a cultivation implement, almost all toolcarriers have been used only as carts.
- Despite optimistic forecasts based on on-station use, it has never been shown that farmers themselves have found that the benefits of toolcarriers justify their high costs.
- No wheeled toolcarrier has yet been proven by sustained farmer adoption in any developing country.

About 10000 wheeled toolcarriers have been made, but few of these were paid for at a realistic price by farmers. The number of toolcarriers of any design that have ever remained in use by farmers as multipurpose implements for at least five years is *negligible*. Research, development and promotional activities are now continuing in at least twenty countries in Africa, Asia and Latin America. Most on-going activities have been started because the national programmes or aid agencies believed that wheeled toolcarrier technology had succeeded somewhere else. To date it has not succeeded and there seems little evidence to justify any optimism for the technology. Prospects for present programmes in Africa and Asia seem very bleak and in general the outlook for wheeled toolcarriers is *not bright.*

8.2 Implications of research methodology

8.2.1 Overall approach

The methodology of almost all toolcarrier research programmes reviewed has been similar, being based on the development of high quality (high cost) solutions proven competent under optimum on-station conditions. For example ICRISAT researchers have described their own approach as follows:

"The path which the Vertisol technology development at ICRISAT has followed is essentially one which from component research to package and system design remained within the research station in Patancheru and then entered into farmers' fields, with the effect that many constraints were understood only at the stage where farmers were confronted with the technology." (von Oppen et al., 1985).

The results of the programmes have also been similar. For example Ahmed and Kinsey in a review of farm equipment in eastern and central southern Africa stated:

"A common finding is the inappropriateness – on the grounds of multiple criteria – of many products produced by farm equipment research and development. It is interesting, for example, that the animal-drawn toolbar, which is reported to be widely used in West Africa, has not been accepted by farmers anywhere in eastern Africa. Yet research and development on toolbars date back some 20 years in the case of Uganda, and a decade or more in other countries. Either adaptive research has failed in this instance, or promotional efforts have been ineffective or aimed at the wrong farming systems." (Ahmed and Kinsey, 1984)

Promotional effort has seldom seemed lacking, but what has often been missing has been a detailed knowledge and sympathetic understanding of the prevailing farming systems. Researchers have seldom ascertained farmer reaction to previous schemes, they have often had a top-down approach, and have tended to work on implements designed for technical excellence in on-station conditions far removed from local realities. It is now clear that all the programmes reviewed would have benefited from much more contact with farmers at all stages.

8.2.2 Analyses of previous experiences

The majority of wheeled toolcarrier programmes have been based on enthusiasm for the relatively new toolcarrier concept and the researchers' own innovative design features. Comprehensive literature reviews have been very few but, as already discussed, simple literature searches would have revealed mainly optimistic reports. There seems to have been very few attempts to understand the actual field experiences of previous initiatives.

It is instructive to see how the international research centre ICRISAT approached the issue of analysis of experience. From its early stages it tried to maintain a global vision by testing wheeled toolcarrier designs from several countries and collaborating with acknowledged experts in the technology from France and Britain. It also gradually assembled documents and reports from several (Anglophone) countries and a review of these was published eight years after the start of the programme (Bansal and Thierstein, 1982). Clearly some genuine attempts were made to analyse previous experience, but (with the expertise of hindsight) the methodology could have been improved.

Firstly, as is normal in any programme, the external collaborators were those already associated with promoting the technology. In the early stages of technology identification, it may also be valuable to seek the advice of those without vested interests but with practical experience of working with smallholder farmers – perhaps those in extension rather than research and preferably the farmers themselves. One effective way of doing this is through field visits and discussions with both farmers and extension workers, and another is through multidisciplinary "networking" meetings involving not just agricultural engineers but extension personnel and research scientists. Secondly, while analysis of experience should be ongoing, a good understanding of previous lessons should be achieved *before* a programme is so committed that changes in direction are difficult. From the various case histories reviewed in previous chapters it is clear that in many instances a few weeks or months of letter-writing and reading reports to establish previous lessons could have saved not only money but many months or years of unproductive work.

Thus future research initiatives should start with a detailed analysis of existing experiences, with information obtained not just from publications but from farmers themselves or those closely in touch with the farmers. Such analyses, combined with a knowledge of the target systems, should lead to precise definitions of the required task and the available resources that are necessary to ensure that equipment will be appropriate.

8.2.3 Domineering (top-down) approaches

Very many of the programmes reviewed have been based on the principle that: "*you* have an inefficient system of agriculture; *we* know the answers". Equipment has been designed and built in France, Britain and Canada and flown out to research stations in developing countries. On research stations staff have tried to develop technologies that will make peasant farmers toolbar-minded and so prepare them for the ascent of notional mechanical ladders leading quite rapidly to four-wheel tractors. There has been little attempt to understand the realities of the farming systems and the ways in which existing practices may be highly efficient in their environmental context.

Colonial domineering approaches in the late 1950s and early 1960s might be explained (some would say justified) by the prevailing social attitudes of that era. However, unfortunately this is not merely an historical problem, for this "top-down" attitude pervades many modern programmes. As recently as 1986, a wheeled toolcarrier programme was justified as a means of proving that equipment appropriate to the needs of the African farmer could be cheaply and efficiently designed in Canada. Not surprisingly it totally failed to demonstrate this.

The problem is not only one of expatriates being patronizing to Third World nationals, for the attitude that researchers and extension workers know best can probably also be found within every national programme. For example a booklet for extension workers describing the use of work oxen, single purpose plows and wheeled toolcarriers starts with the sentence, "The average Ugandan farmer has a small farm; he has a low income, and little farm knowledge know-how". (Akou, 1975). Similar phrases occur throughout the world. Some are merely shorthand for saying that farmers are unfamiliar with modern industrialized agricultural technology, but some imply that the farmers have insufficient knowledge and understanding of their own farming systems. As has been apparent in this review and many other studies, the "failures" of research and extension programmes are generally due to the professionals themselves not understanding the farming systems, and trying to impose on them technology that the farmers consider inappropriate.

It should now be clear that research and development programmes should start with a humble approach and an understanding of local farming systems derived from discussions with farmers. Programmes should work closely with the farmers and jointly identify and evaluate methods of improving farm productivity and incomes.

8.2.4 Pursuit of technical excellence

In most of the case histories reviewed, attempts have been made to develop high quality implements, and thereby high cost solutions to problems. The objectives have been laudable – to produce high incomes for farmers. However this pursuit of technical excellence and high-input, high-output farming systems has not been proven appropriate. Farmers require technology that is effective and affordable, which can be maintained in their villages and which provides reasonable convenience at an acceptable risk. Wheeled toolcarriers though often technically effective have not been shown to pro-

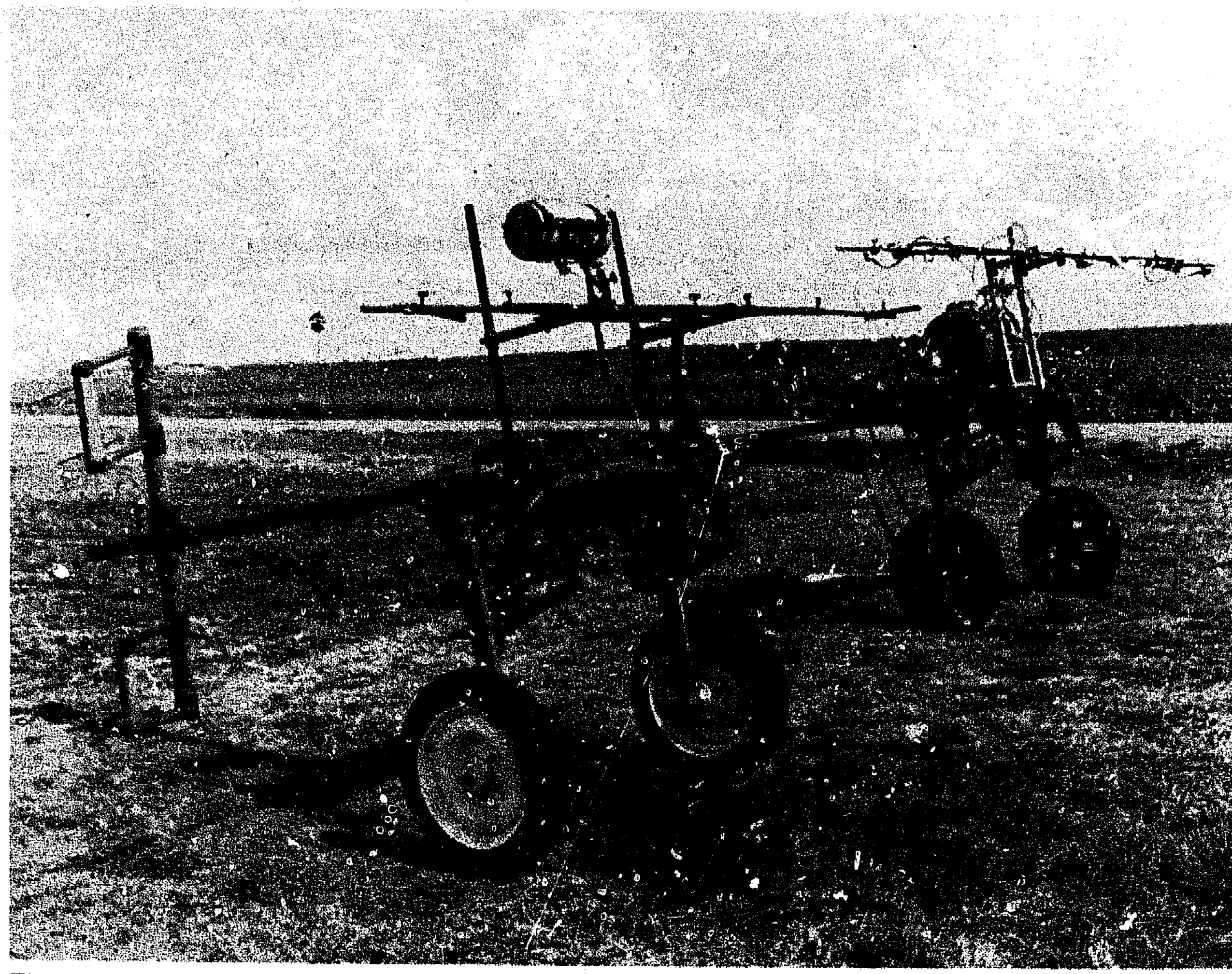
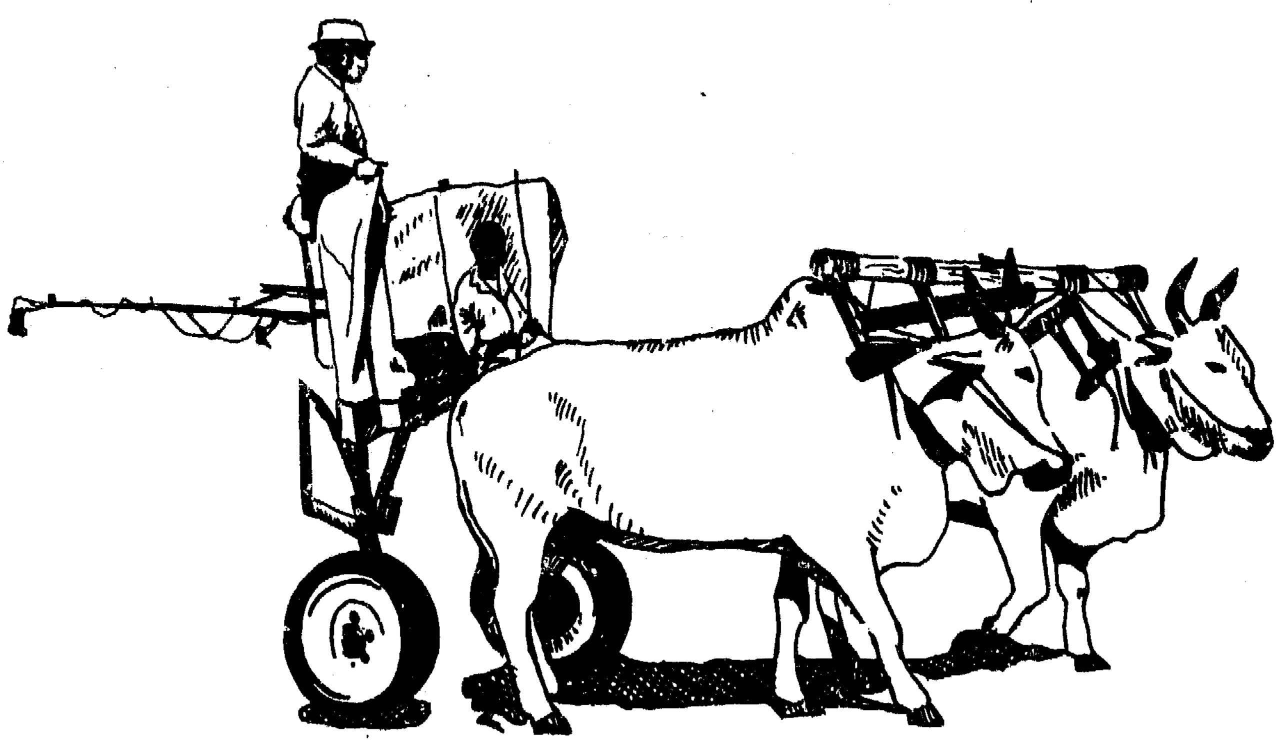


Fig. 8-1: Pesticide sprayers for pigeon peas developed at ICRISAT Centre (note raised Tropicultor chassis and raised yoke). (Top photo: P.H. Starkey; drawing from ICRISAT photo).



vide this combination, whereas some more simple implements have. The more simple implements may not have led to dramatic improvements in production or farmers' incomes, but they have been sustainable.

The lesson appears to be that technology that is intrinsically excellent may not be appropriate. This is not just an observation on wheeled toolcarriers for in other fields of agriculture there are close parallels. Exotic or crossbred cattle may seem ideal draft animals, but farmers require animals that can be conveniently maintained under village conditions, without too great an investment or risk. In most cases this means that adaptability and affordability are more important than genetic excellence. Similarly high yielding crop varieties that need high levels of inputs have often been judged by farmers to be inferior, in the prevailing circumstances, to lower yielding but well-adapted varieties. This does not mean that technical excellence is not important, but that it should be developed in such a way that it is appropriate to the prevailing environment.

8.2.5 The lack of realism of on-station research

Almost all the programmes reviewed have started as research station studies. This is quite normal. However it appears that few, if any, of the studies were replicated on farmers' fields at an early stage. As a result equipment and cultivation systems were designed and tested in highly unrealistic conditions. The draft animals maintained on research stations are often one-and-a-half to two times the weight of village animals. As a result operations easily performed with two animals on station have been considered excessive for pairs of animals owned by farmers. There have also been examples of research stations using tractors as surrogate oxen in testing wheeled toolcarriers. Research station fields have been cultivated for long periods and are generally relatively smooth and free of obstructions. Meanwhile outside the perimeter fences farmers' fields are often irregular in shape, uneven in surface and contain trees, stumps or roots that have to be avoided. On research stations fields are close and access is easy, while farmers may have to travel considerable distances, often negotiationg slopes, valleys or water courses, to reach their fields. Simple repairs such as minor welding and punctures that are quick and routine on station can cause a smallholder farmer to lose hours or even days. Research programmes ensure adequate labour is available for operations at the optimal time, but in villages there may be more urgent matters that are integral to the farming systems and which have to take priority. On research station seeds are often graded and regular and so ideal for mechanized seeding, whereas in villages seeds may be variable in type and quality and of mixed sizes. Sites for research stations have often been selected for their good soils, reliable rainfall and easy access to water and main roads, whereas the reality of most villages is very different.

In *all* the cases reviewed wheeled toolcarriers worked well on the research stations, yet in *none* of the cases did wheeled toolcarriers work sufficiently well under normal village conditions for farmers to continue using them.

In all countries there are innovative farmers willing to try out equipment if they perceive it might be useful (and if they do not, that is itself a valuable lesson). Researchers should work with such farmers from the very first year of trials, so that even if trials are mainly based on station, there are replicates carried out by farmers themselves. (Compensation arrangements in case of failures can usually be negotiated easily.) While cooperation with farmers close to a research station may be convenient, it is ex-

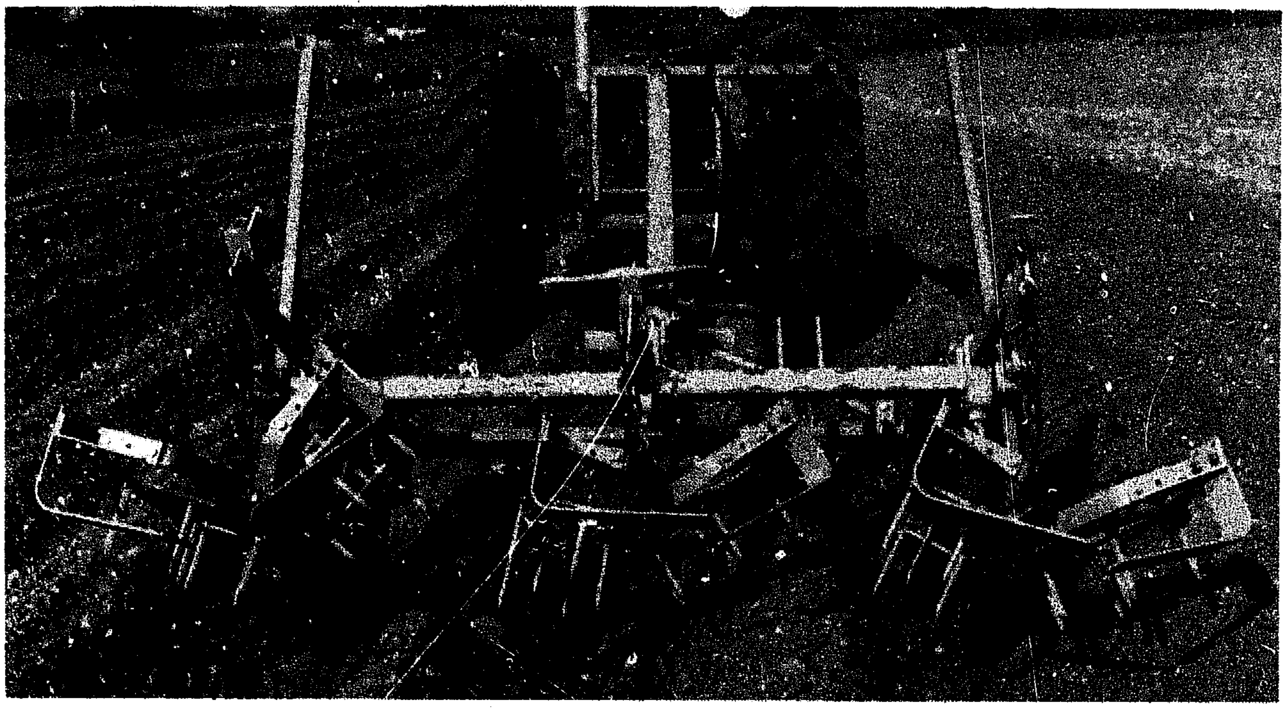


Fig. 8-2: On-station development: prototype weeding harrows on NIAE toolcarrier being tested using a tractor in the U.K., 1967. (Photo: AFRC-Engineering archives).

tremely salutary to try to maintain prototypes in working order in isolated villages. Having gained farmer cooperation, it is essential to ask the advice of such end-users at all stages of research and development from appraisal to evaluation.

Ideally work should continue with several farmers over several years. It is most important to resist the temptation of many researchers to reject on-farm experience in any given year as "atypical". Almost by definition, no cooperating farmer will be typical yet their experiences must be evaluated. Indeed there is no such thing as a typical farmer nor even an average year. Events described in research reports as "atypical" such as dry years and wet years, droughts and floods, pest damage and losses of animals and even social upheaval are actually representative of the realities of rural life. Calamitous events have to be survived by the farmers. Thus, while it may be unrealistic for innovations to be adapted to the worst catastrophes, they certainly should not be designed only for "above average" years.

8.2.6 Interdisciplinary feedback and farmer involvement

The many models of wheeled toolcarriers have naturally been designed by agricultural engineers. Frequently individual professional disciplines remain isolated, and there have been numerous examples from all over the world of agricultural engineers working alone as they develop equipment (or re-invent the wheel). In the case of wheeled toolcarriers, while some prototypes have been built by agricultural engineers working alone, some of the major programmes have been the responsibility of broadly based teams, involving agronomists and social scientists as well as engineers. Thus the Botswana research was in the context of a farming systems programme, and the important ICRISAT involvement was the responsibility of the multidisciplinary Farming Systems Research Program.

The common and generally justified criticism of inappropriate single disciplinary studies is not valid in the context of wheeled toolcarrier development. Indeed it may well be argued that the close involvement of economists was positively disadvantageous. In all cases economists managed to produce economic justification for wheeled toolcarriers, and this justification was probably the major reason why many of the wheeled toolcarrier programmes in Africa, Asia and Latin America continued with such single-mindedness even after negative farmer feedback was apparent. In the circumstances it seems rather hollow to talk about a need for closer interdisciplinary collaboration at all stages.

Something clearly must have been missing to allow so much time to be devoted to developing and refining equipment that the farmers found inappropriate. The repeated theme that is emerging is that there was no representative of the *farmers* in the teams. Historically much of the agricultural equipment developments have arisen from the innovative ideas of farmers, often working closely with village blacksmiths or local equipment workshops. Innovations have developed from specific problems and attempts to find suitable solutions.

While farmers in developing countries are constantly being innovative and carrying out research themselves (Richards, 1985), their rate of progress is considered too slow for modern governments. Resources are allocated to speed up development. Most programmes, instead of trying to accelerate existing innovative processes, have tried to impose solutions developed in different circumstances. The economists' models of profitability would not have lasted long in discussion with highly practical but resource-poor farmers who unfortunately cannot simply remove problems by assumptions.

It seems evident that multidisciplinary teams must include farmers' realism somehow. Farmers are likely to give the most valuable information in their own environments, among their own peers. It seems essential that research programmes should regularly discuss farmers' problems, ideas and reactions while visiting their villages and fields. Farmers should be given the respect, honour and attention generally reserved for external consultants.

The repeated reference to farmer involvement should not be taken as a quick panacea, but as part of a long-term methodology. The author remembers with humility farm visits in Mali in 1986. One farmer was clearly happy to be testing a wheeled toolcarrier and was delighted with the associated prestige and international visitors. Like many farmers he was not prepared to be damning and dismiss the technology lightly, and indeed he tried to be as encouraging as possible, yet it was apparent from discussion and from the reports of the researchers that the Nikart under test was inappropriate to the local situation. However while it seemed easy for the external people to dismiss the toolcarrier there appeared to be no easy alternative solutions to suggest that would allow the innovative farmers at least some hope of raising their standards of living. The farming systems team was working closely with villagers, but the seemingly valuable combination of farmers, research team and consultant found it much easier to cite problems than devise solutions.

8.2.7 Methodological principles for future farm equipment research

From the lessons of the wheeled toolcarrier research it is clear that future animal traction or farm equipment research should be:

– carried out with much more involvement with farmers who might usefully be regarded as "consultants" in problem identification, definition of requirements and very early evaluation of prototypes,

– based on a clearly defined need derived from a knowledge of local farming systems and socio-economic conditions,

– based on studies of actual field experience of previous initiatives.

At the international networkshop "Animal Power in Farming Systems" held in Sierra Leone in September 1986 (Starkey and Ndiamé, 1988) a group discussed the stages required for effective farm equipment development. An edited version of the group's proposed methodological steps is as follows:

1. *Identification of needs:* study of the farming system in which equipment will be used, and context of work for which it will be selected or developed.

2. *Operational requirements:* definition of exactly what the equipment is required to do.

3. *Specifications:* clear listing of weight, draft, size, working width (requirements, limits), affordable costs, technical level of users, maintenance requirements, working life.

4. *Study of options:* review of available equipment (locally or from other countries) that meet specified requirements.

5. *Selection of design.* If none available development of new prototype or adaptation of existing equipment.

6. *On-station testing* and evaluation of selected design.

7. *On-farm testing* and evaluation with farmers.

8. *Standardization* of appropriate design, with formal drawings.

9. *Small batch production* and distribution to farmers.

10. *Further on-farm evaluation* with farmers to establish durability and suitability.

11. *Economic studies* and assessment.

12. *Large-scale production* and extension.

This list should not be taken as definitive (for example socio-economic determinants such as risk have not been cited and economic evaluation should be considered a more continuous process) but it is helpful for identifying a desirable methodological sequence. Stages 1 to 3 (identification, definition, specification) will be highly area-specific and require close work with farmers. Stage 4 (review) is most important to prevent the unnecessary repetition of research. However, most of the programmes reviewed here have tended to start immediately at stage 5 with prototype development. They have then spent time at stage 6 (on-station testing) before jumping quite rapidly to stages 9 and 12 (batch production, large-scale production and extension). Steps 10 and 11 (detailed on-farm evaluation and economic evaluation) have generally been neglected.

This list quoted was produced at the "Animal Power in Farming Systems" networkshop with equipment development in mind, but many of the methodological stages are comparable with those in other fields of development. To conclude this section and at the same time to broaden its scope, the summary of another of the discussion groups at the same networkshop appears highly relevant to this review. Charged with deliberating the subject of animal traction research methodology, the group agreed that a multidisciplinary and farming systems approach was important and that more emphasis should be placed on social and economic issues than has been common in the past. To prevent technically excellent but inappropriate techniques being developed from the very first year of research programmes there should be replicates of any on-station trials or development work on some farmers' own fields. Finally farmers should be closely involved in planning and evaluation at all stages of a research programme.

8.3 Single or multipurpose equipment

Multipurpose equipment inevitably involves compromises in design and generally means that multipurpose equipment is technically inferior to a range of single purpose implements. In general it is more convenient to

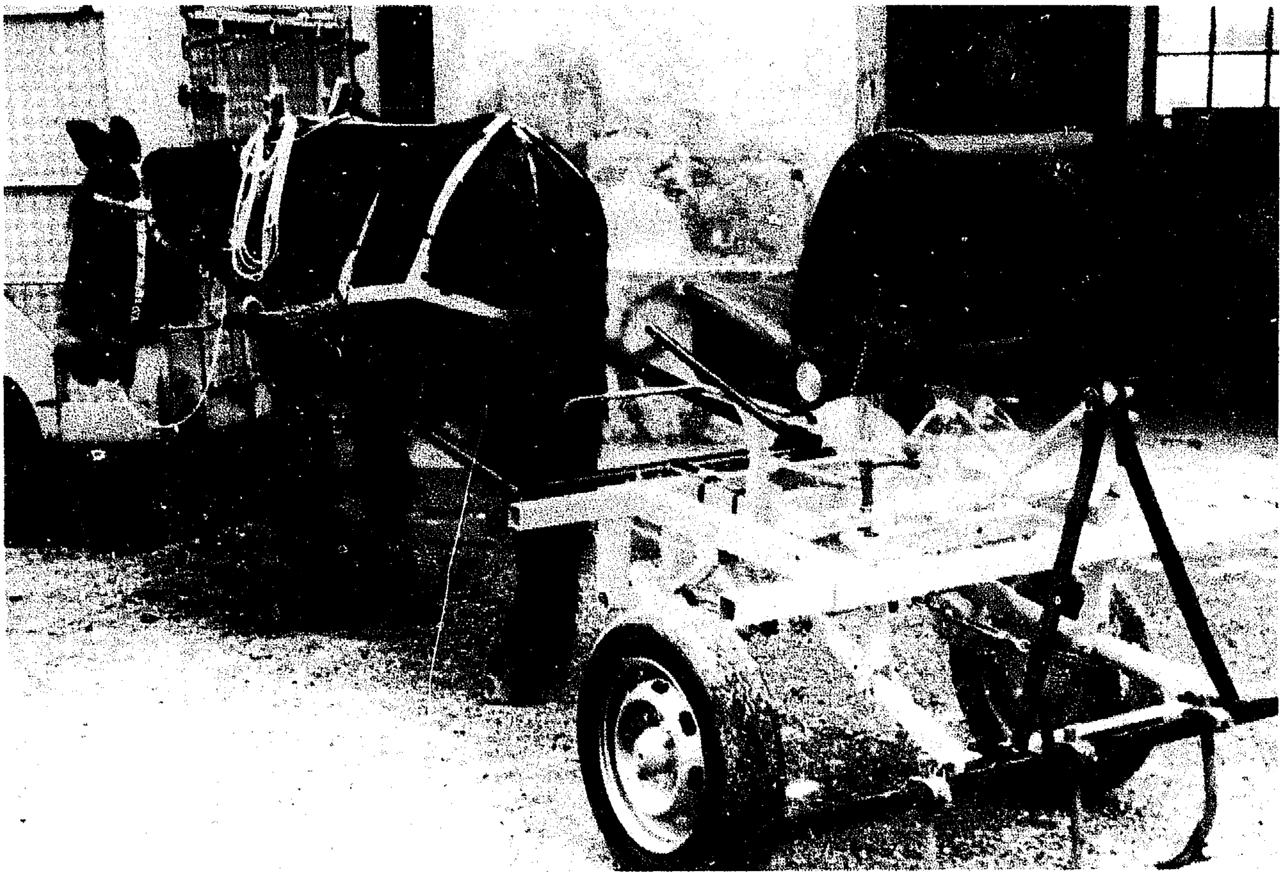


Fig. 8-3: Recent ATSOI wheeled toolcarrier with three-point linkage in France, 1985. (Photo: J.P. Morin).

have separate implements for each operation, as these can be left appropriately set up and adjusted. Multipurpose implements decrease flexibility as two options cannot be used at the same time. Most importantly multipurpose implements increase risk, as one breakage can mean that all implement options become unavailable at the same time. Thus multipurpose equipment is only justified if the cost savings are significantly large to compensate for the decrease in convenience and the increase in risk. The cost advantages of wheeled toolcarriers have been minimal, or nonexistent, and the inconvenience or complexity of changing modes has been such that in the long term farmers have used their implements for only one purpose. (There are many parallel examples of multipurpose implements being used for only one operation, and many western households have multipurpose tools or electrical gadgets left in one mode.)

It would seem that equipment developments that are most likely to succeed are those that reflect the historical trends of separate implements for plowing, for secondary tillage and weeding, for seeding and for transport. The undoubted success in West Africa of simple multipurpose toolbars does not negate this argument. The Houe Sine has succeeded in conjunction with a good single purpose seeder (the Super Eco) and the use of animal-drawn carts. It has been designed to combine only a small spectrum of different operations, and within this limited scope farmers have generally selected an even smaller range. As Jean Nolle noted in the very early stages (Nolle, 1986), the Houe Sine of Senegal (and the Ciwara of Mali) is mainly used as a multipurpose *tine cultivation* implement and in some areas the mouldboard plow attachment is seldom used. An innovation parallel to the Houe Sine can be seen in the multipurpose triangular cultivator in Burkina Faso which is generally sold as a complement to a single purpose plow. These multipurpose implements in West Africa show similarities with the animal-drawn (wheeled) cultivators of European and American agriculture that were often used for several cultivation operations including harrowing, weeding, earthing up and raising root crops. Multipurpose use has become a stated (Nolle, 1986) and unstated design philosophy. A major justification for both simple toolbars and wheeled toolcarriers has been the argument that these can be used to encourage row cultivation (Willcocks, 1969; Mettrick, 1978) and yet row cultivation has been seen to develop using single purpose implements. Thus multipurpose use should not be a *primary* feature of animal-drawn equipment design; rather it should be considered as one option for possible cost savings, in situations where consultation with farmers indicates that the inconvenience or risk factors would be tolerable.

8.4 Vested interests: propaganda or reporting

It must be recognized that individuals, projects, institutions and governments have their own vested interests and their own reference groups. This situation is unlikely to change significantly. The prospects for individuals' promotion will depend on the extent they please their organizations. The chance of a contractor being awarded another project to implement will depend on the impression of competence given in earlier ones. The success of non-governmental organizations in raising funds will reflect the public's perception of past achievements. National institutions and politicians will need to justify to their electorates the specific benefits of their activities to the nation. International centres and agencies will continue to worry about future funding, and will need to justify past funding by showing unequivocal results. Most national and international organizations will continue to work with short time horizons and be expected to produce tangible benefits quickly. All these pressures will tend to encourage the dissemination of favourable images, good public relations material, and even propaganda. However individuals and organizations involved in development should be aware of the dangers and strongly resist these pressures to distort information dissemination.

In the history of wheeled toolcarrier development, there has been an understandable tendency for all individuals and organizations involved to project a more favourable picture than was justified by the circumstances. As a result there has been less learning from each other's experiences, less efficient utilization of human and financial resources and consequently less overall progress. There have been very few attempts to publicize or evaluate disappointing results, presumably because this might be interpreted by the various reference groups as "failure". Yet it cannot be too strongly stressed that *negative lessons are not in themselves failures;* they are only failures if the institutions and individuals fail to learn from the experience. To spend time and money developing equipment that farmers reject does not necessarily mean that the money has been wasted, *provided the lessons are learned and shared.* Institutions funded by national or international aid agencies must be more willing to view "negative lessons" constructively, and not regard them as "failures" of which they should be ashamed. Learning involves both positive and negative experiences and if such institutions are only prepared to release positive information, then the world is losing a major chance to learn from their experiences.

Enthusiasm is a very desirable characteristic, and it is stimulating when this is evident in reports and publications. Measured optimism is also challenging and encouraging. However selective dissemination of only positive information is dangerous and undesirable (it is also unacademic and unscientific). It is therefore most important that professionals can feel as proud of a well-presented *negative* lesson as a *positive* one.

8.5 Networking activities

Many of the problems associated with the last thirty years of the wheeled toolcarrier might have been avoided if there had been more active "networking". Networking implies developing an awareness of comparable programmes and the subsequent exchange of information through correspondence, newsletters, visits and meetings. This may be achieved through a formal organization with structure and secretariat, or simply by a series of networking activities.

Networking by itself is not a panacea, for unless combined with farmer involvement, critical analyses and genuine cross-fertilization of ideas and experiences the activities themselves can even be counterproductive. There have been examples of newsletters disseminating unrealistic information, meetings at which prejudices were mutually reinforced and "field visits" only to research station trials under optimal conditions. Even the success of the ICRISAT's research programme in having its on-station achievements widely known is due to many of the activities associated with networking. Through optimistic information dissemination by correspondence, newsletters, visits and meetings and consequential media attention very many professionals became aware of (part of) ICRISAT's experience. However, if professional seminars and meetings involve village discussions with farmers and if workers admit their problems as well as their successes, networking can play an extremely important role in constructive information exchange. Indeed much of the research for this publication was based on following up a large number of contacts gained from previous networking exchanges.

Networking would certainly not have prevented all the programmes reviewed here from starting or continuing. Indeed it is not even suggested that this would have been desirable for the technology deserved *some* attention. Rather it would have ensured that the lessons from one programme were carried forward to the next one. This would probably have meant that some programmes would not have started and others would have terminated more quickly, moving into more productive areas. This would have been beneficial in the allocation of budgets and human time, thus justifying the modest costs of networking.

8.6 Conclusions

It is difficult to assess the cost of the various wheeled toolcarrier programmes, but taking present-day prices of over US $ 1000 for an equipped toolcarrier, production of 10 000 toolcarriers would be worth over US $ 10 million. Allocating professional time to the design, testing, production and promotion of wheeled toolcarriers is much more difficult. Jean Nolle, NIAE and ICRISAT have together accounted for over fifty senior person years of development work. Research and development programmes in Senegal, The Gambia, Botswana, Tanzania, Uganda, Mexico, Brazil and elsewhere would have accounted for over twenty-five expatriate years and many more years of national experts. To this can be added all the smaller research and development initiatives in Cameroon, Mali, Nigeria, Malawi, Somalia, Zambia, Nicaragua, India and elsewhere which have made or tested prototypes. Clearly one is considering a total of more than one hundred senior person years and several hundred years of less senior staff. In present terms this would represent a labour budget in excess of US $ 15 million. If one wanted one could go on to add miscellaneous costs such as transport and institutional overheads, and it is clear that similar work today would cost over $ 40 million. This can be seen either as a huge investment, or a very small proportion of international aid expenditure.

What has this achieved? It has led to a few competent designs of wheeled toolcarrier. These may perhaps be shown to be useful, although to date they have not been proven anywhere by farmer adoption and it must be admitted that prospects are not bright. If this is all, then most of the money has been wasted. This would have been a huge price to pay for such design work, particularly as there were competent models available twenty years ago.

The programme has also led to some lessons in agricultural engineering and equipment development which, if learned, could assist in many programmes in developing countries. However for these lessons to be learned there is a need for open-mindedness and exchange of actual experiences followed by careful analysis of what succeeded and what failed, and what were the more effective methodologies. Such lessons would be expensive but valuable.

Most importantly while the work referred to has been specific to one kind of animal traction equipment it has provided some very important and fundamental lessons that relate to a whole range of development issues. Among these are:

– The need to involve and consult with the end-user (farmer) at all stages of planning, implementing and evaluating research and development programmes.

– The great danger of developing inappropriate solutions if research is undertaken in unrealistic conditions, if domineering (top-down) research philosophies are adopted or if the criteria for excellence are based on maximizing technical efficiency rather than appropriateness to the needs of the farmers.

– The dangers of aid agencies, international centres and national programmes using their considerable influence and resources to promote through publications, subsidies, credit and gifts, inadequately evaluated technology.

– The significant effect that over-optimistic reporting or misinterpreted terminology can have in promoting a technology to individuals and organizations anxious to achieve quick and visible results.

– The current waste of human and financial resources through continued repetition of similar mistakes because professionals and organizations are seldom prepared to exchange with honesty their experiences and admit and openly discuss setbacks.

– The importance of regarding "negative lessons" as potentially valuable.

If these lessons could be learned, then the wheeled toolcarrier programmes would have been a small price to pay for such significant benefits. In view of the hundreds of millions of dollars spent each year by national and international development agencies, the cost of all wheeled toolcarrier projects could be vindicated by very small percentage improvements in the effectiveness of current programmes. If existing national and international research, development and extension programmes were to make their work more farmer-centred and started to share experiences more openly, the lessons will have been justified. Only if these valuable (negative) lessons are now ignored should past wheeled toolcarrier initiatives be considered expensive "failures".

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