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Introducing Tractors of Less than 25 Horsepower to Small Farms

John S. Balis
Appropriate Technology Officer
Bureau for Latin America and
the Caribbean
Agency for International Development

INTRODUCTION

Improved agricultural implements and tools such as those developed by Allahabad Agricultural Institute, and sold extensively by the Agricultural Development Society, make it possible to double the effective cultivated area commanded by a pair of draft oxen. The use of the combination of soil-turning plow, disk harrow and seeding machine will increase both the command area and the quality of the work done resulting in an increase in crop yields. With extensive promotion by the Government Extension Service and by development agencies, these implements have been tried and adopted by many farmers and are now in production by many small manufacturers in India and other countries.

There are serious limitations to improved, animal-drawn implements. Perhaps the most serious from the farmers' point of view is that the complete set of implements costs about the same amount as the cost of the animals that can be displaced. However, in addition, the single pair of animals are not capable of providing adequate threshing or irrigation capacity at the higher production level. Consequently, it is necessary for the farmer to invest in engines with pumps and threshers as he intensifies his production. Once farmers have mastered the use and care of improved, animal-drawn implements and pump engines, the transition to tractor operation is a modest step.

Interest in the small tractor arises from two basic hypothesis about LDC agriculture. The first is that the small farm enterprise is essentially a permanent institution. While the data is fragmentary, it appears that farmers are getting smaller in the LDCs due to population

pressure and official action in spite of the obvious economic advantages of larger scale enterprises. As a corollary to this first hypothesis, it is speculated that a small farmer with independent control of a small tractor will have a greater return from his enterprise than by shared use of a more efficient, larger machine. The second hypothesis is that the comparatively large number of small farms in the LDCs would enable economies of scale in manufacturing of small tractors that could negate the usual relationship of costs for various tractor sizes. This latter assumption is not crucial but nonetheless of considerable significance when looking at the size stratification of farm enterprises in India or Honduras as a couple of examples (see Tables 1 and 2).

Thus, the question was asked, "What would be the performance of small tractors on Indian farms?" The Ford Foundation provided a grant to Allahabad Agricultural Institute to study this question.

I. The Tractor Evaluation Project

Under the Tractor Evaluation Project, four tractor types were selected for placement on typical farming enterprises. Tractors and matching implements were purchased from commercial production to represent these types. The project provided full backup servicing, spare parts, equipment adaptation and adequate capacity to monitor performance and ensure a simulation of normal farm use. The project provided initial operator training and necessary assistance to maximize the use of the equipment.

Systematic performance monitoring and testing under real field conditions was conducted through the full period of farm use. At the end

of the three-year project, data was available from 29 farmers for periods of 15 to 30 months of tractor use.

The tractors were selected to represent Japanese, European and U.S. engineering practices and implement options. Both walking and riding types were obtained. In many cases, improved animal-drawn implements were modified and attached to provide the farmers with the equipment of their conventional practices. By purchase of commercial machines, the project acquired equipment more quickly and at lower cost than by local development. The expected suboptimum performance of imported equipment was considered a negligible factor. The initial selection of equipment and spare parts provided for a wide range of study (see Table 3).

The farmers were selected for their reputation as progressive managers and for their expressed interest in cooperating with the project. The village-level workers of the Government extension service were asked to nominate a small group from which the project staff selected the cooperating farmers. The farmers were the 3-5% of the size class in which are usually found the innovators of their community. One of the facts discovered in the selection process was that practically every village included one or two farmers who had strong interest in having a small tractor.

The farmers were provided training in the care and operation of equipment and in the maintenance of the service and performance records. The farmers were required to purchase all of the fuel and oil used. Rent was not charged for the use of the equipment in lieu of the farmers' agreement to maintain records and cooperate in occasional detailed

performance measurements for the various implements. Also, as the equipment was on loan to the farmer, it was expected that he would continue to maintain his work animals for use after the project was completed. A team of three Peace Corps Volunteers and four Indian agricultural engineers was used in farmer training, operational support and compilation of the performance records. After the tractor was assigned to the farmer, he made the decisions regarding the use of the tractor. The field staff offered recommendations upon request but minimized their role in decisions regarding use.

Three types of measurements were compiled during the project. The farmers maintained a simple, continuous record of tractor use, servicing and other observations. The operating records were collected weekly, compiled and summarized by the project staff. One engineer was assigned to each tractor type with the task of making comprehensive, precise operating studies for all tools. These performance tests were used as a standard in reviewing the farm performance and also as a basis for equipment comparison and adaptation. One engineer worked full-time in adapting the improved animal-drawn implements for use with the project tractors. Performance data was collected and the adaptations were offered to the farmers as optional equipment. The adaptation work was of a second priority status in the project, but the staff was of sufficient capability to permit a considerable time for this type of activity.

II. What was learned?

The farmers used the tractor more than was expected, reaching 600 hours per year in the second year of use. In the first year they

specialized in tillage, hauling and water pumping. In the second year they tried threshing and planting. Also in the first year they did a considerable amount of custom work, often tillage for a neighbor in exchange for his use of oxen to plant on the tractor user's farm. Generally the farmers shifted to complete tractor use on their own or family land.

Innovations, particularly more intensive land use, were being attempted throughout the project. One of the most interesting observations was that the oxen were sold by all farmers after a month or so of tractor use. A few of the farmers replaced the oxen with milk animals, and others noted that the sale of fodder was an additional source of farm income.

All farmers reported an increase in production which resulted from a combination of more double cropping and increased yields. Before the use of the tractors, the farmers had realized about 130% crop intensity on their land. Tractor use enabled crop intensity to be raised to 150-180% and farmers indicated the intention of going to over 200% if they could continue to have tractor power. All farmers claimed increased per-acre yields because they were using better seeds, more fertilizer and more irrigation as well as better timeliness of field work. Attribution of the yield benefits to tractor use rather than the other inputs was not attempted although there is apparently a strong interdependency (see Table 4).

The placement of tractors on farms was according to the ratio of 1-3 acres per engine horsepower. Initially we were not confident that

the farmers were reporting their farm acreage accurately, nor were we confident of the optimum size relationship. As the project developed we learned that the farmers had underreported their land holdings. As the farmers mastered the use of tractors, they tended to concentrate the use on an area of 1-2 acres per engine horsepower. A few implements were used more extensively for custom work. Another factor tending to reduce the command area was the shift to more double cropping. It appears that one horsepower per acre may be the design basis for intensive farming in the project area.

The impact of tractor use on hired labor was one of the more surprising observations of the project. Because the project anticipated the farmer discontinuing hired labor use with the reliance on tractor power, the farmer was trained as the tractor operator. However, in practically all cases, the farmer trained his permanent hired-man to operate the tractor within a month or so of getting the tractor. This arrangement provided the farmer with more status, more freedom to go to town and, as it turned out, more access to scarce supplies of improved seed and fertilizer. At the same time the greater yields contributed to a higher salary for the permanent hired-man and some increase in daily wage rate work. This phenomena had not been anticipated at the outset, nor was it detected in the first year; consequently, baseline data was not collected for thorough analysis.

The project staff was adequate for all training, servicing, data collection and analysis functions, plus considerable study of equipment adaptation. The training program eventually evolved into a three-day

initial program for a farmer followed by one-day programs for each field implement. The farmer service and data collection requirements were accomplished in weekly visits after the first season of tractor use. Daily visits were necessary only during the first week. At any time the farmers could inform the project headquarters by mail or by visit using bus service, and an engineer could be on his farm the same day or the next day.

Locally made implements were adapted to all tractors for the common and improved cultural practices. All of the imported implements were demonstrated to all of the farmers, but many implements were not accepted because of the complexity of adapting the farm enterprise to their use. For example, a reaper was available for one tractor but farmers were unaccustomed to the early harvest necessary to minimize field shatter losses. In other words, the farmers would have been satisfied with much simpler tractors and implements, at least through the first five years of tractor use.

There were some equipment servicing problems. For example, one farmer replaced the crankcase oil of a diesel tractor with "filtered" oil rather than new oil. Another farmer continued to use a cultivator after bending a standard by hitting a rock. Two operators were hurt seriously and machines were occasionally operated with loose bolts or poor adjustment for the particular field conditions. The fact was that the farmers did follow the instructions as they understood them. It was possible to develop a training program that worked from the third to fifth grade education of the farmers. It was interesting to note that the final list

of service problems did not include anything different from the University of Illinois study of Maintenance of Sixty Farm Tractors.

III. How to Use the Experience

The Tractor Evaluation Project demonstrated the functional utility of small tractors on small farms. Evaluation of the data indicates that a simple tractor and implements would have been adequate for the first five years of tractor use, if not for the life of the tractor. The limited data, however, requires speculation about the economics of small tractor use. From the information available, it appears that the economic analysis is also site specific and should be undertaken in each locality of interest.

The intensive servicing provided by the project was an important aspect differentiating this study from numerous attempts at introducing small tractors to LDC agriculture. The initial training and service requirements were found to be high but they decreased rapidly as farmers gained mastery of the equipment. A specialized mobile field crew for the introductory season may be the strategy for setting up commercial viability in acceptable time frames. By elimination of the adaptation aspects and the data collection work of the project, it would probably have been possible to introduce more than fifty tractors in a radius of 25 kilometers during a one-year period with the seven field staff of the project.

The established use of high-yield technology stands as an essential precondition for tractor use. The high yielding varieties establish a high-yield potential that improved management and tractor power may exploit. The initial use of improved technology also proved to be a reliable

proxy for the farmers having established the commercial linkages necessary for the purchase of fuel, oil and other supplies. This precondition is not a serious constraint to small tractor introduction, as more than 90% of Indian wheat acreage is now in high yielding varieties.

The benefits of small tractor use in some other areas of the world may exceed the benefits observed in India. There are areas in Central and South America where weeds are a serious problem and where land is not cultivated for lack of enough animals or large tractors. Many of these plots are limited by the terrain and are quite likely to be best suited to small tractor operations.

Based upon the Tractor Evaluation Project, it appears that a team of two demonstrators or servicemen might assist a dealer place 20 tractors on farms in one season. If each of these farmers were designated to be a "model farmer" and thereby provided some help to interested neighbors, it might be possible to expect each tractor to stimulate the sale of one or two additional tractors the next work season. If sales grew at the rate of three per year for each tractor in the population, a commercially viable enterprise could be established rather quickly.

Micro and macroeconomics remain largely unexplored. The microanalysis appears to be favorable based upon the potential for sizeable production increase. Further, a quick comparison of simple, small tractor prices with the costs of draft animals and irrigation pumps reveals essentially equal prices. The macroimpact is perhaps even more interesting. A rapid increase in agricultural production is sought by all LDCs. The prospect of achieving this with local industrial enterprise is very

attractive. The additional prospect of the agricultural segment being a net employer and an expanded consumer market is an additional benefit.

There are a number of U.S. small tractors that have the functional requirements indicated by the Tractor Evaluation Project. A further study of these tractors to determine their economic parameters is needed to advance the frontier of knowledge in this field. This hard economic data is needed to provide the firm basis for the investment decisions that are necessary to set up a tractor industry.

TABLE 1

ALL-INDIA FARM POWER SPECTRUM

Farm Size	Power Source	Farms		Area
		Number	Percent	
(acres)		(thousands)		(percent)
0 - 5	Hired	31,076	62.3	19.0
5 - 10	Bullocks	9,646	19.3	20.3
10 - 25	Small Tractors	6,843	13.7	30.8
25 - 50	Small Tractors	1,795	3.6	17.9
50+	Large Tractors	514	1.0	11.8

TABLE 2

FARM SIZE: DISTRIBUTION OF FARM NUMBERS AND AREA

TECHNOLOGY	FARM SIZE (HA)	FARMS		AREA (HA)	
		No:	%	Area	%
Hired	0 - 2	72,417	37.1	75,118	2.8
One Animal Pair	2 - 5	52,330	26.8	163,561	6.1
Small Tractors	5 - 20	47,478	24.3	468,983	17.6
Japanese, 4-wheelers	20 - 50	15,184	7.8	461,464	17.5
Conventional Tractors	50+	7,908	4.0	1,485,849	56.0
TOTAL	-	195,297	100.0	2,655,095	100.0

SOURCE: 1976 Agricultural Census

TABLE 3

RECOMMENDED TRACTOR SPECIFICATIONS*

	I	II	III	IV
Tractor Style	Walking	Walking	Riding	Riding
Engine Horsepower	5	10	10	15
Weight (lbs.)	325	650	1,000	1,500
Drive Wheel Size	4 X 10	650 X 16	6 X 16	8 X 24
Wheel Tread Min. (in.)	14	24	32	37
Wheel Tread Max. (in.)	24	36	36	48
Clearance (in.)	6	8	10	16
Wheelbase (in.)	-	-	48	60
Front Wheel Size (in.)	-	-	4 X 10	4 X 10
Turning Radius (in.)	-	-	66	84

* Source: Progress Report No. 5--Recommendations of Specifications for Tractors of Less Than 15 Horsepower Which are to be Used in India, Tractor Evaluation Project, Allahabad Agricultural Institute, October 1966.

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TABLE 4

SMALL TRACTOR PERFORMANCE SUMMARY TABLE*

Years of tractor use	1 - 3	3 - 5	5 - 10
Land area controlled (A/Hp)	4	4	3
Cropping intensity (percent)	150	200	225
Irrigation pumping (hours)	200	250	300
Tillage (hours)	125	175	225
Carting[a/] (hours)	50	50	50
Seeding (hours)	-	50	150
Threshing (hours)	-	25	100
Spraying (hours)	-	25	50
Miscellaneous (hours)	-	25	25
Hired out (hours)	100	100	-
TOTAL HOURS	500	700	900

* John S. Balis, Progress Report No. 14--Summary of the Project, The Tractor Evaluation Project, Allahabad Agricultural Institute, March 1967

a/ Does not include travel to market or near villages for family, social or similar purposes.

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