THE ECONOMICS OF THE MOLDBOARD PLOW AND THREE-TINE CULTIVATOR IN TWO DISTRICTS IN UTTAR PRADESH*

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The use of improved bullock-drawn implements is increasing rapidly in many parts of India. This is partly a result of efforts by extension agencies but more basically is because farmers are recognizing the definite advantages of some of these tools.

A sufficient number of farmers are now using some implements to permit an economic evaluation of their use under actual farm conditions. Two of the more popular improved implements in Uttar Pradesh are the moldboard plow and three-tine cultivator. The purpose of this study is to determine the economic benefits obtained on various types of farms by changing from the use of the wooden *deshi* plow, exclusively, to the use of one or both these tools.

The nature of these benefits is examined from two points of view. The first is the contribution of these two implements to the national goal of increased agricultural production. The second is their impact on the net farm income of individual farmers through their influence on both yields and costs of production.

This analysis should be useful to farmers and to those advising them on the adoption and use of improved tools. Farm planners can use it as a basis for recommendations on the adoption of these improved implements and for their calculations on the income results of adoption. Manufacturers can develop estimates of their potential market and make use of the information in their selling efforts.

Data on the use of the moldboard plow were collected in Allahabad district while the three-tine cultivator data were obtained in Etawah district. A total of 169 records were completed. The original plan was to obtain records from an equal number of users and non-users of the improved implements. This plan was successfully completed for the plow farms in Allahabad district, but few non-users of the cultivator were found in Etawah district. Analysis of the cultivator data, therefore, is more limited than that of the plow data. The analysis of benefits to farmers is based on the partial budget method.

The paper starts with a discussion of the ways in which these two implements are being used by farmers. Discussion of possible increases in yield and decreases in cost of production is followed by presentation of eight partial budgets showing the income benefits from using these tools on different types of farms.

Use of the word "plow" throughout this paper indicates the moldboard plow under study. When reference is made to the traditional pointed wooden plow,

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the words "*deshi* plow" are used. This entire study is based on the actual use of these implements by farmers and not on the use which could or should be made of them.

USE OF THE TWO IMPLEMENTS

Although it was the original intention to study each implement separately, data collected indicate that the moldboard plow is usually used prior to the cultivator. This discussion, therefore, will emphasize use of the moldboard plow alone in Allahabad district and of the plow-cultivator combination in Etawah district.

Since the use of these implements varies not only from farm to farm, but also from crop to crop on each farm, patterns of use are rather complex. Typical practices are presented in some detail and the nature of variation from these practices is indicated.

Use of the Moldboard Plow

The primary use of the moldboard plow is, of course, in seed-bed preparation. Typical methods of preparing seed-beds for major crops on farms of users and non-users of the plow are shown in Table I.

TABLE I—TYPICAL METHODS* OF SEED-BED PREPARATION FOR SPECIFIED CROPS, USERS AND NON-USERS OF THE MOLDBOARD PLOW, 96 FARMS, ALLAHABAD DISTRICT, U.P., 1964

Crop	Farms reporting		Number of plowings with			Median total plowings	Total hours per acre**
	Type	Number	Moldboard plow	Three-tine cultivator	*Deshi* plow		
Jowar (*Kharif*)	Users	46	—	—	3	3	36
	Non-users	46	—	—	2	2	24
Bajra (*Kharif*)	Users	44	1	—	4	5	60
	Non-users	49	—	—	5	5	60
Paddy (*Kharif*)	Users	25	—	—	3	3	36
	Non-users	24	—	—	4	4	48
Wheat (*Rabi*)	Users	36	2	1	10	13	149
	Non-users	31	—	—	12	12	144
Barley (*Rabi*)	Users	40	2	—	10	12	144
	Non-users	39	—	—	11	11	132
Birra (*Rabi*)	Users	22	1	—	8	9	108
	Non-users	37	—	—	10	10	120
Gram†	Users	37	—	—	4	4	48
	Non-users	33	—	—	5	5	60
Peas†	Users	15	—	—	4	4	48
	Non-users	23	—	—	4	4	48

* Based on median number of total plowings.

** Moldboard plow—12 hours per acre; Cultivator—5 hours per acre; *Deshi* Plow—12 hours per acre. These figures may be 10-20 per cent too high because of enumerator bias.

† Usually grown in the *rabi* season following *kharif* crops of paddy or fodder.

The moldboard plow is not used as a substitute for the *deshi* plow. With the exception of *birra* (a combination of barley and gram) the average total number of plowings was higher on plow user than on non-user farms for all crops on which the moldboard plow was commonly used. The plow is apparently often used for an additional first plowing and is then followed by the normal number of plowings with the *deshi* plow.

It is at least clear that the moldboard plow is not associated with a reduction in total number of plowings. This conclusion is accepted in spite of the statement by eight moldboard plow users that it does permit such a reduction. Analysis of the plowing patterns on these eight farms showed an average number of plowings equal to or higher than the non-user average for all crops on which use of the moldboard plow is common.

A second general conclusion is that use of the moldboard plow does not reduce the time required for seed-bed preparation. The time required to plow an acre is at least as long with a moldboard plow as with a *deshi* plow and since there is no reduction in number of plowings, the time required is not reduced.

The use of the moldboard plow varies from farm to farm. Its use is most common on the *rabi* season crops of wheat, barley, and *birra*. About half the plow users used it on the *kharif* crop of bajra but use on other crops was uncommon. The *deshi* plow, on the other hand, was used by all farmers on all crops with the exception of three farmers who prepared their jowar seed-bed by plowing twice with the cultivator.

Variation in use of the plow from farm to farm indicates a considerable amount of experimentation by farmers on just how this new implement can most advantageously be used. They are experimenting with the crops on which it should be used, the number of times it should be used per crop, the times of the year it should be used and the extent to which it can substitute for the *deshi* plow. Use of the cultivator in Allahabad is in an even more tentative and experimental stage. This experimentation indicates an intelligence and initiative towards their farming on the part of village farmers that may surprise some. It also indicates the nature of the process of adjustment to a new implement. Such experimentation was necessary if farmers were to use the plow at all since answers to these practical problems of use are apparently unavailable from sources outside the village such as extension workers and salesmen.

Use of the Plow-Cultivator Combination in Etawah District[1]

To the extent that the name "cultivator" implies use for weeding or interculture, the three-tine cultivator is misnamed. In terms of its use by farmers, a more correct name would be "three-tine harrow" since it is used almost exclusively for seed-bed preparation. There was not a single report of its use for interculture in this study.

Typical seed-bed preparation methods for *kharif*, *rabi*, and annual crops in Etawah district are shown in Table II. The moldboard plow is used once on crops

1. Farmers have been classified into user and non-user groups on the basis of their cultivator use.

requiring a small number of plowings and twice on crops with a larger number. The cultivator tends to be used for somewhat more than half of the remaining plowings on user farms.

TABLE II—TYPICAL METHODS* OF SEED-BED PREPARATION FOR SPECIFIED CROPS, USERS AND NON-USERS OF THE THREE-TINE CULTIVATOR, 48 FARMS** IN ETAWAH DISTRICT, U.P., 1964

Crop	Farms reporting		Number of plowings with			Median total plowings	Total hours per acre†
	Type	Number	Moldboard plow	Cultivator	*Deshi* plow		
Jowar (*Kharif*)	Users	23	1	2	1	4	23
	Non-users	7	—	—	4	4	36
Bajra (*Kharif*)	Users	33	1	2	2	5	32
	Non-users	14	—	—	5	5	45
Wheat (*Rabi*)	Users	33	2	5	3	10	57
	Non-users	14	1	—	9	10	90
Sugarcane (Annual)	Users	24	2	5	3	10	57
	Non-users	4	1	—	7	8	72

* Based on median number of total plowings.
** These data were obtained from 48 of the 73 farmers interviewed in the district.
† Moldboard and *deshi* plows each 9 hours per acre; cultivator 2.5 hours per acre.

Little variation in average total number of plowings on user and non-user farms is indicated except for sugarcane where the four non-user farms had a lower average. However, since the cultivator requires only about 2.5 hours per acre while the plows require nine hours per acre, use of the cultivator effects a substantial reduction in the amount of time required for seed-bed preparation when it substitutes for the *deshi* plow. Average figures indicate a time saving of almost half for *rabi* crops and one-third for *kharif* crops (Table III). The saving is less for sugarcane but this may be influenced by the small number of observations on non-user farms. These average savings in time amount to about 8 days of work per acre for *rabi* crops and 2 to 3 days per acre for other crops.

The moldboard plow-cultivator combination is widely used in Etawah district and, on users' farms, is generally used on all crops. Its use does not result in any change in total number of plowings but does substantially reduce the amount of time required for seed-bed preparation since the cultivator can cover a field much faster than either of the plows. The *deshi* plow continues to be used for plowings prior to planting. The cultivator is apparently considered an effective substitute for the *deshi* plow, at least for the first several plowings following the use of the moldboard plow.

TABLE III—PER CENT DIFFERENCES IN AVERAGE TOTAL NUMBER OF PLOWINGS AND SEED-BED PREPARATION TIME ON THREE-TINE CULTIVATOR, USER AND NON-USER FARMS, BY CROPS, 48 FARMS IN ETAWAH DISTRICT, U.P., 1964

Crop	Difference in average number of all plowings*	Difference in average hours per acre*
		(per cent of non-users' average)
Jowar	9	—28
Bajra	8	—30
Wheat	—5	—48
Sugarcane	22	—17

* Negative figure indicates that cultivator users averaged less plowings or less time per acre than non-users.

Other Uses of the Two Implements

Farmers were asked if they use either of these implements for other work in addition to seed-bed preparation. The plow is used only for seed-bed preparation. A few farmers reported use of the cultivator for planting; two for covering broadcast *kharif* crops and, with the available seedling attachment, four for drilling other crops.

Reasons for Use and Non-use of the Implements

Farmers in Allahabad district clearly consider the use of the moldboard plow an important part of their weed, especially grass, control programme. Its greater ability to control grass compared with the *deshi* plow was mentioned by 96 per cent of its users as a reason for buying and using it. It permits a substantial reduction in interculture labour and results in direct cash savings for many farmers. A third of the farmers reported improved pulverization of the soil and several farmers indicated other contributions of the plow to increased yields. A few consider its use an important part of their green manure programme.

In questions such as this, some reasons may have considerable importance but receive only few mentions because they require more sophistication to identify and express. The plow's contribution to increased yields may be of this nature and will be further discussed in the next section. A similar reason may be the possibility of plowing in June, given by only one farmer. This might be a significant advantage of the moldboard plow which is not being exploited by most farmers.

Use of the plow takes on added significance when the farmer begins to use the cultivator. The plow apparently makes use of the cultivator feasible since most farmers use the plow on the field prior to the cultivator.

Farmers' reasons for using the cultivator in Etawah district contrast sharply with reasons associated with the plow. The dominant reasons are the saving of time, labour and money mentioned by almost all farmers. About half of the farmers also feel that the cultivator helps in grass control and a few feel that it improves the seed-bed. An interesting and perhaps significant omission from this list is reference to increased yields.

Reasons for non-use imply that most non-users are convinced of the advantages of these implements and desire to use them. For both implements, lack of purchase money and weak bullocks are the dominant reasons for non-use. Antagonism to the tools exists but is apparently limited to a few farmers. Some objected to the plow's poor evaporation control, its tendency to create clods when used after the monsoon ends and the dead furrow in the middle of the field. One farmer said that the cultivator caused a decline in yield.

Use of Time Saved by the Implements

Etawah farmers were asked about their use of the time saved by the cultivator. Their answers are somewhat discouraging. Few of the farmers reported productive use of this saved time unless one considers additional plowings productive. Plowing the fields again and again was the most common answer. Four farmers reported use of bullocks for hauling purposes and two made fencing and/or ridges. These answers seem to indicate little alternative opportunities for the use of the saved time of bullocks and labour in the study area. Since both bullocks and labour are fixed cost inputs in many farm situations, the benefits of the cultivator may be less than the saving of time indicates. Further analysis of this is presented below.

Adjustment to Use of the Two New Implements

The two study districts provide an instructive contrast in the process of adjustment to these two additions to the farming environment. Farmers in Etawah have learned how to make extensive use of them in combination with each other and with the *deshi* plow. In Allahabad, on the other hand, farmers are making tentative first steps in the process of integrating them into their farming system.

The process of adjustment to these new tools on any one farm evidently starts with the use of the moldboard plow as an extra first plowing on *rabi* crops for grass control. This permits a maximum number of plowings with the *deshi* plow after the moldboard plow use and before planting to minimize the risk of any adverse effect of the moldboard plow. The use of the plow is gradually extended to include more and more of the crops grown on the farm. As confidence in the moldboard plow is developed, consideration is given to the cultivator. Its use is started first in a rather tentative way with one or two plowings after the moldboard plow and prior to major use of the *deshi* plow, first on *rabi* crops and perhaps jowar. Use of the cultivator is gradually increased with concurrent reduction in the use of the *deshi* plow. The ultimate adjustment, apparently, is the complete abandonment of the *deshi* plow. No farmer was found who has been willing to take this final last step although several in Etawah district are approaching it.

INCREASE IN YIELDS ASSOCIATED WITH USE OF THE PLOW AND CULTIVATOR

From the national point of view, the major interest in these two improved implements is the possible increase in yield associated with their use. There are several justifications for a hypothesis of increased yields.

Some of these are indicated by reasons for use given by farmers. An improved seed-bed, better germination, deeper plowing, an increase in organic matter by plowing under farmyard manure, green manure, weeds and crop residue, better moisture retention, and better weed (grass) control were mentioned by one or more farmers. An additional impact from the cultivator could come from improved timeliness of operation but this is not an influence of the plow. Both implements might contribute to the effectiveness of other improved practices in such ways as fertilizer mixing and placement and a better seed-bed for improved seeds.

Methods of Studying Yields

Study of increased yields associated with use of the implements was based on comparison of yields on paired implement user and non-user farms. Farmers were not asked their yields directly but were asked the area and total production of each crop for the most recent harvest (March, 1964, for *rabi* crops and September-December, 1964, for *kharif* crops). Yields were then calculated from this information. User and non-user farms were paired for purposes of analysis on the basis of similar size of farm, number of bullocks, combination of crops, proportion of cropland irrigated and location within the same village. Because an insufficient number of non-user records were obtained in Etawah district, analysis is limited to differences between plow users and non-users in Allahabad district.

A difficult analytical problem resulted from the prevalence of mixed crops. Nearly all crops, except paddy, are grown in mixtures which have no standard proportion of the different crops. Yields of individual crops, therefore, are not comparable among farms. This problem was handled by converting acre yields of each crop on each farm to a value figure, using wholesale market prices in March, 1964[2] and adding values of each crop in the mixture together to determine the value of production per acre for the mixture.

Another analytical problem in studying the impact of the implements on yields was the possible differential use of other improved practices on user and non-user farms. It seems reasonable to expect that use of other new practices is more common on farms where the improved implements are used. In fact, the plow makes possible some improved practices such as green manure. If this differential use exists, yield differences could result from this rather than from use of the implements. This possibility was recognized and information on use of six other improved practices was obtained from all farmers.

Yields on User and Non-user Farms

With some exceptions, differences between users and non-users are small (Table IV). A somewhat greater percentage of implement users use chemical fertilizer in both districts and in Etawah district cultivator users make substantially more use of improved seed. These figures do not indicate the extent of use of these practices on each farm in the two groups. They do, however, support the conclusion that, except for some influence from chemical fertilizer, the differential use of improved practices is not an important explanation of any yield differences found between user and non-user farms in Allahabad.

2. Index of Wholesale Prices in India, Revised Series, for Week ending March 28, 1964 Office of the Economic Adviser to the Government of India, New Delhi.

TABLE IV—USE OF OTHER IMPROVED PRACTICES BY USERS AND NON-USERS OF THE MOLDBOARD PLOW AND THREE-TINE CULTIVATOR, 96 FARMS IN ALLAHABAD DISTRICT AND 73 FARMS IN ETAWAH DISTRICT, U.P., 1964

Improved practice	Allahabad District		Etawah District	
	Users	Non-users	Users	Non-users
	(Per cent using practice)			
Chemical Fertilizer	81	59	88	57
Interculture of *kharif* crops	100	98	98	93
Green manure	23	18	14	21
Farmyard manure	100	100	100	93
Improved seeds	6	2	42	7
Number of farms in group	47	49	59	14

The average value of production per acre for the common crop mixtures in Allahabad district is shown in Table V. For every crop mixture, the average value per acre was greater on user farms. None of the differences for the individual mixtures, however, was significant, primarily because of the extreme yield variation from farm to farm. The standard deviation for paddy and for barley, for instance, was about Rs. 180 when the average value per acre for all farms was about Rs. 300. The difference of Rs. 35 per acre (15 per cent) in the all-crop averages was significant at the ten per cent but not at the five per cent level.

TABLE V—AVERAGE CROP VALUE PER ACRE ON FARMS OF PAIRED USERS AND NON-USERS OF THE MOLDBOARD PLOW, 60* FARMS IN ALLAHABAD DISTRICT, U.P., 1964

Crop	Number of farmers reporting crop (in pairs)	Average crop value per acre		Difference
		Users	Non-users	
		Rs.	Rs.	Rs.
Paddy	42	352	287	65
Jowar mixtures	58	201	187	14
Bajra mixtures	60	231	224	7
Wheat mixtures	38	242	210	32
Barley mixtures	54	334	266	68
All crops**	—	268	233	35†

* The other 36 farms from which records were obtained in Allahabad district could not be paired.

** Weighted by number of farmers reporting crop but not by acreage of crop per farm.

† This all-crop difference is significant at the 10 but not at the 5 per cent level. None of the other differences is significant at these levels.

The only known published experimental study of the influence of the moldboard plow and cultivator on yields reports only small and non-significant differences among plots on which the *deshi* plow was used alone and plots on which various combinations of improved implements were used.[3]

Study of these data leads to the impression that use of the moldboard plow does result in somewhat higher yields as compared with use of the *deshi* plow alone. Although opinions among farmers vary, a majority of farmers would apparently agree with this general conclusion and several suggested reasons why the plow does increase yields.[4]

The extent of this increase in yields, however, cannot be measured by available data. The numerous weaknesses in the data and the non-significance of differences that were found make any estimate tentative. In the partial budgets found in the last section of this paper, it will first be assumed that use of the moldboard plow makes no impact on yield. An amendment to each budget will then be made to show the influence of 7.5 per cent increase in yields, one-half the average difference found between users and non-users of the plow. Since no analysis of the cultivator's impact on yields was possible, it will be assumed that it has no additional impact on yields above increases assumed for the plow, alone.

The total picture of production increases from the national point of view would be incomplete without mentioning a possible increase in milk production. This could result from a decrease in bullock requirements which would release fodder for feeding additional milk buffalo. A more complete discussion of this possibility is presented below.

CHANGES IN COST OF PRODUCTION ASSOCIATED WITH USE OF THE TWO IMPLEMENTS

The nation is primarily interested in the impact of new implements on total production. Most farmers, however, are interested in their influence on net income. Income can be influenced not only by changes in production but also by changes in the cost of production.

The Moldboard Plow Used without the Cultivator

Hypothesized savings in production costs associated with the plow were based on the assumption that the plow saves time and thus reduces bullock labour expense. That this is not true has been demonstrated in the discussion on the use of the plow.

Use of the plow does apparently, permit a saving in the cost of interculture. All but one of the 47 users of the plow hired some labour for the weeding of paddy, jowar and bajra. This is often a sizable production cost, the average for all plow users being Rs. 98 per year. Weeding is often done on contract although sometimes the farmer acts as his own contractor.

3. S. E. Roy, "Effect of Selected Cultivation Practices comparing Local with Improved Implements on Physical Condition, Moisture, and Fertility Status of Soil," *Allahabad Farmer*, Vol. 33, No. 6, November, 1959, pp. 529-31.

4. The questionnaire used did not include a direct question about farmers' opinions on the plow's impact on yields.

There was little agreement on the amount of savings. About 40 per cent would claim no savings for the plow. Among the 60 per cent who did report savings, opinion on the proportion of cost saving varied from 10 to 60 per cent with an average of 30 per cent or about Rs. 3 per crop acre. On the basis of these data and the relative importance given to grass control as a reason for using the plow, a 30 per cent saving on interculture costs from use of the moldboard plow seems to be a reasonable estimate.

The annual costs of owning and operating the plow (depreciation, interest, and repairs) are not offset by any savings in the operation of the *deshi* plow. The *deshi* plow continues to be used about as much as before the adoption of the moldboard plow.

The Plow-Cultivator Combination

When a farmer uses both the moldboard plow and the three-tine cultivator, he clearly saves time on seed-bed preparation. This saved time has a substantial impact on production costs in certain farm circumstances although in others, it may have almost no impact. Since an insufficient number of non-users' questionnaires was completed for comparison purposes, most conclusions must be based on data from users themselves.

Users were asked the number of additional bullocks they would need to farm their land if they stopped using their cultivators (Table VI). Farmers with up to about 8 or 9 acres could continue to farm with only one pair of bullocks although there is a difference of opinion among farmers having 7.5 to 8.5 acres. Nearly all users having 9 to 14 acres who are now farming with one pair of bullocks would require a second pair if they gave up use of the cultivator. This same relationship is shown among users who presently have two or more pairs of bullocks. Among the non-users of the cultivator, all with one pair of bullocks had seven acres or less while the one farmer with two pairs had only 10 acres.

Adoption of the cultivator in Etawah district permits an increase in the amount of land which is farmed with one pair of bullocks from 8 or 9 acres up to about 15 acres. This conclusion is roughly consistent with the amount of time saved by the cultivator as discussed previously. This means the cultivator, as typically used in the district, enables farmers having 9 to 15 acres to save the entire annual cost of owning and feeding a second pair of bullocks. They also may save the wages of the hired labourer no longer needed to drive the second pair of bullocks. On larger farms, the savings are the same or greater, depending on acreage.

On smaller farms of 8 acres or less where one pair of bullocks is sufficient when the *deshi* plow is used alone, and where there is a fixed family labour force, the new implements provide a much smaller income advantage.[5] The farmer continues to need his one pair of bullocks after he adopts the new implements and continues to have the same labour force. He realizes little cash saving on his bullocks or on labour to drive them.

5. According to the 1951 Census of Agriculture, 81 per cent of the farms in Uttar Pradesh had less than 5 acres and 94 per cent had less than 10 acres.

He can, of course, do his work faster with the new implements and can obtain income benefits from this saved time by making other concurrent changes in his business. These usually require a substantial level of sophistication on the part of the farmer and a strong desire to increase income.

TABLE VI—EXPRESSED NEED FOR ADDITIONAL BULLOCKS IF USE OF THE THREE-TINE CULTIVATOR WERE STOPPED, BY SIZE OF FARM, 73 FARMS IN ETAWAH DISTRICT, U.P., 1964

Size of farm		Users of cultivator		
Present number of bullocks	Acres of plowed land	Need more bullocks without cultivator	No change in bullocks without cultivator	Non-users of cultivator
		(number of farms)		
One bullock ..	2.75 to 6.75	—	2	3
One pair ..	2.75 to 7.0	1	17	10
	7.5 to 8.5	4	5	—
	9.0 to 14.0	12	1	—
Two pairs ..	Less than 15.0	—	2	1
	15.0 to 37.5	13	—	—
More than two pairs ..	25 to 31.5	2	—	—
Total ..		32	27	14

One possible step would be to sell one bullock from his team and then arrange to trade bullock work with another small farmer who has also adopted the cultivator and also keeps only one bullock. Such an arrangement presently exists among very small farmers and use of the plow-cultivator would make it feasible for farmers with up to 6 to 7 acres each. This would save, for each farmer, the cost of keeping one bullock for a year, a relatively substantial sum. One farmer in the study may have made this adjustment. He was using the cultivator and had only one bullock to farm his 6.75 acres of cropland.

It is unlikely that many farmers will be willing to make this adjustment. The change from owning two bullocks to owning one bullock will result in a substantial decline in prestige for the farmer. Few farmers will consider a Rs. 500 or so increase in income an adequate payment for this of loss prestige. In addition, co-operation with another farmer, in circumstances where timeliness of operation is often critical, can lead to unpleasant situations if not actual loss.

Instead of selling only one bullock, the small farmer could consider selling both the bullocks and hiring all his bullock work, perhaps, from another small farmer who adopted the plow and cultivator but chose to keep his pair of bullocks. This would result in an even greater loss of prestige than selling one bullock. Because of lack of direct control over his draft power, his general sense of insecurity would also be sharply increased. This adjustment, therefore, is unlikely.

Perhaps the easiest adjustment would be to retain both the bullocks and to hire them out in the time saved by the implements. In both the study areas, the practice of hiring out bullocks and alternative opportunities for using saved time are currently uncommon. This adjustment, therefore, is probably possible only when another farmer has been willing to make the adjustment of selling both of his bullocks, a rather unlikely step as discussed above.

It is probable that a single farmer in a village can expand the size of his farm either through renting or buying more land. His bullocks and labour will then continue to be fully employed and his income can increase substantially. This adjustment, however, cannot be generally followed by all small farmers because of the fixed amount of land in a village.

A final type of adjustment would be to find additional employment for the bullock and labour resources released by use of the plow and cultivator. This could be on the existing farm through reorganizing the combination of enterprises to provide more bullock and labour employment or through land improvement and similar activities. Another alternative would be to find non-farm employment, such as hauling with a bullock cart or hiring out to other farmers as suggested above.

Answers to the questions on uses of saved time indicate that farmers are presently unsuccessful in making productive use of this time. Although they said that they plowed their fields again and again, they did not plow more often than non-users. Few farmers reported hauling work with their bullocks or hiring out to other farmers.

Productive use of this saved time is clearly a subject on which farmers need help if they are to obtain maximum benefits from these new implements. It is a new experience for most farmers to have their traditional operations and use of time upset in this way and they are unable to make beneficial adjustments. In addition, possible adjustments are probably not well understood by those in a position to help the farmers. Research on this general subject would be useful to both farmers and their advisers.

The True Nature of Savings on Bullock Costs

Since the major bullock expense is feed, most of which is home-grown crop residues, much of the saving on bullocks will not be in the form of additional cash staying in the farmers' pocket but will be a pile of unutilized fodder. The most profitable use of this fodder was not a subject for study here but a few thoughts about its use may be of interest. Many farmers might find it advisable to feed their remaining bullocks more adequately to enable them to pull larger

implements and to increase speed. A limited number of farmers in an area might be able to sell the extra fodder but opportunities for sale are probably limited in most communities where some kind of a feed balance already exists prior to a reduction in the number of bullocks.

An obvious use is to add or expand the dairy enterprise on the farm by feeding this fodder to buffaloes as a supplementary enterprise. According to one informant familiar with Etawah district over a long period of time, this is exactly what farmers of the district have done. Milk production for sale and for home consumption has increased substantially. A major ultimate national benefit from the use of the plow and cultivator is, apparently, an increase in milk production.

Other Changes in Production Costs

When seed-bed preparation time is reduced, labour costs as well as bullock costs may be reduced on farms hiring labour. All the 59 users in Etawah district hire some labour and 54 said they would hire more labour if they stopped using the cultivator. This extra labour would be needed for plowing (13 farmers), weeding (2 farmers) or both (39 farmers).

Analysis of interculture costs in Etawah district support the conclusion that the cultivator makes no further reduction in weeding costs beyond that achieved by use of the plow.

The annual ownership costs of the two implements, of course, represent additional expense for the farmer. Because he continues to own and use his *deshi* plow, he continues to have its ownership costs although these may be slightly reduced because of less use.

PARTIAL BUDGETS SHOWING NET INCOME EFFECTS OF THE TWO IMPLEMENTS

The actual change in income which will result from the use of the moldboard plow and cultivator depends on the characteristics of the individual farm. A total of eight partial budgets have been developed to show the income changes on various types of farms. The first two budgets show minimum and maximum income benefit situations from use of the moldboard plow alone. The next four show income changes resulting from various alternative adjustments to the use of both the plow and cultivator on small farms. The final two show the income increases from use of both the implements on larger farms.

All budgets are based on previously described conclusions from this study and have been constructed to show conservative or low estimates of possible increases in income from use of the two implements. All budgets make use of the same cost and income figures for identical items. These are typical figures as obtained from farmers or based on averages as determined in this study. Each budget has first been developed with the assumption that use of the improved implements has no impact on yields. A second change of net income figure is shown based on a 7.5 per cent increase in yield. This is half the average difference in yields between users and non-users of the plow in Allahabad district.

As is true with all general budgets, these illustrate income influences in various typical situations. To determine the income change on a particular farm, a budget based on the specific characteristics of that farm would be needed.

The assumptions and figures applicable to all budgets are shown in Table VII. This is followed by Table VIII which shows the income changes calculated in each.

TABLE VII—ASSUMPTIONS AND BASIC DATA USED FOR CONSTRUCTION OF PARTIAL BUDGETS

Item	Amount
1. Added income :	
(a) Increased production of 7.5 per cent is shown as a separate item at the bottom of the budget	.. Rs. 17.50 per acre
(b) Earning power of a pair of bullocks with a man and implements	.. Rs. 6.00 per day
2. Reduced expense :	
(a) Cost of a young bullock	.. Rs. 300.00
(b) Working life of a bullock	.. 10 years
(c) Rate of interest	.. 5 per cent
(d) Value of feed for one bullock	.. Rs. 1.25 per day
(e) Other costs for treatment and worship	.. Rs. 15.00 per year
(f) 30 per cent saving on hired interculture labour	.. Rs. 3.20 per crop acre
(g) Wages of a year-round hired labourer	.. Rs. 400.00 per year
3. Reduced income :	
(a) Arbitrary 5 per cent reduction in yield as a result of poorer timeliness when there is partial or full dependence on someone else's bullocks	.. Rs. 13.00 per acre
(b) Value of manure produced by one bullock	.. Rs. 12.00 per year
4. Increased expenses:	
(a) Moldboard plow :	
(i) Purchase price (including beam)	.. Rs 22.00
(ii) Length of life	.. 8 years
(iii) Annual cost of repairs	.. Rs. 3.00
(b) Three-tine cultivator:	
(i) Purchase price	.. Rs. 43.00
(ii) Length of life	.. 9 years
(iii) Annual cost of repairs	.. Rs. 4.00
(c) *Deshi* plow :	
(i) Purchase price (including beam)	.. Rs. 13.50
(ii) Length of life	.. 3 years
(iii) Annual cost of repairs	.. Rs. 4.00
(d) Rate of interest	.. 5 per cent

TABLE VIII—CHANGES IN NET INCOME RESULTING FROM ADOPTION OF THE MOLDBOARD PLOW AND THREE-TINE CULTIVATOR ON FARMS WITH VARIOUS SPECIFIED CHARACTERISTICS AS SHOWN BY PARTIAL BUDGET CALCULATIONS

Budget number	Implements adopted	Farm characteristics		Changes in net income	
		Acres	Labour force	With no change in yields (Rs.)	With a 7.5 per cent increase in yields (Rs.)
I	Plow	3	None hired	Minus 7	45
II	Plow	12	Interculture all hired	31	241
III	Plow and cultivator	5	None hired	Minus 17	70
IV	Plow and cultivator	5	None hired	408	498
V	Plow and cultivator	5	None hired	612	699
VI	Plow and cultivator	5	None hired	295	382
VII	Plow and cultivator	12	One labourer and interculture hired	1,301	1,511
VIII	Plow and cultivator	25	Two labourers and all interculture hired	2,628	3,065

of the eight budgets. Each budget is discussed and Budget No. 4 is shown to illustrate the method used in calculating the changes in net income. Other budgets have been omitted from this paper for the sake of brevity but all are included in the full report on this project.

Budget No. 1 : Adoption of a Moldboard Plow on a Three-Acre Farm depending entirely on Family Labour except for Some Harvest Labour.

This budget illustrates a situation of minimum income advantage for the plow and represents a number of farms in Uttar Pradesh and elsewhere in India. When the plow is used on a farm using only a fixed supply of family labour, there is little opportunity to increase income by use of the plow. There is no saving on interculture costs since the family will do the work. Since they will continue to use the *deshi* plow, they add the annual costs of the moldboard plow to their expenses without any offsetting decrease in costs.

Without considering increased yield, the family's income declines by Rs. 7 per year but the frustrating job of removing grass from the *kharif* crops is made easier and quicker, probably an attractive bargain for most families. If it is assumed that use of the plow is associated with a 7.5 per cent increase in yields, the plow can pay for itself and provide a modest income increase of Rs. 45.

Nearly all farms in this study made some expenditure for interculture labour. Farms reporting some saving on interculture cash costs averaged savings of about Rs. 3 per acre of cropland. On farms of three acres or more where interculture labour is hired, the plow can apparently pay for itself from this saving alone.

Budget No. 2: Adoption of Moldboard Plow on a 12-Acre Farm with All Interculture Hired on Contract.

This is a maximum benefit situation when the moldboard plow is used as the only improved tool. Although changes in income are modest, the plow easily pays for itself through savings in interculture costs. In fact, the annual increase in net income amounts to more than the purchase price of the plow and beam. If an increase in yield of 7.5 per cent is assumed, the estimated increase in income from use of the plow is Rs. 241.

Budget No. 3: Adoption of Both a Moldboard Plow and Three-tine Cultivator on a Five-Acre Farm with No Hired Labour.

This budget has been made to show the minimum advantage situation for use of these two tools. It is assumed that the farmer continues to own his pair of bullocks and continues to use his *deshi* plow for up to half his plowings. There will be no saving on interculture costs because the family provides all interculture labour. This budget represents the situation on many farms in Uttar Pradesh.

In these circumstances, the annual net income will decline by Rs. 17, the annual cost of using the plow and cultivator. In return, the family will save an estimated 30 days of labour on seed-bed preparation and interculture. On most farms, no productive use will be made of this saved time. If an increase in yield of 7.5 per cent is achieved by use of the two implements, they pay for themselves and provide an income increase of Rs. 70.

Budget No. 4: Adoption of Both a Moldboard Plow and Three-tine Cultivator on a Five-Acre Farm with No Hired Labour, assuming the Sale of One Bullock.

A small farmer can make several adjustments in the farm to increase his income advantage from using these two implements. This and the next two budgets show the income results of various adjustments in the use of bullocks. Other adjustments for which budgets would be difficult without more information on a specific farm, include increasing acreage, changing the combination of enterprises and working on a non-farm job in the time saved by use of the implements.

The budget assumes that the farmer makes an arrangement with a similar farmer who has also adopted the implements. Each agrees to sell one bullock and to make a team of their remaining bullocks to cultivate both farms.

The farmer saves the annual cost of keeping one bullock, estimated to be about Rs. 500. He may experience some decline in production due to possible difficulties of getting all the work done on time on both farms. This will not be a problem as far as the amount of work to be done is concerned, but co-operation between the two men might not be perfect. The annual costs of the new implements will be added and he will continue to use the *deshi* plow.

With no increase in yields, his income increases by Rs. 408 per year. It should be noted that this added income is not realized in cash until he sells his

BUDGET 4—ADOPTION OF BOTH A MOLDBOARD PLOW AND THREE-TINE CULTIVATOR ON A FIVE-ACRE FARM WITH NO HIRED LABOUR, ASSUMING THE SALE OF ONE BULLOCK

	Rs.	Rs.	Rs.
Added income :			
Increased production (see below):		0	
Reduced expenses		502	
Annual cost of keeping one bullock :			
Feed	450		
Depreciation	30		
Interest	7		
Other (treatment and worship)	15		
Total	502		
Total Income Increasing Factors			502
Reduced income		77	
5 per cent reduction in production due to poorer timeliness of operation	65		
Value of loss in manure production	12		
Total	77		
Added expenses		17	
Annual cost of using plow and cultivator :			
Depreciation	8		
Interest	2		
Repairs	7		
Total	17		
Total Income Decreasing Factors			94
Difference :			
Change in net income from use of the plow-cultivator			408
Change in net income assuming a 7.5 per cent increase in production is associated with use of the improved implements (Rs. 87 for five acres)			495

unutilized fodder or uses it for some other productive use such as milk production. If a 7.5 per cent increase in yields is assumed, the added net income rises to Rs. 495 per year. If interculture labour is hired, which is probable on a five-acre farm, income will further increase by about Rs. 15 from savings in interculture costs.

Budget No. 5: Adoption of Both a Moldboard Plow and Three-tine Cultivator on a Five-Acre Farm with No Hired Labour, assuming Sale of Both Bullocks.

Another adjustment which a small farmer might make is the sale of both of his bullocks. He would then hire his bullock work by the day from a small farmer who had adopted the tools but had kept his bullocks.

In this case, he saves the cost of keeping a pair of bullocks, about Rs. 1,000 per year. He probably will experience a decline in timeliness since the other farmer will always do his own work first. He will also experience the added risk and insecurity associated with lack of control over his primary source of draft power. In addition he will experience a substantial decline in prestige. He will have the added expense of hiring bullocks for all his work but will not have the expense of owning the new tools since these will be provided by the bullock owner. He can discard his *deshi* plow for the same reason.

Under these conditions, with no increase in yields, his net income increases by Rs. 612, provided he can sell his unutilized fodder or use it for a productive purpose. If yields increase by 7.5 per cent, this figure becomes Rs. 699. Average saving on hired interculture labour would raise these figures by about Rs. 15.

Because of the loss of prestige and the insecurity involved in depending on hired bullocks, this is a rather unlikely adjustment for most farmers.

Budget No. 6: Adoption of Both a Moldboard Plow and Three-tine Cultivator on a Five-Acre Farm with No Hired Labour, assuming No Change in Number of Bullocks, but Hiring Bullocks Out in Time Saved by Implements.

This is a budget for the farm which provides the bullocks for the farmer in Budget No. 5. It probably represents the easiest and most attractive adjustment for most small farmers but requires another farmer in the same or a nearby village who is willing to give up his bullocks entirely as shown in Budget No. 5.

In this case, his extra cash income from hiring out his bullocks will be about Rs. 312. He will not have a decline in timeliness since he will do his own work first but he will have the added cost of owning the two new implements.

The man who retains his bullocks and hires them out increases his income by Rs. 295 while the man who sells his bullocks and depends on hired bullocks increases his income by Rs. 636. This man, however, experiences both a loss of prestige and an increase in insecurity and must dispose of his fodder in some way before he realizes this higher income.

Budget No. 7: Adoption of Both a Moldboard Plow and Three-tine Cultivator on a 12-Acre Farm with at least One Year-Round Hired Labourer, Two Pairs of Bullocks and All Interculture Labour Hired on Contract.

This budget shows the typical increase in income realized by a farmer of this size when he starts using these two implements. He will be able to dispose of one

pair of bullocks and will no longer need the year-round hired labourer who was needed to drive them. He will also save on interculture costs.

He will need some additional casual labour to replace the year-round man at harvest time and perhaps for some other times of the year. He will also have the ownership costs of the new implement with no reduction in the annual costs of the *deshi* plow.

Income on this type of farm will increase by Rs. 1,301. If an increase in yields of 7.5 per cent is realized, the added income will be Rs. 1,511. These figures are the annual returns on a Rs. 65 investment, a 2,000 per cent return on investment (no increase in yield). He must, of course, dispose of his unutilized fodder before he realizes all of this income increase.

Budget No. 8: Adoption of a Moldboard Plow and Three-tine Cultivator on a 25-Acre Farm with Three Pairs of Bullocks, at least Two Year-Round Hired Labourers and All Interculture Hired on Contract.

This budget has been made to show the apparent maximum advantage from use of these two tools. It is based on the characteristics of one farm included in this study where 27 acres were being farmed with one pair of bullocks. This is only possible by almost complete abandonment of the *deshi* plow and a substantial reduction in the total number of times plowed. This farmer's yields were equal to the average for all users of the two implements.

The budget assumes disposal of two of these three pairs of bullocks, the hiring of the two year-round labourers needed to drive these bullocks and disposal of the *deshi* plow. He will need more casual labour and will have the annual expense of the improved implements.

The increase in income on this farm, assuming no change in production, is Rs. 2,628. With a 7.5 per cent yield increase, income goes up by Rs. 3,065. To realize all this increase, however, he must dispose of nearly Rs. 1,800 worth of unutilized fodder.

SUMMARY

The objective of this study was to determine the benefits from use of the moldboard plow and three-tine cultivator as substitutes for the wooden *deshi* plow. The contribution of these two improved implements to both the national goal of increased agricultural production and the farmer's goal of increased income was studied.

Farmers adopt the moldboard plow primarily because of its assistance in grass control. It is not used as a substitute for the *deshi* plow nor does it save time in seed-bed preparation. The three-tine cultivator, on the other hand, does save substantial time when it is used as a substitute for the *deshi* plow and this is the primary reason for its adoption by farmers. Farmers are doing an impressive amount of experimentation on how these two implements can be used.

The study is inconclusive on the question of the contribution of these implements to increased yields. There is considerable evidence of some yield effect from the plow but yield differences were not significant when tested statistically. The yield influence of the cultivator was not studied because of the small number of records obtained from non-users. It seems reasonable to conclude that a 5 to 10 per cent increase in yields is associated with the use of these improved implements.

Reduction in production costs resulting from use of these implements is associated mainly with savings on interculture costs for the plow and a reduction in the number of bullocks and hired labourers to drive them for the cultivator. On most farms, the plow can pay for itself through savings in interculture costs and may increase income if a yield increase is achieved. The changes in income from the plow, alone, however, are small.

On larger farms with two or more pairs of bullocks prior to use of the improved implements, the plow-cultivator combination provides a large increase in income, amounting to a 2,000 per cent return on investment in the two implements since the implements make possible the disposal of one pair of bullocks. On smaller farms, where one pair of bullocks was sufficient when the *deshi* plow was used alone, substantial income increases can result from use of the cultivator but to realize them, other adjustments must be made on the farm. Possible adjustments include increasing acreage, hiring out bullocks and labour in time saved by cultivator, selling bullocks and hiring bullock work by the day, selling one bullock and teaming up with another small farmer who has also sold one bullock, changing the combination of enterprises to provide productive work in the time saved by the cultivator and work on an off-farm job or cottage industry in the saved time. Few of these alternatives may be feasible or attractive for most farmers.

These two new implements are a new and disturbing but beneficial addition to Indian agriculture. Their successful addition to established methods of farming requires experimentation and adjustment but benefits are sufficiently great to encourage farmers to adopt them.