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ECONOMIC ANALYSIS OF THE ATIP DOUBLE PLOUGHING TRIALS, 1983-87

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ECONOMIC ANALYSIS OF THE ATIP DOUBLE PLOUGHING TRIALS, 1983-87*

INTRODUCTION

Interest in double ploughing (DP) systems, including winter and spring ploughing systems, is not new in Botswana. This type of tillage system may have a long history, as I am told, there is a traditional Kalanga word describing the practice. Pre-independence agricultural research focused on identifying an appropriate package of "modern farming methods" for progressive farmers, which developed into the "pupil farmer" system and did include a winter ploughing component.

During the 1970s research tended to concentrate on developing mechanical implements appropriate for minimum tillage systems and then trying to adapt the systems developed to on-farm situations. Double ploughing was not intensively studied during this period although it continued to receive some support from extension. [Baker]

Early ATIP research was primarily focused on modifications in the traditional broadcast, single plough system with emphasis on minor modifications including adding additional tillage operations. In 1982, the Mahalapye team chose double ploughing as a research area because EFSAIP had found that double ploughing seemed to improve water infiltration and soil tilth. In 1983, when the Francistown team was initiated, the decision was made to examine the performance of the commonly recommended extension package for cereal grains, which included a double ploughing component.

This presentation on ATIP's experience with double ploughing has several parts. The first part is a brief overview of the evolution of DP research in the ATIP areas followed by a general discussion of the economics of double ploughing. Technical agronomic issues in current DP research will be discussed by Dr. Siebert, after which I will present a brief discussion of the economics of a few of the technical issues. Finally, some possible implementation scenarios and remaining issues will be discussed.

EVOLUTION OF ATIP DOUBLE PLOUGHING RESEARCH

An initial interest in double ploughing has been pursued by ATIP over the entire course of the project. DP was first examined to determine if the agronomic benefit of the practice, identified by other research projects, was also obtainable in the areas where ATIP worked. When the increased yield potential of DP had been demonstrated, emphasis shifted to determining if there was an economic benefit for the farmers. Table 1 summarizes the evolution of ATIP double ploughing research.

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*Significant contributions to this paper were made by the following ATIP staff: D. Baker, G. Heinrich, S. Masika-a, E. Modisakgotla and J. Seibert. Presented at Department of Agricultural Research Seminar on Double Ploughing, September 7, 1987, Sebele, Botswana.

TABLE 1 EVOLUTION OF DOUBLE PLOUGHING RESEARCH, ATIP, 1982-87

SEASON	MAHALAPYE	FRANCISTOWN
1982-83	RMFI trials to examine planting methods. Measured establishment and yield. DP provided substantial benefits.	----
1983-84	RMFI trials included deep and shallow ploughing, and harrowing. Looked at time of operation vs depth of ploughing. DP improved stand, no yield due to drought.	RMFI test of potential benefits of extension recommended package. DP out yielded TC. Limited yield due to poor rains.
1984-85	RMFI trials with first ploughing on drying conditions to reduce opportunity cost. Managerial aspects of how DP fits into system. DP benefits stat. significant but not large. Phosphate trials superimposed.	RMFI continued test of prior years trials. DP out yielded TC but sensitive to negative management practices. Need for simple-robust system identified.
1985-86	RMFI trials for farmer assessment across soils & environments. Yield increase of 54 percent, but low yields. Improved weed control with DP. RI trials of phosphate effect.	RMFI trials to refine technology and collect data for economic analysis. Trial included feeding of draught animals for early plough. RMFI trials for farmer assessment. DP results good.
1986-87	RMFI trials on high potential and low potential sites. Examination of technical factors.	RMFI trials repeated for economic data. RMFI trials expanded for broad scale testing. DP results good even in poor rainfall year.

Sources: Baker, ATIP RR2, ATIP PR F86-3, and ATIP PR F87-5.

Following the early demonstrations of positive agronomic benefits from DP, two economic questions were addressed:

[a].Should a farmer double plough (DP) or single plough (SP1) a given hectare? This question might be of interest to a farmer with limited land resources.

[b].Should a farmer double plough a single hectare or single plough two hectares (SP2)? This may be of interest to a farmer with limited weeding labour resources.

The first question is generally addressed by comparing a DP and a single ploughed traditional check (TC2) plot planted on the same day. The second question is more complex, as it involves placing a value on the time spent in the first ploughing of the DP plot. This has generally been approached by taking the yield from a plot plough/planted on the same day the DP plot was first ploughed, traditional check one (TC1), as the opportunity cost of the time spent on the first DP ploughing. A simple trial layout which provides the necessary information is shown in Figure 1.

FIGURE 1 SIMPLE TRIAL LAYOUT FOR DOUBLE PLOUGHING TRIALS

TRADITIONAL CHECK 1	DOUBLE PLOUGH	TRADITIONAL CHECK 2
PLOUGH/PLANTED ON RAIN 1	FIRST PLOUGH ON RAIN 1 (SAME DAY AS TC1)	
	PLOUGH/PLANTED ON RAIN 2 OR LATER RAIN	PLOUGH/PLANTED ON RAIN 2 OR LATER RAIN (SAME DAY AS DP)

GENERAL ECONOMIC ANALYSIS

This economic analysis is primarily based on two factors: 1) the returns, based on yields, from different treatments, and 2) the costs, primarily labour, incurred in obtaining those returns. This section will briefly examine the yields for the three systems, the labour required by the systems, and returns to labour. The primary economic comparisons will be based on a partial budget analysis. Finally, risk and some other factors will be discussed.

Yields

An overview of yields received under the systems is presented in Table 2. The primary conclusion which can be drawn is that DP significantly increases yield, (average 77 percent, range from 36 to 368 percent) over a single ploughed plot planted the same day, SP1. In comparing DP and SP2, the experience is different between locations. In Mahalapye the TC1 plots have tended to yield quite well thus causing SP2 to out yield DP by an average of 143 kg/ha. On the other hand, the Francistown experience has tended more towards outcomes with DP and SP2 being approximately equal. These relative differences in yields are reflected in the economic analysis.

TABLE 2 AVERAGE YIELDS FOR DOUBLE PLOUGHING AND TRADITIONAL CHECKS, BY AREA AND CROPPING SEASON, ATIP, 1983-87.

SEASON	LOCATION	TC 1 YLD	(SP1) TC 2 YLD	(DP) DP YLD	(SP2) TC1+TC2 YLD
		KG/HA			
1983-84	Mahalapye	52	24	117	77
1984-85	Mahalapye	208	200	271	409
1985-86	Mahalapye	89	93	174	175
1985-86	Francistown	176	166	347	342
1986-87	Mahalapye	313	221	321	534
1986-87	Francistown	54	54	109	106
Overall Average (weighted)		140	122	218	262

Sources: Baker, ATIP PR F86-3, ATIP PR F87-5, Dr. Siebert's data.

Labour

Labour date was collected on the RMFI double ploughing trials in Francistown for 1985-86 and 1986-87. This labour data is presented in Table 3. The data is based on timings of activities on 10 by 50 plots, and as such is probably not representative of labour times on larger areas, however, the date does give an indication of how person hours of labour are distributed within the three systems.

TABLE 3 AVERAGE LABOUR TIME, PERSON HOURS/HECTARE, RMFI DOUBLE PLOUGHING TRIALS, FRANCISTOWN AREA, 1985-87/a

	YIELD KG/HA	ACTIVITY TIME PREP/b HOURS	WEED HOURS	PROC/c HOURS	TOTAL HOURS
AV SINGLE PLOUGH					
1985-86	166xq	33a	32x	38a	103a
1986-87	54xr	28a	36a	11x	75xa
2 YEAR AVG	110a	30a	34a	24a	89a
AV DOUBLE PLOUGH					
1985-86	347yq	71b	48y	66b	185bq
1986-87	105yr	58b	37a	28	124yar
2 YEAR AVERAGE	228b	65b	43a	47b	155b
AV SINGLE PLOUGH 2HA					
1985-86	342yq	73b	75z	71bq	218b
1986-87	108 r	58b	103b	17yb	177b
2 YEAR AVERAGE	225b	66b	89b	44b	201c

a.Within columns, by years, means followed by different letters [a,b,c] and [x,y,z] differ significantly [P < .01] and [P < .05], respectively. Based on pairwise comparisons between treatments. Between years, by treatment, means followed by different letters [q,r] and [q,r] differ significantly [P < .01] and [P < .05], respectively.

b.PREP TIME = Preparation Time includes ploughing and planting.

c.PROC TIME = Processing Time includes harvesting and threshing.

Several observations can be made concerning the labour data in Table 2:

[a].As would be expected, person hours of preparation time were about equal for DP and SP2, and were about double SP1 preparation time.

[b].Weeding time was significantly greater (more than double) for the SP2 plots when compared to DP or SP1. In one year DP weeding time was significantly greater than SP1 weeding time, however, this is an unexpected exception as the average [for Mahalapye and Francistown data combined] difference in weeding time between SP1 and DP is 6.2 hours, with DP requiring less weeding time. The overall average weeding time for SP2 is 38.6 hours greater than for DP. Farmer assessment surveys over the two years in the Francistown area indicate that approximately 80 percent of the farmers thought they spent less

time weeding the DP plots than they spent weeding the companion SP1 plots [these trials had no TC1 plots].

[c].Processing hours relate to harvest, with 5 kg/hour being a reasonable average time for harvesting and threshing grains.

[d].For the Francistown trials there was a significant increase in total labour in moving from single ploughing one hectare, to double ploughing one hectare, to single ploughing two hectares.

[e].There were approximately 30 percent less total person hours used in the DP system in producing the same yield as in the SP2 system.

[f].An increase of 42 percent in total labour from the SP1 system to the DP system resulted in a 107 percent yield increase over the two years.

Team Ploughing Hours

Average team ploughing hours for Francistown, 1985-87, are reported in Table 4.

TABLE 4 AVERAGE TEAM PLOUGHING HOURS/HECTARE, RMFI DOUBLE PLOUGHING TRIALS, FRANCISTOWN AREA, 1985-87/a

	YIELD KG/HA	FIRST PLOUGH HOURS	PLOUGH/ PLANT HOURS	TOTAL TEAM HOURS
AV SINGLE PLOUGH				
1985-86	166xq	0	15a	15a
1986-87	54xr	0	14a	14a
2 YEAR AVG	110a	0	14a	14a
AV DOUBLE PLOUGH				
1985-86	347yq	16	14a	30b
1986-87	105yr	15	12a	27b
2 YEAR AVG	228b	15	14a	29b
AV 2 SINGLE PLOUGH				
1985-86	342yq	0	32b	32b
1986-87	108 r	0	27b	27b
2 YEAR AVG	225b	0	30b	30b

a.Within columns, by years, means followed by different letters [a,b] and [x,y] differ significantly [P < .01] and [P < .05], respectively. Based on pairwise comparisons between treatments. Between years, by treatment, means followed by different letters [q,r] and [q,r] differ significantly [P < .01] and [P < .05], respectively.

Two brief observations can be made concerning team ploughing hours. First, team ploughing hours were consistent over years. These figures are slightly higher than the 11.9 hrs/ha reported by Mahalapye in 1983-85 and are about the same as the donkey ploughing time of 15.4 hrs/ha used by Mahalapye in 1985-86. [Baker] Second, slightly less ploughing time was required for the second ploughing on the double ploughed plots, a finding substantiated by

greater for DP compared to SP1, but significantly less than for SP2.

(c). Over the two years the net returns to labour were significantly greater (46%) for DP compared to SP2. While not significant DP showed a net return to labour 18 percent greater than for SP1.

(d). The net returns per preparation hour for DP were, while not significant, 47 percent and 72 percent greater than for SP1 and SP2, respectively.

(e). Net returns to labour in the DP system for 1986-87, a poor rainfall year, equaled the labour based drought relief wage of P.38/hr.

(f). Net returns to team ploughing hours are of interest if there is a plough/planting field time constraint. If this is the case, then net returns to traction hour spent on DP were 27 percent and 70 percent greater than returns to traction hours spent on SP1 or SP2, respectively.

(g). While returns to SP2 traction time were negative in 1986-87, a poor rainfall year, they were approximately equal to the urban minimum wage rate for the DP traction time. In the better year, 1985-86, returns to traction for DP were seven times the urban minimum wage rate.

Partial Budget Analysis

One way of comparing the economics of two systems is to estimate the net gain (or loss) in changing from one system to the other. Partial budget analysis provides a useful tool to do this comparison. In the partial budget analysis only those costs or benefits which are different between the two systems are considered. Consideration is given to reduced costs and added benefits of changing from one system to the other, which give positive gains. Losses due to the shift are considered under added costs and reduced benefits, which are totaled and subtracted from the gains to produce a net gain (or loss) from changing systems.

A partial budget analysis for the combined Mahalepye and Francistown DP data sets is presented in Table 6. The changes considered are: (a) to double plough one hectare instead of single plough one hectare, and (b) to double plough one hectare rather than single plough two hectares. The first part of the table presents a basic partial budget analysis based on overall average figures. The second part of the table reports on a number of sub-sets of data by location and season. It also includes sensitivity analysis to changes in labour and grain values.

To the extent possible resources were valued at their opportunity cost. For labour the Labour Based Drought Relief wage was used and for yields a rough average of local prices was used. This analysis is aimed primarily at draught controlling households as animal traction was used in the analysis.

farmer assessment interviews in which most farmers reported that it took less time to plough the second time on the DP plots, 80 percent saying they took 75 percent or less time the second ploughing.

Returns Analysis

Returns to labour were calculated for the Francistown DP trials, 1985-87, and are reported in Table 5. Returns to team ploughing hours are also reported. As with the other labour data, these returns should be taken as indicators of relative returns not absolute values. More complete Tables on returns to labour and to team ploughing hours are included in Appendix A (Tables A1 and A2) as is a complete set of the data on which the returns to labour are based (Table A3).

TABLE 5 AVERAGE RETURN TO LABOUR, PREPARATION TIME AND TEAM PLOUGHING HOURS, IN PULA, RMFI DOUBLE PLOUGHING TRIALS, FRANCISTOWN AREA, 1985-87/a

	YIELD KG/HA	GTVP/b PULA	POST/PL LABOUR COST	NET RETURN LAB/HR	NET RETURN/c PREP/HR	NET RETURN TRAC/HR
AV SINGLE PLOUGH						
1985-86	166xq	71.29exq	26.45a	0.63	1.32q	2.93q
1986-87	54xr	23.26xr	17.82a	0.31	0.07r	0.11r
2 YEAR AVERAGE	110a	47.28a	22.14a	0.47	0.70	1.52
AV DOUBLE PLOUGH						
1985-86	347yq	149.34yq	43.29b	0.79	1.85q	3.78q
1986-87	109yr	46.75yr	24.95a	0.38	0.26r	0.52r
2 YEAR AVERAGE	228b	99.05b	34.12b	0.57x	1.03	2.09
AV 2 SINGLE PLOUGH						
1985-86	342yq	147.15bq	52.47	0.56	1.33q	1.33q
1986-87	108	46.38r	45.41b	0.23	-0.13r	-0.42r
2 YEAR AVERAGE	225b	96.76b	50.53c	0.39y	0.60	1.23

a. Within columns, by years, means followed by different letters (a,b,c) and (x,y) differ significantly (P < .01) and (P < .05), respectively. Based on pairwise comparisons between treatments. Between years, by treatment, means followed by different letters (q,r) and (q,r) differ significantly (P < .01) and (P < .05), respectively.

b. GTVP = Gross Total Value Product (yield x price) where price = P.43/kg.

c. Post planting labour, valued at P.38/hr, was subtracted from the Net Total Value Product before returns to Preparation hours or Traction hours were calculated.

A number of observations can be made concerning the returns to labour, to preparation time, and to team ploughing hours:

(a). Labour was the major input to the cropping systems. Gross and net returns were close to the same value because of the low non-labour input costs. Thus only net values are reported in Table 5.

(b). Post planting labour costs over the two years were significantly

TABLE 6 PARTIAL BUDGET: DOUBLE PLOUGHING TRIALS, MAHALAPYE AND FRANCISTOWN AREAS, 1983-87

	DP 1 HA VS SP 1 HA		DP 1 HA VS SP 2 HA	
BASIC BUDGET ANALYSIS/a				
REDUCED COST (in Pula)				
Seed Saving (@ 39 t/kg)	-----		2.25	
Weeding Time Saving (@ 28 t/hr)	2.37		14.84	
SP Harvesting Time (@ 38 t/hr)	9.51		19.91	
ADDED BENEFIT				
Double Plough Yield (@ 43 t/kg)	84.71		84.71	
SUB-TOTAL INCREASES		96.59		121.71
ADDED COST				
DP Second Plough (@ 36 t/hr)	11.30		-----	
DP Harvesting time (@ 36 t/hr)	16.64		16.64	
REDUCED BENEFIT				
Single Plough Yield (@ 39 t/kg)	47.87		103.03	
SUB-TOTAL DECREASES		75.81		119.67
NET GAIN		20.78		2.04
SENSITIVITY ANALYSIS				
YIELDS/b				
Mahalapye Area, 1983-84, RMFI, n=7	23.73		28.14	
Mahalapye Area, 1984-85, RMFI, n=10	16.82		-27.43	
Mahalapye Area, 1985-86, RMFI, n=31	16.13		9.40	
Mahalapye Area, 1986-87, RMFI, n=14	32.37		-37.47	
Francistown Area, 1985-86, RMFI, n=10	16.72		16.49	
Francistown Area, 1986-87, RMFI, n=10	3.72		22.07	
RESOURCE USE AND VALUATION/c				
Labour valued at 53 t.hr./d	14.45		10.08	
Grain valued at 26 t/kg./e	10.40		7.21	

a. Basic budget calculated using weighted average of labour values and yields reported for the years and number of observations shown under sensitivity analysis. Labour valued at Labour Based Drought Relief wage and grain valued at approximate prevailing rate.

b. Values used are those reported in individual studies and valuation of grain varies slightly from year to year.

c. Based on averages of all observations used in basic budget.

d. The urban minimum wage rate.

e. The approximate SAMB guaranteed price for producers of number 2 mixed sorghum over this period.

Several observations can be made concerning the partial budget analysis:

(a). Based on the combined data, a shift from single ploughing 1 hectare to double ploughing one hectare would raise the value of production from the hectare by P37 and would produce a net gain of P20.78.

(b). A corresponding shift from single ploughing 2 hectares to double ploughing one hectare would reduce the value of production by P16 and would produce a net gain of only P2.04.

(c). The sensitivity analysis shows there would be a net gain for all years and locations from a SP1 to DP shift. For both years in Francistown and for two of the four in Mahalapye a shift from SP2 to DP would produce a net gain, however this is counter balanced by two years which show a relatively large net loss for this shift.

(d). Increasing the value of labour and decreasing the value of grain both cause a reduction in net gain on the shift from SP1 to DP while there was an increase in net gain for this change in valuation of resources for the shift from SP2 to DP.

(e). While there is a tendency to show a net gain from a shift to the DP system it is important to note that the magnitude of the gains, or losses, is relatively minor, not exceeding P40/ha.

Risk Analysis

Generally a farmer will have some idea of the risk of crop failure under the cropping system he/she currently uses. When considering a shift to a different cropping system consideration is taken not only of cost of additional inputs (both labour and cash), the potential net gain in returns (whether considered in terms of yield or cash value), but also the increased or decreased risk of having a crop failure. If farmers perceive an increased risk under the new system, then they will often want to see a larger than usual net gain from the shift to compensate for the increased risk. The opposite is also true, a perceived decrease in risk will often induce farmers to shift systems even if the gains from doing so are minimal. Under the DP system which ATIP has been testing, the number of plough/plant days available to a farmer is reduced. Because one of the risk reducing strategies used by farmers is to spread the number of plantings over as long a period and as many days as possible, the shift to DP may involve a perceived and/or real increase in risk.

Accurate measurement of risk is very difficult as it generally involves trying to measure farmer's perceptions of risk. A few indicators of risk have been applied to the Francistown data and are reported in Table 7.

Several observations may be made concerning risk:

(a). A stochastic dominance analysis (a risk analysis technique based on cumulative distribution functions and using the decision rule that the farmer prefers more yield or returns) of the Francistown RMFI Double Ploughing Trial results indicated that yields from both DP and SP2 dominate (are preferred to) SP1 yields. No other conclusions concerning risk can be drawn from stochastic dominance analysis of yields or returns at the first and second degree levels.

(b). One measure of risk is the skewness of the distributions. This is an indication of how often the actual yield may be less than the mean. As might be expected, the distributions are left skewed, as in more than half of the years the actual yield was less than the mean.

TABLE 7 SOME INDICATORS OF RISK, DOUBLE PLOUGHING TRIALS, ATIP, 1983-87

VARIABLE	N	MEAN	MEDIAN	% < MEAN	% > MINIMUM
FRANCISTOWN - RMFI DOUBLE PLOUGH TRIALS 1985-87					
YIELDS KG/HA					70 KG/HA
S PLO 1 HA	20	110	88	80	65
DP 1 HA	20	228	191	70	75
S PLO 2 HA	20	225	[illegible]	60	00
NET RETURN TO TOTAL LABOUR PULA/HR					P 0.38/HR
S PLO 1 HA	20	0.47	0.42	55	55
DP 1 HA	20	0.57	0.42	60	65
S PLO 2 HA	20	0.39	0.24	60	45
NET RETURN TO PREPARATION TIME PULA/HR					P 0.36/HR
S PLO 1 HA	20	0.75	0.52	55	55
DP 1 HA	20	1.03	0.52	75	65
S PLO 2 HA	20	0.64	0.11	70	40
NET RETURN TO TRACTION HOURS PULA/HR					P 1.00/HR
S PLO 1 HA	20	1.64	1.07	60	50
DP 1 HA	20	2.12	1.15	75	65
S PLO 2 HA	20	1.37	0.25	70	40
FRANCISTOWN - TOTAL RM COMPARISONS INVOLVING DP 1983-87					
YIELDS KG/HA					70 KG/HA
S PLO 1 HA	49	203	127	59	69
PD 1 HA	49	385	214	63	82
FRANCISTOWN - TOTAL FM COMPARISONS INVOLVING DP 1985-87					
YIELDS KG/HA					70 KG/HA
S PLO 1 HA	81	76	0	73	27
DP 1 HA	61	135	0	69	36
YIELDS KG/HA [WITHOUT COMPARISONS WITH 0 YIELD]					70 KG/HA
S PLO 1 HA	41	160	100	61	61
DP 1 HA	41	299	210	61	80
MAHALAPYE - ALL DP COMPARISONS 1983-87					
YIELDS KG/HA					100 KG/HA
S PLO 1 HA	71				58
DP 1 HA	71				72

[c].The DP variables in the RMFI analysis tended to be less than the mean at a slightly higher rate than either the SP1 or SP2 systems. Thus, while the mean may be attractive, the farmer is not going to achieve that mean quite as often as he/she will achieve the mean under the SP1 or SP2 systems.

[d].The medians tended to be higher for DP compared to SP1 and SP2.

[e].One type of risk analysis is the safety first analysis. This analysis determines how each system performs in attaining a pre-determined minimum for one or more variables. In a comparison of Francistown

yields, based on a minimum of 70 kg/ha, DP out performed SP1 in all cases and SP2 in all but one case. DP achieved a specified minimum return more consistently than either SP1 or SP2, thus indicating a lower risk. Using a minimum of 100 kg/ha in Mahalapye, DP and SP1 results were similar to Francistown. Although the data is not included, it is likely that, for Mahalapye, the SP2 system will reach the minimum more often than the DP system due to the high TC1 yields in many trials.

Other Factors

Whether farmers will shift from one cropping system to another is not only determined by the agronomics and economics of the shift but is influenced by physical, social and psychological considerations. There has been a great deal of interest in DP in the Francistown area but much less interest in the Mahalapye area. Several factors have been hypothesized as contributing to this difference, including:

[a].Differences in economic orientation. Farmers in the Mahalapye area may be somewhat more oriented towards maximizing returns for a minimum of inputs. While farmers in the Francistown area may be more concerned with some of the social-psychological issues.

[b].Physical factors. These factors may include differences in soil types and the generally more difficult destumping of land in the Tutume area.

[c].Social-psychological issues. For example, if farmers are willing to increase the intensity of their efforts DP will increase output without a decrease in area cultivated. However, if farmers do not wish to increase the intensity of their efforts, then a shift to DP will require a reduction in area cultivated, which may not be acceptable. It is possible that farmers in the Francistown area are more willing to increase their efforts (or perhaps they have fewer alternatives in which to invest their effort) more than are farmers in the Mahalapye area.

Another factor, which seems to be important psychologically in the Francistown area, is the effect of viewing side by side comparisons. Farmers have mentioned many times that they like the looks of the double ploughed plots (vigor, stand density, height of plants, etc.) and are willing to invest the extra effort in DP. They also indicate they think they will get yields in drought conditions from DP when they will not from SP1.

CONCLUSIONS:

From ATIP's experience with double ploughing we have drawn several general conclusions:

[a].There is an increase in yield from double ploughing one hectare compared to single ploughing that hectare.

[b].The economic analysis has not produced a clear cut answer. There appears to be a benefit from a SP1 to DP shift. The benefits from a shift from SP2 to DP are mixed.

[c].The analysis has been performed on two ends of a continuum, in the

sense that the opportunity cost of the first DP ploughing has been either no opportunity cost [outside of the ploughing labour] or the value of the full yield of the hectare not planted on the first ploughing. Actual farmer practice will probably fall between these two extremes as they may well be willing to do some of the first ploughing on reduced soil moisture when they would not normally plough/plant.

[d]. Thus we concluded that there was a need for an in-depth examination of specific agronomic and managerial questions which will allow for the improved targeting of the recommendation to use DP in terms of: [1] site considerations, [2] soil moisture considerations, and [3] implementation strategies.

TECHNICAL ISSUES

Dr. Siebert has discussed a number of technical issues. I would like to focus on the economics of two issues, high potential sites and tractor hire, and briefly mention a third, phosphate use. These issues may be addressed through partial budget analysis [Table 8]. From information contained in Table 8 several points can be made:

[a]. The identification of high potential sites for DP will allow the shift from SP1 to DP to be more profitable. Thus in a system where the farmer is using DP, it would mos. profitable to concentrate on ploughing the high potential sites first.

[b]. For farmers who must hire traction, the negative return to hiring tractor encountered in going from a SP1 to a DP system would not justify the shift. In fact, given that the returns from the SP1 yield do not cover the tractor hire cost, and a shift to DP is a net loss, it would be better for the farmer not to plough at all if tractor hire is the only source of ploughing. If the farmer must hire draught, the lower cost animal draught is at least profitable.

[c]. A shift from SP2 to DP is more complicated. If funds were available from the government or remittances only for ploughing, then double plough half as much land would have a slight net advantage. The shift would reduce labour requirements but also reduce total farm production. Thus, for drought dependent households, the choice to make the shift will depend on a combination of labour availability, restriction on the use of funds, and relative importance of profitability versus total farm production.

[d]. Phosphate use provides good returns on high potential sites in shifting from SP1 to DP, but not for all sites combined. However, if a farmer is using phosphate, a shift from SP2 to DP would lead to a loss in most cases, and the advantage would be to stay with single ploughing two hectares.

TABLE 8 PARTIAL BUDGET: DOUBLE PLOUGHING TRIALS, MAHALAPYE AND FRANCISTOWN AREAS, 1983-87

	DP 1 HA VS SP 1 HA	DP 1 HA VS SP 2 HA
BASIC BUDGET ANALYSIS/a		
REDUCED COST [in Pula]		
Seed Saving [@ 39 t/kg]	-----	2.25
Weeding Time Saving [@ 38 t/hr]	2.37	14.84
SP Harvesting Time [@ 38 t/hr]	8.51	19.91
ADDED BENEFIT		
Double Plough Yield [@ 43 t/kg]	84.71	84.71
SUB-TOTAL INCREASES	96.59	121.71
ADDED COST		
DP Second Plough [@ 38 t/hr]	11.30	-----
DP Harvesting time [@ 38 t/hr]	16.64	16.64
REDUCED BENEFIT		
Single Plough Yield [@ 39 t/kg]	47.87	103.03
SUB-TOTAL DECREASES	75.81	119.67
NET GAIN	20.78	2.04
SENSITIVITY ANALYSIS		
High Potential Sites/b	105.94	-34.56
All Sites/c	20.60	-85.99
High Potential Sites, with Phosphate/b	145.25	9.70
All Sites, with Phosphate/c	0.43	-97.66
Traction cost at 50 P/ha./d	-17.51	2.04
Traction cost at 25 P/ha./e	7.09	2.04

a. Basic budget calculated using weighted average of labour values and yields for Mahalapye and Francistown.
b. Based on Mahalapye RI trials 1985-86, high potential sites have deep to moderately deep soils with high total water holding capacity.
c. Based on all Mahalapye RI trials 1985-86.
d. Basic budget using ARAP tractor hire rate.
e. Basic budget using average donkey hire rate.

IMPLEMENTATION SCENARIOS:

ATIP has identified several scenarios where we think DP would be a good cropping system. Most of the scenarios are premised on traction ownership or control, as having to hire traction greatly reduces the potential gain especially during low yield drought years. In addition control of traction allows farmers a greater choice in the timing of plough operations.

[a]. Land Constraint - Where a farmer faces a land constraint either because no additional land is available [i.e. NE District] or because there is a small area cleared, and additional area is difficult to clear [i.e. Matobo], then utilizing the available land more intensively with DP will increase yield from the available land.

[b]. Weeding Labour Constraint - If a farmer faces a weeding labour constraint, then weeding labour can be reduced significantly by shifting from single ploughing 2 hectares to double ploughing one

hectare. Bird scaring and harvest labour might also be reduced as the farmer would have to cover only half the area. There is also a small decrease in weeding labour in shifting from SP1 to DP.

[c]. Low First Plough Opportunity Cost - When the opportunity cost of the first ploughing of the double plough system can by reduced, possibly by ploughing in the period after a rain when farmers will no longer plough/plant because they consider the soil too dry but while it is still moist enough to be ploughed, the potential benefit in shifting from SP2 to DP increases.

[d]. High Potential Sites - If high potential sites, with deep soils and high water holding capacity, can be identified then DP will concentrate resources on those sites to produce a greater response. In a DP scheme ploughing should start with these sites.

[e]. Subsidized Ploughing - If subsidized tractor ploughing is available, it is hypothesized that it would be beneficial to have the first ploughing of the DP system done by tractor on non-planting soil moisture conditions. Animal traction could then be used to plant the DP plots on subsequent rains. Better weed control would be obtained if the tractor ploughing could be done at intervals with animal plough/planting between. This system would greatly reduce the potential risk of total crop failure inherent in a system of tractor plough/planting a large area on a single date as is common under the subsidized tractor schemes.

[f]. Traction Time Constraint - Where there is a traction time constraint due to limited days of borrowed team availability or because of limited planting rains, the returns to team time may be greater if time is spent on DP.

REMAINING ISSUES

There are several issues concerning the implementation of double ploughing which ATIP would like to see addressed. Some of these are listed here:

[a].Resource implications for implementation of DP on a whole farm basis.
[b].Effect of different seeding rates.
[c].Combinations of DP with row planting (should they be extended as a package?)
[d].Additional work on combining DP with phosphate applications.
[e].Potential response of DP when rainfall returns to more normal levels.
[f].Additional work on risk considerations.

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APPENDIX A

TABLE A1 AVERAGE RETURN TO LABOUR, IN PULA, RMFI DOUBLE PLOUGHING TRIALS, FRANCISTOWN AREA, 1985-87/a

	YIELD KG/HA	ACTIVITY TIME PREP/b HOURS	POST/PL/c HOURS	TOTAL HOURS	GTVP/d PULA	POST/PL LABOUR COST	NTVP/e PULA	GROSS RETURN/f LAB/HR	NET RETURN LAB/HR	GROSS RETURN PREP/HR	NET RETURN PREP/HR
AV SINGLE PLOUGH											
1985-86	166xq	33a	70a	102a	71.29axq	26.45a	68.59axq	0.60	0.62	1.41q	1.32q
1986-87	54xr	28a	47a	75ax	23.26xr	17.82a	20.56xr	0.35	0.31	0.17r	0.07r
2 YEAR AVERAGE	110a	31a	58a	89a	47.28a	22.14a	44.58ax	0.50	0.47	0.79	0.70
AV DOUBLE PLOUGH											
1985-86	347yq	71b	114b	185b	149.34yq	43.29b	143.94yq	0.80	0.79	1.93q	1.85q
1986-87	109yr	58b	66a	124ay	46.76yr	24.95a	44.06yr	0.40	0.38	0.30r	0.26r
2 YEAR AVERAGE	228b	64b	90b	154b	96.05b	34.12b	92.65y	0.61x	0.57x	1.12	1.03
AV 2 SINGLE PLOUGH											
1985-86	342yq	73b	146b	220b	147.15bq	62.47	141.75bq	0.59	0.56	1.41q	1.33q
1986-87	108	58b	119b	177b	46.38r	45.41b	40.98r	0.26	0.23	-0.04r	-0.13r
2 YEAR AVERAGE	225b	65b	133c	199c	96.76b	50.53c	91.36b	0.42y	0.39y	0.68	0.60

a.Within columns, by years, means followed by different letters (a,b,c) and (x,y) differ significantly (P < .01) and (P < .05), respectively. Based on pairwise comparisons between treatments. Between years, by treatment, means followed by different letters (g,h) and (q,r) differ significantly (P < .01) and (P < .05), respectively.

b.PREP TIME = Preparation Time includes ploughing and planting.

c.POST PLANTING TIME includes weeding, harvesting and threshing.

d.GTVP = Gross Total Value Product (yield x price) where price = P.43/kg.

e.NTVP = Net Total Value Product (GTVP - COSTS) where COSTS (per hectare) = seed - P.30/kg for 4 kg, equipment estimated P1.50

f.GROSS and NET RETURNS are averages of RETURNS by plot, so are slightly different than RETURNS calculated using the averages of activity times and values.

TABLE A2 AVERAGE RETURNS TO TEAM PLOUGHING HOURS IN PULA, RMFI DOUBLE PLOUGHING TRIAL, FRANCISTOWN AREA, 1985-87/a

	YIELD KG/HA	TOTAL TEAM HOURS	POST PLANT HOURS	POST/PL GTVP/b PULA	POST/PL LABOUR/c COST	NTVP/d PULA	GROSS RETURNS/e PER HR	NET RETURNS/e PER HR
AV SINGLE PLOUGH								
1985-86	166xq	15a	70a	71.29axq	26.45a	68.59axq	3.11q	2.93q
1986-87	54xr	14a	47a	23.26xr	17.82a	20.56xr	0.33r	0.11r
2 YEAR AVERAGE	110a	14a	58a	47.28a	22.14a	44.58ax	1.72	1.52
AV DOUBLE PLOUGH								
1985-86	347yq	30b	114b	149.34yq	43.29y	143.94yq	3.95q	3.78q
1986-87	109r	27b	66a	46.76r	24.95a	44.06r	0.63r	0.52r
2 YEAR AVERAGE	228b	29b	90b	96.05b	34.12b	92.65y	2.29	2.09
AV 2 SINGLE PLOUGH								
1985-86	342yq	32b	146b	147.15bq	55.58y	141.75bq	3.04q	2.87q
1986-87	108yr	27b	119b	46.38yr	45.41b	40.98yr	-0.20r	-0.42r
2 YEAR AVERAGE	225b	30b	133c	96.76b	50.53c	91.36b	1.42	1.23

a.Within columns, means followed by different letters (a,b) and (x,y) differ significantly (P < .01) and (P < .05), respectively. Based on pairwise comparisons between treatments. Between years, by treatment, means followed by different letters (g,h) and (q,r) differ significantly (P < .01) and (P < .05), respectively.

b.GTVP = Gross Total Value Product (yield x price) where price = P.43/kg.

c.POST PLANTING LABOUR COSTS = Labour for weeding and processing valued at the Labour Based Drought Relief wage rate of P.35/hour.

d.NTVP = Net Total Value Product (GTVP - COSTS) where COSTS (per hectare) = seed - P.30/kg for 4 kg, equipment estimated P1.50.

e.GROSS and NET RETURNS to TRACTION are averages of returns by plot, so are slightly different than returns calculated using the averages of activity times and values.

TABLE A3 LABOUR TIME, PERSON HOURS/HECTARE, IN PULA, RMFI DOUBLE PLOUGHING TRIALS, FRANCISTOWN AREA, 1985-8

YEAR	LOC	PLOT	YIELD KG/HA	ACTIVITY TIME PREP/a HOURS	POST/PL/b HOURS	TOTAL HOURS	GTVP/c PULA	POST/PL LABOUR COST	NTVP/d PULA	GROSS RETURN LAB/HR	NET RETURN LAB/HR	GROSS RETURN PREP/HR	NET RETURN PREP/HR
						SINGLE PLOUGHED PLOTS							
67	1	3	85	29.54	58.25	87.79	37.63	22.14	34.93	0.43	0.40	0.52	0.43
67	1	5	75	33.84	55.50	89.34	32.25	21.09	29.55	0.35	0.33	0.33	0.26
67	2	3	0	18.69	48.75	67.44	0.00	18.53	-2.70	0.00	-0.04	-0.39	-1.14
67	2	5	8	15.69	27.00	42.69	3.23	10.26	0.53	0.09	0.01	-0.46	-0.82
67	3	3	158	24.74	21.25	45.99	67.73	8.03	65.03	1.47	1.41	2.47	2.30
67	3	5	0	24.99	32.25	57.24	0.00	12.26	-2.70	0.00	-0.05	-0.45	-0.60
67	4	3	125	31.25	84.00	115.25	53.75	31.92	51.05	0.47	0.44	0.70	0.61
67	4	5	88	30.63	24.50	55.33	37.63	9.31	34.93	0.68	0.63	0.92	0.85
67	4	6	1	37.09	27.50	64.59	0.43	10.45	-2.27	0.01	-0.04	-0.27	-0.34
67	5	5	0	35.56	90.00	125.56	0.00	34.20	-2.70	0.00	-0.02	-0.96	-1.04
55	1	3	150	33.41	98.50	131.91	64.50	37.43	61.80	0.46	0.47	0.81	0.73
58	1	5	43	31.51	23.25	55.76	19.49	10.74	15.79	0.31	0.26	0.25	0.16
56	2	3	10	33.98	5.50	39.48	4.30	2.09	1.60	0.11	0.04	0.07	-0.01
56	2	5	93	31.83	30.25	62.08	39.99	11.50	37.23	0.64	0.60	0.90	0.81
56	3	3	88	27.75	85.00	112.75	37.84	32.30	35.14	0.34	0.31	0.20	0.10
56	3	5	355	31.87	57.25	89.12	153.08	21.76	150.38	1.72	1.69	4.12	4.04
56	4	3	265	28.00	125.25	153.25	114.38	47.60	111.68	0.75	0.73	2.39	2.29
56	4	5	283	63.49	104.50	167.99	113.06	39.71	110.33	0.67	0.66	1.16	1.11
56	4	8	184	26.53	74.50	101.03	79.12	28.31	76.42	0.76	0.76	1.92	1.81
56	4	10	205	24.13	87.00	111.13	88.15	33.06	85.45	0.79	0.77	2.29	2.17
AV SINGLE PLOUGH			110	30.74	58.25	88.99	47.28	22.14	44.58	0.50	0.47	0.79	0.70
						DOUBLE PLOUGHED PLOTS/e							
67	1	2	80	70.79	69.00	139.79	34.40	26.22	29.00	0.25	0.21	0.12	0.04
67	1	2	228	78.28	140.25	218.53	97.83	53.30	92.43	0.45	0.42	0.57	0.50
67	2	2	0	44.59	167.00	211.59	0.00	63.45	-5.40	0.00	-0.03	-1.42	-1.54
67	2	4	23	45.50	37.75	84.55	9.68	14.35	4.28	0.11	0.05	-0.10	-0.22
67	3	2	183	64.71	23.00	87.71	78.40	8.74	73.08	0.83	0.83	1.08	0.99
67	3	4	50	47.77	54.75	102.52	21.50	20.81	16.10	0.21	0.15	0.01	-0.10
67	4	2	200	51.45	74.00	125.45	85.00	28.12	80.50	0.63	0.64	1.12	1.02
67	4	4	125	59.62	30.50	90.12	53.75	11.59	48.35	0.60	0.54	0.71	0.52
67	4	7	200	63.92	38.75	102.67	85.00	14.73	80.60	0.64	0.73	1.12	1.03
67	5	4	0	51.70	21.50	73.20	0.00	8.17	-5.40	0.00	-0.07	-0.16	-0.26
56	1	2	239	68.46	160.25	228.71	102.77	60.90	97.37	0.45	0.40	0.61	0.53
56	1	4	214	72.09	70.25	142.33	92.02	26.70	86.62	0.65	0.61	0.91	0.81
58	2	2	24	114.55	36.25	150.80	10.32	13.78	4.92	0.07	0.03	-0.03	-0.28
56	2	4	145	101.60	42.00	143.60	62.35	15.99	56.95	0.43	0.40	0.45	0.40
58	3	2	213	71.19	138.50	209.69	91.59	52.63	86.19	0.44	0.41	0.55	0.47
56	3	4	483	55.07	69.75	124.82	207.69	26.51	200.29	1.66	1.62	3.25	3.19
56	4	2	439	51.02	209.00	260.02	189.77	79.42	183.37	0.73	0.71	2.14	2.04
56	4	4	130	75.73	123.75	204.49	55.90	46.93	50.50	0.27	0.25	0.09	0.02
56	4	7	875	59.37	158.75	218.12	378.25	60.33	370.85	1.72	1.70	5.32	5.23
56	4	9	711	43.47	125.75	169.22	305.73	47.79	300.33	1.81	1.77	5.33	5.81
AV DOUBLE PLOUGH			228	64.62	89.79	154.41	98.05	34.12	92.65	0.61	0.57	1.12	1.03

TABLE A3 (Continued)

YEAR	LOC	PLOT	YIELD KG/HA	ACTIVITY TIME PREP/a HOURS	POST/PL/b HOURS	TOTAL HOURS	GTVP/c PULA	POST/PL LABOUR COST	NTVP/d PULA	GROSS RETURN LAB/HR	NET RETURN LAB/HR	GROSS RETURN PREP/HR	NET RETURN PREP/HR
						TWO SINGLE PLOUGHED PLOTS COMBINED							
67	1	1 & 3	94	55.64	135.75	191.39	40.31	51.59	34.91	0.21	0.18	-0.20	-0.30
67	1	1 & 5	81	55.94	133.00	192.94	34.94	50.54	29.54	0.16	0.15	-0.26	-0.35
67	2	1 & 3	0	43.93	129.75	173.68	0.00	43.31	-5.40	0.00	-0.03	-1.12	-1.25
67	2	1 & 5	8	40.92	108.00	148.92	3.23	41.04	-2.18	0.02	-0.01	-0.92	-1.06
67	3	1 & 3	243	50.85	103.50	154.35	104.49	39.33	99.01	0.65	0.64	1.26	1.18
67	3	1 & 5	85	51.10	114.50	165.60	36.50	43.51	31.15	0.22	0.19	-0.14	-0.24
67	4	1 & 3	125	69.54	125.75	195.39	53.75	47.76	46.35	0.28	0.25	0.09	0.01
67	4	1 & 5	88	69.21	66.25	135.46	37.63	25.18	32.23	0.29	0.24	0.19	0.10
67	4	6 & 8	105	74.19	98.75	172.94	45.29	37.53	39.53	0.26	0.23	0.10	0.03
67	5	1 & 5	250	63.56	179.75	243.31	107.50	68.31	102.10	0.44	0.42	0.62	0.53
56	1	1 & 3	170	72.04	107.25	179.29	73.10	40.76	67.70	0.41	0.38	0.45	0.37
56	1	1 & 5	63	70.14	37.00	107.14	27.09	14.06	21.69	0.25	0.20	0.19	0.11
56	2	1 & 3	13	100.16	43.25	143.42	5.59	16.44	0.19	0.04	0.00	-0.11	-0.16
56	2	1 & 5	96	96.03	68.00	166.03	41.28	25.84	35.88	0.25	0.22	0.16	0.10
56	2	1 & 3	237	54.46	180.00	234.46	101.91	68.40	96.51	0.43	0.41	0.62	0.52
56	3	1 & 5	505	58.58	152.25	210.83	217.15	57.89	211.75	1.00	1.00	2.72	2.63
56	4	1 & 3	640	65.31	210.75	276.06	275.20	92.63	269.80	0.89	0.87	2.75	2.67
56	4	1 & 5	637	101.80	223.00	324.80	273.91	84.74	268.51	0.84	0.83	1.86	1.81
56	4	6 & 8	520	55.50	199.75	255.25	223.60	75.53	218.20	0.86	0.85	2.63	2.53
56	4	6 & 10	541	54.10	211.25	265.35	232.63	80.28	227.23	0.86	0.86	2.92	2.72
AV 2 SINGLE PLO			225	65.56	132.98	198.53	96.76	50.50	91.36	0.42	0.39	0.68	0.60

a.PREP TIME = Preparation Time includes ploughing and planting.
b.POST PLANTING TIME includes weeding, harvesting and threshing.
c.GTVP = Gross Total Value Product (yield x price) where price = P.43/kg.
d.NTVP = Net Total Value Product (GTVP - COSTS) where COSTS (per hectare) = seed - P.30/kg for 4 kg, equipment estimated P1.50
e.Costs for double ploughed plots include two equipment costs and one seed cost (P4.20/ha).