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PROGRESS REPORT

1987-88 WATER HARVESTING TRIAL
(RESEARCHER MANAGED/RESEARCHER IMPLEMENTED)

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PREFACE

ATIP Progress Reports are prepared and circulated to make ATIP research findings easily available to GOB personnel and researchers interested in Botswana farming systems. A major objective of the Progress Report series is to make research findings available in a timely manner. These reports are not subject to professional review outside the Francistown team. Therefore, data and findings presented in the Progress Report series may be subject to further revision and should not be cited without permission of the authors. Findings in this report do not necessarily reflect the official views of ATIP, DAR or MIAC.

This Progress Report presents information on the Researcher Managed/Researcher Implemented (RMRI) Water Harvesting Trial carried out in at three locations in Tutume Agricultural District, during the 1987-88 cropping season. The report covers the agronomic and labour data collected.

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WATER HARVESTING TRIAL

ABSTRACT

The objective of this RMRI trial was to test a system for concentrating rainfall and runoff into a specific cropping area and to determine if such a system was technically and economically feasible when compared to the traditional system and double ploughing. The system tested was contour band ploughing which involved two metre wide strips, ploughed on the contour, alternating with unploughed two metre strips. There were problems with the implementation of the trial and severe pest attacks, which made drawing definitive conclusions from the one year trial impossible. However, the trial did demonstrate that such a system would need an adequate mechanical weeder to clear the strips, and that management of the ploughing could be a problem. The yields were comparable to the traditional check and double ploughing, even though only half the area was planted under the contour band ploughing system. Thus it was concluded that the system may have merit, but that ATIP Francistown does not have the time to develop the implementation procedures to make the system practical.

OBJECTIVES

The objectives of this RMRI trial were to determine whether:

(a). A simple system could be used to concentrate rainfall and runoff water in specific cropped areas of the field.
(b). This system improved per hectare crop yields and reduced the risk of crop failure over the traditional cropping system.

(c). This system improved on the yield and stability benefits of double ploughing on the contour.

(d). Implementing this system in the field could be both practical and economical.

JUSTIFICATION

The low and highly variable rainfall in Botswana poses considerable risks to arable crop production, and limits crop production potential in most seasons. The system being tested was designed to concentrate rainfall from the whole field into half of the field area. On soils with good water holding capacity, the increased moisnure available to plants growing in the cropped area should have (a) improved the growth and productivity of those plants generally; and (b) reduced the risk of crop failure by ensuring that more water was stored in the soil beneath the cropped areas when dry periods began.

APPROACH

The system being tested is referred to as contour band ploughing (CBP). Soil contours were first laid out using a string level. Then bands two metres wide were ploughed along the contour. Between these bands, two metre strips were left unploughed to enhance runoff into the ploughed areas. Thus half the field was ploughed, and half was not. In Tutume Agricultural District, unploughed soils tend to become quite hard, causing considerable runoff during heavy rains.
After an interval of one rainfall (of more than 10 mm) seed was broadcast on ploughed areas (beds) and ploughed down. (So the beds were ploughed a total of two times.) Beds were weeded by hand, while the inter-bed areas were to be weeded mechanically. (An implement for this purpose was designed by the Farm Management Development Unit at Sebele.) Theoretically this system should have:

(a). Increased moisture available in the beds through both double ploughing and collection of runoff from the adjacent unploughed areas;

(b). Not increased ploughing labour requirements per hectare (because only half the field was double ploughed); and
(c). Reduced weeding time requirements because half the field could be mechanically weeded.

Double ploughing has been shown to produce approximately twice the per hectare grain yield of single ploughing under many different climatic situations in Tutume Agricultural District. Thus double ploughing half the area should have produced the equivalent of what could have been produced on the whole area with the traditional system. The runoff from the unploughed areas should have helped to increase yields and reduce risk.

The contour band ploughing system was tested in Tutume Agricultural District in 1986-87 and was seen to conserve water. It was tested both in Tutume Agricultural District and at Sebele in 1987-88.

In Tutume Agricultural District, the trial was conducted as follows: three systems were compared; i.e., CBP, double ploughing, and the traditional system. Plots were 10 metres wide by 40 metres long, and were laid out across the slope, in a randomised complete block design, with two replications per location. Preliminary ploughing was done by tractor. Later plough/planting was done with animal draught power. Trials were conducted on three sites with soil of 70cm or deeper. All labour and input data were collected. Plant stand and grain yield data were collected, but soil moisture status was only monitored at Sebele.

The economic focus for these trials was to collect sufficient labour use, input cost, and harvested output information for the formulation of budgets for each proposed intervention. The budgets were used in comparing potential interventions with traditional technologies in order to determine which interventions were economically feasible.

In a departure from the planned approach, grassy weeds growing on the un-ploughed run off strips (CBP treatments) were cut by hand, using slashers. This was done because the animal drawn weeding implement was not sufficiently robust to remove the heavy weed growth. Sorghum, variety Segaolane, was planted at the rate of 4kg/ha on all ploughed areas. Dates of all operations are given by plot in Table 1.

TABLE 1: DATES OF OPERATIONS, WATER HARVESTING TRIALS, FRANCISTOWN AREA, 1987-88 *

LOC	TREATMENT*	PLOUGH	PLOUGH/ PLANT	WEEDING	STAND COUNT	SLASH1	SLASH2	HARVEST
1	1	93	133	183	196	142	191	0
1	2	91	331	97	196	-	-	289
1	3	-	133	183	196	-	-	0
1	1	93	133	184	196	142	191	0
1	2	93	133	197	196	-	-	288
1	3	-	133	184	196	-	-	288
2	1	99	119	-	224	136	159	247
2	2	99	119	-	224	-	-	247
2	1	99	119	-	224	136	159	247
2	2	99	119	-	224	-	-	247
3	1	94	127	-	221	136	-	222
3	2	94	127	-	221	-	-	222
3	3	-	127	-	221	-	-	222
3	1	94	127	-	221	136	-	222
3	2	94	127	-	221	-	-	222
3	3	-	127	-	221	-	-	222

In numbered days starting from September 1, 1987 (Sept. 1, 1987 = 1, etc.)
Treatments: 1 = Contour band ploughing, 2 = Double ploughing, 3 = Traditional check

RESULTS

Monthly rainfall totals from the nearest rain gauge are given in Table 2. Blocks were laid out along the contour to minimize the bias occurring due to different amounts of rainfall runoff entering the plots from up-slope. However, the plots were 40m long, with a 10m turn strip between plots, making the trial a total of 140m long and 40m wide. It was difficult to find uniform areas of this length in farmers fields. Hence some adjustments were made to the trial designs in the field. At location 3, one traditional check plot was shifted up-slope to avoid a tree in the originally designated area. At location 2 the original design was modified because the farmer planted her own crops over the pegged areas, leaving only four plots for treatments. The traditional checks were therefore dropped from the trial.

TABLE 2: RAINFALL DATA BY MONTH, FROM NEAREST RAIN GAUGE, WATER HARVESTING TRIALS, FRANCISTOWN AREA, 1987-88

LOCATION	MONTH RAINFALL IN MM								TOTAL IN MM
	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APRIL	
1*	0	7	55	267	44	215	136	4	728
2-3,	0	9	126	233	39	383	126	32	928

Rain gauge located in experimental field
Rain gauge located within 2km of trial

Ploughing the CBP treatment plots also presented problems. First, tractor drivers showed considerable cultural bias against leaving unploughed areas in the plots. They had a tendency to make the ploughed strips too wide, leaving runoff strips smaller than originally designed. Ploughing the strips with oxen was also difficult because each plot contained three strips. The first two strips could be ploughed at one time by ploughing up one and down the other. But the last strip presented a problem, because of its narrow width (cattle teams have a problem turning sharply), and the fact that it was necessary to start in the middle of the strip to keep the dead furrows on the outside edges. The whole operation was complicated by the fact that cattle teams need to turn consistently in the same direction to avoid confusing the animals. Thus the starting point had to be carefully planned. If such a system is used in future, it would be wise to use wider plots, and an even number of ploughed strips.

Rainfall in all three locations this year exceeded the long term average by 70 to 100 percent. Waterlogging occurred on all trial sites in December, February and March. While sorghum is generally quite tolerant of waterlogging, it seemed that ammonification and leaching of soil nitrates caused problems. Plants were generally thin and less green than normal. As these soils are generally low in nitrates and organic matter, it was hypothesized that further reductions of soil N probably contributed significantly to the poor crop performance (even in the presence of sufficient soil moisture.)

After heading, grain yields were further reduced by pests. Damage was particularly severe at locations 1 and 3. At location one, the trial was slightly removed from the farmer's own crops. Both grasshopper and bird attacks were severe. The farmer was so busy trying to protect his own field that he spared little time for the trial plot. At this location, grasshoppers reduced yields in three plots to zero, and by greater than 50 percent in the remaining plots. The grasshopper attack was similar to locusts in that even the plant leaves were stripped to the mid-rib in only a few days. At location three, bird and grasshopper damage combined to reduce crop yields by an estimated 50 to 70 percent. The multitudes of grasshoppers observed this year were probably related to the heavy rains.

Plants stands and grain yields are given by plot in Table 3. Mean yields by treatment and location are given in Table 4. Analysis of variance was not conducted because of the lack of observable differences in treatments, and the problems caused by differences in trial layout in the early part of the season.

TABLE 3: PLANT STANDS AND GRAIN YIELDS, BY PLOT, WATER HARVESTING TRIALS, FRANCISTOWN AREA, 1987-88

LOCATION	REPLICATION	TREATMENT*	PLANTS/HA(X1000)	KG/HA
1	1	1	9.2	0
1	1	2	21.9	106
1	1	3	37.8	212
1	2	1	13.6	0
1	2	2	[illegible]	152
1	2	3	40.9	0
2	1	1	5.4	384
2	1	2	11.5	370
2	1	3	0	0
2	2	1	3.8	300
2	2	2	18.3	260
2	2	3	0	0
3	1	1	15.1	139
3	1	2	36.5	88
3	1	3	18.8	160
3	2	1	6.1	114
3	2	2	23.6	189
3	2	3	23.1	111

*. Treatments: 1 = Contour band ploughing, 2 = Double ploughing
3 = Traditional check

TABLE 4: TREATMENT MEAN GRAIN YIELDS BY LOCATION, WATER HARVESTING TRIALS, FRANCISTOWN AREA, 1987-88

LOCATION	TREATMENT: CONTOUR BAND PLOUGHING	DOUBLE PLOUGHING	TRADITIONAL CHECK
	Grain yield in kg/ha		
1	0	129	106
2	342	315	M*
3	127	139	136

*. M = Missing

LABOUR ANALYSIS

Labour data were collected for all operations and are reported in Appendix A, Table A1. Unfortunately timings were not taken on the tractor ploughing for farmer 1 nor for the broadcasting of seed by farmer 2. Because these activities take relatively little time and are fairly consistent over trials, it was decided to use the average of the values reported by the other farmers for the missing values. For the ploughing times the average within the treatment was used, while the average for all plots was used for the broadcast time. The estimated numbers are noted in Appendix A.

Table 5 reports the average labour times by treatment. The tractor ploughing (plow 1) time for the CBP was less than for the DP plots. Because half the area is ploughed in the CBP plot, it would be expected that the tractor ploughing time would be about half. If one high ploughing time is omitted in the CBP, this is the case. Ploughing time (plow 2) for the traditional check was slightly higher than for plow 2 time on the CBP and DP plots. The ploughing times for the CBP and DP were virtually the same which is unexpected as the CBP involves one-half the area of the DP.

TABLE 5: AVERAGE LABOUR TIMES, PERSON HOURS PER HECTARE, BY TREATMENT, WATER HARVESTING TRIAL, FRANCISTOWN AREA, 1987-88

	YIELD KG/HA	PLOW 1 HR/HA	PLANT HR/HA	PLOW 2 HR/HA	WEED HR/HR	SLASH 1 HR/HA	SLASH 2 HR/HA	HARVEST HR/HA	THRESH HR/HA	TOTAL HR/HA
CONT BAND	156	1.7	1.0	20.9	13.4	26.6	32.6	9.1	17.2	122.5
DOUBLE PL.	194	2.6	0.8	21.1	40.7	0.0	0.0	22.7	20.2	108.1
TRAD CHECK	121	0.0	0.7	24.4	70.4	0.0	0.0	10.9	11.2	117.6
OVERALL AV	162	2.1	0.9	21.9	37.9	10.0	12.2	14.6	16.8	116.4

There is a great deal of variation in the weeding times, including slash times on the unplanted portions of the CBP treatment. Total labour invested in weed control was greatest for the CBP, but only slightly more than the traditional check treatment, with both requiring at least 72 percent more labour time than the double plough treatment. However, because of the great variability in weeding times between farmers and treatments, it is not possible to draw firm conclusions concerning the average weeding labour requirements. It is apparent that weed control on the unplanted areas in the CBP treatment required a major investment of labour.

Harvesting and threshing time are generally related to total yield, but there seems to be a high degree of variability between individual plots. Total labour time for the CBP system was 13 percent higher than for the DP system, which required the least amount of labour. The labour data provides some indication of relative labour used for each treatment, but should be considered gross estimates due to problems with the trials and data.

RETURNS ANALYSIS

Returns per hectare and returns to person hours of labour were calculated and are reported in Table 6 (full data set in Appendix A, Table A2). Costs used in calculating net returns were based on a tractor hire rate of P50 per hectare and seed costs of P2 per hectare. The crop was valued a P.45/kg, which is higher than the BAMB price for grain but consistent with the value of grain used in the last two years analysis.

TABLE 6: AVERAGE YIELD AND RETURNS TO LABOUR, IN PULA, WATER HARVESTING TRIAL, FRANCISTOWN AREA, 1987-88

	YIELD KG/HA	TOTAL TIME HR/HA	GTVPa PULA/HA	COSTSb PULA/HA	NTVPc PULA/HA	RETURNS TO LABOUR GROSSd PULA/HA	RETURNS TO LABOUR NETe PULA/HR
CONTOUR BAND P	156	122.5	70.27	52.00	18.27	0.57	0.15
DOUBLE PLOUGH	194	108.1	87.35	52.00	35.30	0.81	0.33
TRAD CHECK	121	117.5	54.34	2.00	52.34	0.46	0.44
OVERALL AVG	162	116.4	72.69	39.50	33.19	0.62	0.29

a. GTVP = Gross Total Value Product (yield x price) where price = P.45/kg
b. COSTS: Tractor hire = P50/ha, Seed = P2/ha
c. NTVP = Net Total Value Product (GTVP - COSTS)
d. Gross Return to Labour = GTVP/Total Hours
e. Net Return To Labour = NTVP/Total Hours

Due to insect problems, and the general character of the crop year, there was a great deal of variability in the yield outcomes, which caused a corresponding variability in the gross total value product for the treatments. The highest yield, and GTVP, was produced by the DP treatment. If the two CBP plots which were destroyed by pests are excluded, the average yield for the treatment was 234 kg/ha (producing a GTVP of P105), 20 percent greater than the DP average yield.

Gross returns to labour for all treatments are greater than the labour based drought relief wage of P.38/hr. However, due to the cost of tractor hire, the net return to labour for the CBP and DP treatments falls below this figure. In the case of CBP the net return was approximately one-third of the return from the traditional system.

Because of the problems with trial implementation and data collection, and the total loss of three replications, there was insufficient data to examine the question of stability of the systems. From the data obtained it appears that the least likelihood of producing a net loss was obtained with the traditional system. This was coupled with the highest expected net return. Thus, in terms of risk avoidance, the traditional system would probably be preferable when compared with tractor ploughing systems.

Because the initial ploughing on the CBP and DP systems were done with a tractor, there is a high cost involved. If, as would be more likely for a draught controlling farmer, the initial ploughing were done with owned draught animals then the net returns and returns to

labour would be closer to the gross returns and gross returns to labour. In this case there would be a higher labour investment for the initial ploughing which would be more than balanced by the lower cost of not hiring the tractor, and the CBP and DP systems would probably perform slightly better than the traditional system.

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 included. Partial budget analysis has been carried out comparing the CBP and DP systems with the traditional check. The major factors considered were differences in labour, yield and traction hire. The losses from changing to one of the new systems are relative between the two systems and, unlike the returns discussed above, are not absolute values.

TABLE 7: PARTIAL BUDGET ANALYSIS OF SHIFT FROM TRADITIONAL SYSTEM TO OTHER SYSTEMS, NET CHANGE IN PULA PER HECTARE, WATER HARVESTING TRIAL, FRANCISTOWN AREA, 1987-88

	CHANGES IN COSTS AND BENEFITS IN PULA CONTOUR BAND PL	DOUBLE PLOUGH
	INCREASES:	
REDUCED COST		
Traditional Labour[a]	44.69	44.69
ADDED BENEFITS		
GTVP New System[b]	70.27	87.35
	DECREASES:	
ADDED COSTS		
New System Labour[a]	46.55	41.08
Tractor Hire	50.00	50.00
REDUCED BENEFITS		
GTVP Traditional[b]	54.34	54.34
NET CHANGE	-35.93	-13.38

Labour valued at: Labour Based Drought Relief wage = P.38/hr
GTVP = Yield x Price, with grain valued at P.45/kg

Table 7 reports the results of the partial budget analysis. Using this analysis a shift from traditional check to either the CBP or DP systems will produce a net loss, caused primarily by the high cost of traction hire. If, as was suggested above, owned animal traction were used on the first ploughing and if it is assumed it takes approximately as long to plough the

first time as it does the second time, then the net gain for switching to contour band ploughing from the traditional system would be approximately P 6.75 per hectare. There would be a gain of approximately P 29.50 per hectare from switching to a double ploughing system.

DISCUSSION

Firm conclusions cannot be drawn from a single year's data, particularly in such a variable climate as is found in Botswana. This is particularly true of these trials, given the difficulties with implementation, crop growth and insect pests. Nonetheless, there are some points of interest worth noting. First, it is clear that if such a system ever proved to have production and risk advantages, careful thought and testing would have to be given to the ploughing logistics. This system might be economically feasible for tractor owners whose operating costs are less than the P50/hr used in the economic analysis. The system might also be practical for draught controlling farmers who could do initial ploughing on less than optimal soil moisture conditions with their own animals. Second, slashing the run-off areas by hand requires a lot of labour (See economic analysis). A robust cultivator would be required to deal with the heavy weed cover that can develop on these strips in seasons of good rainfall. Third, average grain yields from the CBP treatments were not much different from those of the DP or TC treatments (except in location one, where both CBP plots were destroyed by grasshoppers.) This was in spite of the reduced planted area in the CBP treatments. Thus these trials did not disprove the theory that a CBP system could be a more efficient production system (assuming the use of animal draught power and that an effective animal drawn weeder was developed).

In conclusion, experience with the CBP system in the past year suggests that:

(a). There are logistical problems with implementing a CBP system, (particularly in regards to tillage, and weed control on the unploughed strips).

(b). There is no evidence to suggest that a CBP system would lower per hectare grain yields below the level of the traditional system.

(c). The cost of hired tractor traction has a major impact on the system, and the cost of the first ploughing must be reduced to make the CBP system economically competitive.

The CBP system, in theory, would have the advantages of allowing a concentration of resources (rainfall, seed and fertiliser inputs) allowing mechanical weeding on at least half the field area, reducing hand weeding labour requirements per hectare through double ploughing cropped areas and mechanical weeding on unploughed strips, making crop rotations easy and reducing soil erosion through contour ploughing. Thus the system is still very much worth consideration, especially since the only test performed was done in an unusually wet year, which would have masked any water harvesting effects.

Unfortunately, it is clear that developing the system to an operational level for farmers would require a fairly intensive research effort for several years. The ATIP research team in Tutume Agricultural District does not have sufficient time or resources to complete this task, and given the number of competing priority research topics, it has been decided to drop this line of investigation. However, the theory would still merit further investigation by researchers concentrating on potentially useful water harvesting techniques.

APPENDIX A

TABLE A1: LABOUR TIMES, PERSON HOURS PER HECTARE, BY TREATMENT, WATER HARVESTING TRIAL, FRANCISTOWN AREA, 1987-88[a]

LOC/REP	YIELD KG/HA	PLOW1 HR/HA	PLANT HR/HA	PLOW2 HR/HA	WEED HR/HA	SLASH1 HR/HA	SLASH2 HR/HA	HARVEST HR/HA	THRESH HR/HA	TOTAL HR/HA
					CONTOUR BAND PLOUGHING					
1-1	0	1.7[b]	1.1	21.3	44.6	51.5	45.6	0.0	0.0	165.9
1-2	0	1.7[b]	0.8	30.7	35.9	37.7	89.5	0.0	0.0	196.2
2-1	384	1.0	0.9[c]	13.4	0.0	33.8	22.4	23.2	35.1	129.9
2-2	300	1.4	0.9[c]	16.6	0.0	18.6	38.0	13.2	21.0	109.6
3-1	139	2.8	1.3	19.1	0.0	18.1	0.0	7.6	26.4	75.4
3-2	114	1.5	1.1	24.4	0.0	0.0	0.0	10.5	20.9	58.3
AVERAGE	156	1.7	1.0	20.9	13.4	26.6	32.6	9.1	17.2	122.5
					DOUBLE PLOUGHING					
1-2	152	2.6[b]	0.7	13.7	133.0	0.0	0.0	13.7	5.1	168.8
1-1	106	2.6[b]	1.1	30.7	111.4	0.0	0.0	10.8	3.3	159.9
2-1	370	2.3	0.9[c]	12.3	0.0	0.0	0.0	35.8	26.5	77.7
2-2	260	2.7	0.9[c]	28.9	0.0	0.0	0.0	58.3	41.2	132.0
3-1	88	2.8	0.7	21.1	0.0	0.0	0.0	5.3	13.7	43.7
3-2	189	2.6	0.7	19.7	0.0	0.0	0.0	12.2	31.3	66.5
AVERAGE	194	2.6	0.8	21.1	40.7	0.0	0.0	22.7	20.2	108.1
					TRADITIONAL CHECK					
1-1	212	0.0	0.6	27.3	132.5	0.0	0.0	21.5	10.3	192.2
1-2	0	0.0	0.6	15.8	148.9	0.0	0.0	0.0	0.0	165.3
3-1	160	0.0	0.8	28.1	0.0	0.0	0.0	6.1	15.3	50.4
3-2	111	0.0	0.9	26.5	0.0	0.0	0.0	16.1	19.2	62.7
AVERAGE	121	0.0	0.7	24.4	70.4	0.0	0.0	10.9	11.2	117.6
OVERALL AV	162	2.1	0.9	21.9	37.9	10.0	12.2	14.6	16.8	116.4

a. Totals may not add due to rounding errors
b. Timing of tractor ploughing missing, average of other tractor ploughing times within treatment used
c. Seed broadcast time missing, average of other seed broadcast times used

TABLE A2: YIELD AND RETURNS TO LABOUR, IN PULA, WATER HARVESTING TRIAL, FRANCISTOWN AREA, 1987-88

LOC/REP	YIELD KG/HA	TOTAL TIME HR/HA	GTVP* PULA/HA	COSTS* PULA/HA	NTVP* PULA/HA	RETURNS TO LABOUR GROSS* PULA/HR	RETURNS TO LABOUR NET* PULA/HR
				CONTOUR BAND PLOUGHING			
1-1	0	165.9	0.00	52.00	-52.00	0.00	-0.31
1-2	0	196.2	0.00	52.00	-52.00	0.00	-0.26
2-1	384	129.9	172.80	52.00	120.80	1.33	0.93
2-2	300	109.6	135.00	52.00	83.00	1.23	0.76
3-1	139	75.4	62.55	52.00	10.55	0.83	0.14
3-2	114	58.3	51.30	52.00	-0.70	0.88	-0.01
AVERAGE	156	122.5	70.27	52.00	18.27	0.57	0.15
				DOUBLE PLOUGHING			
1-2	152	168.8	68.40	52.00	16.40	0.41	0.10
1-1	106	159.9	47.70	52.00	-4.30	0.30	-0.03
2-1	370	77.7	166.50	52.00	114.50	2.14	1.47
2-2	260	132.0	117.00	52.00	65.00	0.89	0.49
3-1	88	43.7	39.51	52.00	-12.49	0.90	-0.29
3-2	189	66.5	85.01	52.00	33.01	1.28	0.50
AVERAGE	194	108.1	87.35	52.00	35.35	0.81	0.33
				TRADITIONAL CHECK			
1-1	212	192.2	95.40	2.00	93.40	0.50	0.49
1-2	0	165.3	0.00	2.00	-2.00	0.00	-0.01
3-1	160	50.4	72.00	2.00	70.00	1.43	1.39
3-2	111	62.7	49.95	2.00	47.95	0.80	0.76
AVERAGE	121	117.6	54.34	2.00	52.34	0.46	0.44
OVERALL	AV162	116.4	72.69	39.50	33.19	0.62	0.29

* GTVP = Gross Total Value Product (yield x price) where price = P.45/kg
* COSTS: Tractor hire = P50/ha, Seed = P2/ha
* NTVP = Net Total Value Product (GTVP - COSTS)
* Gross Return to Labour = GTVP/Total Hours
* Net Return To Labour = NTVP/Total Hours