Comparison of conservation farming demonstration plots with conventionally farmed control plots

Introduction

The Conservation Farming Unit[1], CFU, in Zambia in the 2002/3 cropping season had demonstration plots with three-year rotations based on maize, legume and cotton in Central, Western and Southern regions of Zambia in the region IIa agro-ecological zone. The purpose of the demonstrations, which are on going, is to show farmers how to apply conservation farming method (CF) to small-scale farming.

An important and recognised constraint to achieving higher yields in small-scale agriculture is planting early, and one of the key benefits of CF is preparing the land during the dry season, using conservation farming basins[2], so that planting can occur with the first planting rains. CFU advocates that land preparation is best undertaken using a hand hoe as soon as possible after the harvest when the soil is still relatively friable, labour costs are at their lowest and there is little or no hunger[3].

On the other hand, conventional farming method leaves land preparation until the rains have arrived, because the land is too hard to plough by oxen before then and is much easier to work with a hand hoe after then. There are two options. The first is to prepare the land using oxen and then plant behind the oxen. This is relatively fast once the oxen are available. Since oxen substitutes an overhead cost of household labour for the immediate cash cost of oxen hire, the use of oxen may be explained by a combination of relatively smaller richer households and a scarcity of hirable labour, and larger currently farmed areas.

The second and final option is to prepare the land with a hand-hoe and plant thereafter, which is slower and more arduous but does not impose a cash cost. The method is most likely associated with poorer farmers. The yield outcome arising from an earlier planting date in the competition between hand hoe and oxen is dependent on the availability of oxen; because corridor disease has decimated the availability of working oxen, farmers using oxen are expected to plant even later than hand-hoe farmers. In both cases, the land is prepared after the rains have come; so both plant later than the conservation farming method proposed by CFU.

---

[1] Peter Aagaard and Dutch Gibson established the Conservation Farming Unit as part of the Zambia National Farmers Union to promote conservation farming method to small-scale farmers. The first cropping season was 1996/7.

[2] The basins are 0.60m long, 0.15m wide and 0.20m deep, spaced every 0.70m on row spacing of 0.90m.

[3] Later in the dry season, the land becomes hard to cultivate, food is scarcer and competition for labour rises as the planting season approaches.

The yield of maize from the demonstration plot is measured and compared with the yields from adjacent control plots where the farmer receives the same inputs but no extension advice. The dependent variable is the maize yield and the key factor is whether the farmer uses conservation farming or conventional methods. Whether the farmer uses oxen or hand-hoe may however be a function of the availability of household labour, because if there is insufficient household labour, either labour or oxen must be hired. On the other hand, if the household is wealthy, the farmer can avoid the drudgery of land preparation. The result however of using oxen for whatever reason appears to be very late planting which is reflected in much lower yields. So the hypothesis is that planting date is a function of oxen use, available household labour and wealth. Since yield is a function of planting date, yield must also be a function of oxen use, available household labour and wealth.

An important caveat is that since there is no supervision of the control plots there is no guarantee that the farmer applied the inputs to the control plot.

Although the purpose of this trial is explicitly to find whether there is a yield difference between conservation farming method and conventional farming method using comparable equipment, i.e. the hand-hoe, the cost of using oxen is measured by default.

The questions are 1) what is the yield difference between the three-year rotation in conservation farming basins and the conventional farming practice; 2) what is the economic contribution of conservation farming basins per hectare; 3) what are the contributions of early planting and basins to conservation farming; 4) and what do oxen contribute to yields?

Data

Table 1 shows the distributions of maize yield and planting dates from demonstration plots in Western, Southern and Central regions. From the 210 demonstrations, the average yield is 3,846kg ha^{-1} with a standard deviation of 2,212kg. The median is 3,430kg, slightly lower suggesting a positive skew that implies that some farmers had higher yields than normally expected. The lowest yield per hectare was 237kg and the highest 11,186kg.

The average number of days farmers planted after the first farmer planted was 27.85 days, with a standard deviation of 19.04 days. The median of 26 days suggests that some farmers planted later than normally expected. The latest planting was 68 days after the first planting.

In the sample of 210 farmers, 54 used oxen (25.7 per cent) for the joint land preparation and planting sequence.

Table 1 shows the distributions of maize yield and planting dates from demonstration plots in Western, Southern and Central regions. The percentage oxen utilisation is also reported.

Demonstration plots						
	n	**Mean**	**Median**	**StDev**	**Minimum**	**Maximum**
Yield	210	3,846kg	3,430kg	2,212kg	237kg	11,186kg
Planting date	210	27.85	26	19.04	0	68
Oxen	210	0.2571				

Table 2 shows the distributions of the demonstration plots (DP) and the auxiliary plots (ADP). The mean maize yield from 100 auxiliary plots is 3,010 kg ha^{-1} with a standard deviation of 1,667kg. This compares with the 4,606kg ha^{-1} yield found from 110 demonstration plots, with a standard deviation of 2,373kg. The difference is 53 per cent. The null hypothesis that the means come from the same sampling distribution fails to be accepted, with an F-statistic of 31.22.

Table 2 shows the distributions of the demonstration plots (DP) and the auxiliary plots (ADP).

```
ANALYSIS OF VARIANCE ON Yield
SOURCE     DF         SS         MS         F         p
Trial       1 133435520 133435520    31.22    0.000
ERROR     208 888953664   4273816
TOTAL     209 1.022E+09

                                    INDIVIDUAL 95% CI'S FOR MEAN
                                    BASED ON POOLED STDEV
 LEVEL      N       MEAN      STDEV  ---+---------+---------+---------+---
    AP    100       3010       1667  (-----*-----)
    DP    110       4606       2373                        (-----*----)
                                    ---+---------+---------+---------+---
POOLED STDEV =      2067             2800      3500      4200      4900
```

Table 3 shows the distributions of the maize yields from farmers using hand hoes and from farmers using oxen. The average maize yield of 156 hand hoe farmers is 4,234kg ha^{-1} with a standard deviation of 2,284kg; in comparison the average maize yield from 54 oxen farmers is 2,724kg ha^{-1} with a standard deviation of 1,518kg. The yield of hoe farmers is 55.4 per cent higher than oxen farmers. The null hypothesis that they are from the same population of mean yields fails to be accepted with an F-statistic of 20.43.

Table 3 shows the distributions of the maize yields from farmers using hand hoes and from farmers using oxen.

```
ANALYSIS OF VARIANCE ON Yield
SOURCE     DF         SS         MS         F         p
Oxen        1   91457400   91457400    20.43    0.000
ERROR     208 930931776    4475634
TOTAL     209 1.022E+09

                                    INDIVIDUAL 95% CI'S FOR MEAN
                                    BASED ON POOLED STDEV
 LEVEL      N       MEAN      STDEV  ----------+---------+---------+------
Hand hoe  156       4234       2284                            (---*----)
Oxen       54       2724       1518   (-------*-------)
                                    ----------+---------+---------+------
POOLED STDEV =      2116                    2800      3500      4200
```

Table 4 shows the distributions of planting dates of hand hoe farmers and oxen farmers. The 156 hand hoe farmers planted on average 22.5 days after the first farmer planted, with a standard deviation of 17.6 days. On the other hand, 51 oxen farmers planted an average of 45 days after the first farmer planted with a standard deviation of 11.22 days. The null hypothesis that there is no difference between the means fails to be accepted, so oxen farmers plant 23 days after hand hoe farmers. It also seems that some late planting is the result of the oxen cultivation.

Table 4 shows the distributions of planting dates of hand hoe farmers and oxen farmers.

```
ANALYSIS OF VARIANCE ON Planting Date
SOURCE     DF        SS        MS        F        p
Oxen        1     20119     20119    75.98    0.000
ERROR     205     54285       265
TOTAL     206     74404

                                  INDIVIDUAL 95% CI'S FOR MEAN
                                  BASED ON POOLED STDEV
 LEVEL      N      MEAN     STDEV  -+---------+---------+---------+-----
Hand hoe  156     22.51     17.60   (--*-)
Oxen       51     45.39     11.22                        (---*----)
                                  -+---------+---------+---------+-----
POOLED STDEV =    16.27            20        30        40        50
```

Results

Table 5 shows the results from a general linear model. The difference in maize yield between the conventional farming practice and conservation farming basins method is highly significant at 1 and 202 degrees of freedom, against an F-statistic of 33.26. The same is true of the planting date with an F-statistic of 5.68. In the presence of the planting date variable, the use of oxen does not help to explain maize yields in the plots.

After accounting for planting dates and the use of oxen, the adjusted mean yield of maize from the auxiliary plots is 3, 446kg ha^{-1} with a standard deviation of 255.7kg. This is higher than the 3,010kg ha^{-1} found earlier. The adjusted mean from the demonstration plots is 4,678kg ha^{-1} with a standard deviation of 250kg. This is slightly higher than the earlier estimate of 4,606kg ha^{-1}. The adjusted yield increase attributed to the conservation farming basin method over conventional farming practice is 33.7 per cent, which is lower than the earlier estimate of 55.4 per cent. The value of the 24.6 by 50kg bags incremental yield per hectare is K739,200 (US$154) per hectare.

Table 5 shows the results from a general linear model.

```
F-test with denominator: Error
Denominator MS =  4108981 with 202 degrees of freedom

Numerator      DF   Seq MS      F       P
DP              1 1.37E+08  33.26   0.000
PDate(DP)       2 23358756   5.68   0.004
Ox              1   344841   0.08   0.772
```

Table 6 shows the estimation of the slopes of the covariate and the regressor. The constant term suggests the unadjusted mean yield is 4,509kg ha^{-1} with a standard error of 331, which is highly significant with a t-statistic of 14.48. Farmers using conventional farming practice lose a significant 40.6kg ha^{-1} per day late planting with a standard error of 14.67, significant at better than one per cent. This is about 0.9 per cent per day. Farmers practicing conservation farming basins may benefit slightly from better planting timeliness, but it is not significant. The use of oxen may have a slightly negative effect on yields, after accounting for planting dates, although it is also not significant.

Table 6 shows the estimation of the slopes of the covariate and the regressor.

Term		Coeff	Stdev	t-value	P
Constant		4509.1	311.4	14.48	0.000
PDate(DP)					
	0	-40.61	14.67	-2.77	0.006
	1	11.17	11.71	0.95	0.341
Oxen		-133.3	460.1	-0.29	0.772

We have already seen however, that hand hoe farmers are planting much earlier than oxen farmers, and oxen farmers have to plant after the land is soft enough to plough or rip. Table 7 shows the regression of yield on planting date and oxen. The constant term is a significant maize yield of 4,632kg ha^{-1} with a t-statistic of 17.57, which is the average yield before taking account of the planting date and the use of oxen. The planting date result suggests a significant 17kg ha^{-1} per day is lost per day late planting at a ten per cent level, with a standard error of 9kg. The oxen account for a significant loss of yield, 1,184kg ha^{-1} off the constant yield of 4,632kg ha^{-1}. Since this is all late planted, around 45 days after the first hand hoe farmer planted, the loss also includes the late planting due to oxen. This implies that farmers lose 17.7kg ha^{-1} per day late planted, 0.4 per cent, and oxen farmers then lose another 1,183kg ha^{-1} for using oxen, 25.5 per cent of the whole crop.

Table 7 shows the regression of yield on planting date and oxen.

The regression equation is
Yield = 4632 - 17.7 PDate - 1184 Ox

Predictor	Coef	Stdev	t-ratio	p
Constant	4631.8	263.5	17.57	0.000
PDate	-17.677	9.014	-1.96	0.051
Ox	-1183.8	396.6	-2.98	0.003

s = 2100 R-sq = 11.2% R-sq(adj) = 10.4%

Conclusions

1) The difference between maize yields from conservation farming basins method and conventional farming practice in the region IIa) agro-ecological zone is 33.7 per cent.

2) The incremental maize yield is 24.6 fifty kilogram bags, which has a value of K739,200 hectare (US$154).

3) Conventional farmers on average lose about one per cent of their yield per day late planting. Conservation farmers do not experience this loss, but it is premature to assert that they increase their yields by timeliness of planting.

4) More generally, hoe farmers lose 0.4 per cent of their yield per day late planting and oxen farmers lose this and 25.5 per cent of their maize yield; thus oxen farmers planting 45 days late lose 795.5kg, 17.2 per cent of the crop potential, and 1,184kg from using oxen, 25.5 per cent of the crop potential. The loss is worth K1.19 million (US$247).

The caveat is that the results reflect the characteristics of the 2002/3 cropping season in region IIa agro-ecological zone.