The response of maize to lime and the viability of maize intercropped with sunnhemp

Introduction

The purpose is to find

1) the response of maize to lime under conservation farming basins in region IIa agro-ecological zone.

2) if maize intercropped with red sunnhemp and rotated *in situ* is viable as a sole-cropped maize in conservation farming basins in region IIa.

Data

The average yield from the 195 treatments is 2,916kg ha^{-1} with a standard deviation of 1,306kg. The median is 2,970kg ha^{-1}, suggesting a normal distribution. The minimum yield was 506kg and the maximum 5,878kg.

Dunavant maize sunnhemp trial						
	n	**Mean**	**Median**	**StDev**	**Minimum**	**Maximum**
Yield	195	2,916kg	2,970kg	1,306kg	506kg	5,878kg

Table 1 shows the results of a one-way analysis of the yields of each of the treatments. There are four treatments, 1) with no lime and no sunnhemp, 2) with no lime and sunnhemp, 3) with lime and no sunnhemp and 4) with lime and sunnhemp. The yield of the treatment without lime and without sunnhemp is 3,405kg ha^{-1} with a standard deviation of 1,165kg; the yield with sunnhemp but without lime is 2,298kg ha^{-1} with a standard deviation of 1,203kg; with lime but without sunnhemp, 3,512kg ha^{-1} with a standard deviation of 1,164kg; and with lime and sunnhemp 2,462kg ha^{-1} with a standard deviation of 1,252kg. There is a significant difference between the yield treatments.

Table 1 shows the results of a one-way analysis of the yields of each of the treatments.

```
ANALYSIS OF VARIANCE ON Yield
SOURCE     DF         SS         MS         F         p
C104        3   57557308   19185770    13.40     0.000
ERROR     191  273562176    1432263
TOTAL     194  331119488
                                      INDIVIDUAL 95% CI'S FOR MEAN
                                      BASED ON POOLED STDEV
 LEVEL      N      MEAN     STDEV  --------+---------+---------+--------
     1     49      3405      1165                      (-----*----)
     2     49      2298      1203   (----*-----)
     3     48      3512      1164                        (-----*----)
     4     49      2462      1252     (-----*-----)
                                     --------+---------+---------+--------
POOLED STDEV =     1197               2400      3000      3600
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Table 2 shows the maize yields with and without lime. The maize yield without lime is 2,952kg ha^{-1} with a standard deviation of 1,303kg and with lime, 2,981kg ha^{-1} with a standard deviation of 1,314kg. There is no significant difference between the yields.

Table 2 shows the maize yields with and without lime.

```
ANALYSIS OF VARIANCE ON Yield
SOURCE     DF         SS         MS         F         p
Lime        1     820509     820509      0.48     0.490
ERROR     193  330298976    1711394
TOTAL     194  331119488

                                      INDIVIDUAL 95% CI'S FOR MEAN
                                      BASED ON POOLED STDEV
 LEVEL      N       MEAN      STDEV  -+---------+---------+---------+-----
    -1     98       2852       1303   (------------*------------)
     1     97       2981       1314          (------------*------------)
                                      -+---------+---------+---------+-----
POOLED STDEV =      1308           2600      2800      3000      3200
```

Table 3 sbows the maize yields with and without sunnhemp. The yield without sunnhemp is 3,458kg ha^{-1} with a standard deviation of 1,160kg, and with sunnhemp, 2,380kg ha^{-1} with a standard deviation of 1,224kg. The difference between the yields is highly significant.

Table 3 sbows the maize yields with and without sunnhemp.

```
ANALYSIS OF VARIANCE ON Yield
SOURCE     DF         SS         MS         F         p
Sunnhemp    1   56624968   56624968     39.81     0.000
ERROR     193  274494528    1422251
TOTAL     194  331119488

                                      INDIVIDUAL 95% CI'S FOR MEAN
                                      BASED ON POOLED STDEV
 LEVEL      N       MEAN      STDEV  --------+---------+---------+--------
    -1     97       3458       1160                          (----*----)
     1     98       2380       1224   (----*---)
                                      --------+---------+---------+--------
POOLED STDEV =      1193                 2500      3000      3500
```

Table 4 shows the maize yields for each of the regions. The average yield in Western region is 3,155kg ha^{-1} with a standard deviation of 1,146kg; Southern region has an average yield, 2,947kg ha^{-1} with a standard deviation of 1,481kg; and Central region has the lowest mean yield, 2,451kg ha^{-1} with a standard deviation of K1,216kg. The null hypothesis that the means from the regions are from the same population fails to be accepted.

Table 4 shows the maize yields for each of the regions.

```
ANALYSIS OF VARIANCE ON Yield
SOURCE     DF         SS         MS         F         p
Region      2   14968590    7484295      4.55     0.012
ERROR     192  316150912    1646619
TOTAL     194  331119488

                                      INDIVIDUAL 95% CI'S FOR MEAN
                                      BASED ON POOLED STDEV
 LEVEL      N       MEAN      STDEV  --------+---------+---------+--------
     0     83       3155       1146                    (------*------)
     1     65       2947       1481                (-------*-------)
     2     47       2451       1216  (--------*---------)
                                      --------+---------+---------+--------
POOLED STDEV =     1283                 2400      2800      3200
```

Table 5 shows the distributions of the maize yields for different trial ages. The 55 treatments from the newest farmers had an average yield of 2,907kg ha^{-1} with a standard deviation of 1,436kg, the 136 treatments from first-year farmers had yields of 2,935kg ha^{-1} with a standard deviation of 1,270kg. The average yield from the four treatments of the one second-year farmer was 2,386kg ha^{-1} with a standard deviation of 512kg. There is no significant difference between the mean yields.

Table 5 shows the distributions of the maize yields for different trial ages.

```
ANALYSIS OF VARIANCE ON Yield
SOURCE     DF         SS         MS         F         p
C120        2    1180336     590168      0.34     0.710
ERROR     192  329939168    1718433
TOTAL     194  331119488

                                      INDIVIDUAL 95% CI'S FOR MEAN
                                      BASED ON POOLED STDEV
 LEVEL      N       MEAN      STDEV  -----+---------+---------+---------+-
     0     55       2907       1436                       (----*----)
     1    136       2935       1270                         (--*--)
     2      4       2386        512   (-----------------*-----------------)
                                      -----+---------+---------+---------+-
POOLED STDEV =     1311                1400      2100      2800      3500
```

Results

Table 6 shows the results of a general linear model. Outliers with studentised residuals beyond two standard deviations are omitted and the trial age was removed after showing no significance. The site mean is highly significant, as expected. Lime is significant at a five per cent level, with adjusted mean yields of 2,812kg ha^{-1} without lime and 2,957kg ha^{-1} with lime, suggesting a 5.2 per cent increase in yield. Sunnhemp is also significant, suggesting that the adjusted mean yield of the intercropped maize and sunnhemp of 2,387kg ha^{-1} is 29.4 per cent lower than the sole-cropped 3,381kg ha^{-1}, and there is no significant influence from the number of years farmers have been practicing the method. We can therefore conclude that the lower yield found when sunnhemp is intercropped with maize is significantly lower than sole-cropped maize on a per hectare basis; but on a per plant or planting station basis, the intercropped maize yield is 41.2 per cent higher than sole-cropped maize.

Table 6 shows the results of a general linear model.

F-test with denominator: Error
Denominator MS = 251329 with 179 degrees of freedom

Numerator	DF	Seq MS	F	P
Sitemean	1	2.00E+08	797.21	0.000
Lime	1	979831	3.90	0.050
Sunnhemp	1	45716452	181.90	0.000
Lime*Sunnhemp	1	28704	0.11	0.736
Lime*Sitemean	1	303738	1.21	0.273
Sunnhemp*Sitemean	1	105667	0.42	0.518

Figure 1 shows the yields of maize with and without lime, the green line is without lime and the red line, with lime. The black line is the yield after deducting the cost of the lime in terms of yield. Although significant, the margins are thin, maize with lime becomes viable at yields of 2,000 kg ha^{-1} and more. The divergence is not important to yields.

Figure 2 shows the yields without sunnhemp (green) and with sunnhemp (red). The black line shows the benefit from the reduction in initial costs from using sunnhemp. The cost saving per hectare from planting sunnhemp is K155,000 per hectare. This saving in terms of kilograms per hectare is 258 kilograms at K600 per kilogram, which is added back but is not sufficient to cover the lost sole-cropped maize yield.

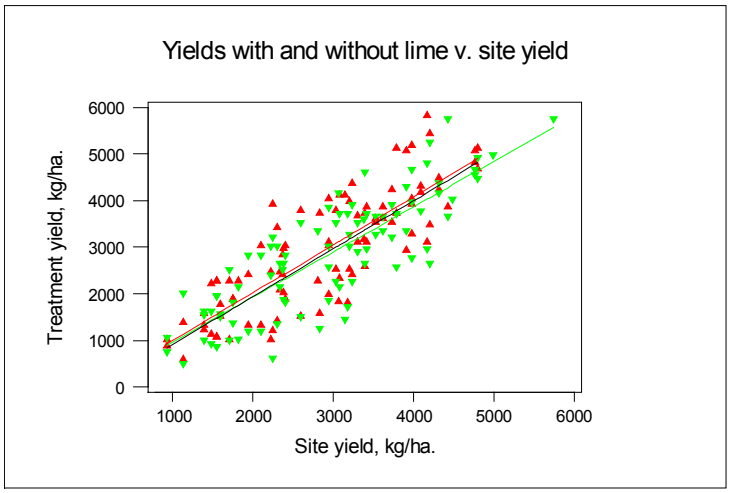

Figure 1 shows the yields of maize with and without lime, the green line is without lime and the red line, with lime. The black line is the yield after deducting the cost of the lime in terms of yield.

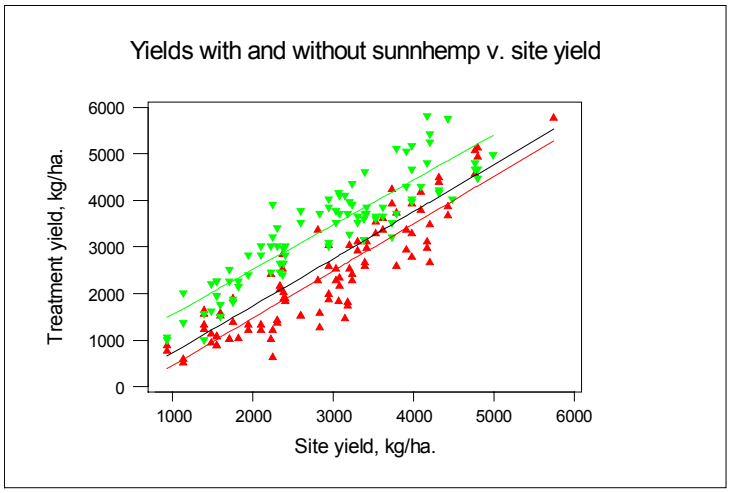

Figure 2 shows the yields without sunnhemp (green) and with sunnhemp (red). The black line shows the benefit from the reduction in initial costs from using sunnhemp.

Conclusions

1) Lime makes an important contribution to maize, increasing yields by 5.2 per cent. Although this yield increment only recovers the cost of lime over 2,000kg ha^{-1}, conservation farmers normally exceed this yield under conservation farming basins in the region IIa agro-ecological zone.

2) Maize intercropped with sunnhemp and rotated in situ yields 29.4 per cent less than sole-cropped maize on a per hectare basis, but 41.2 per cent more on a per plant or planting station basis, in conservation farming basins in the region IIa agro-ecological zone.