Trip Report: FACT/ADPP Project Mozambique Sept./Oct 2009

Flemming Nielsen

Schedule

10 to 12 September

Seminar: "Produção de Biocombustíveis em Moçambique" (Production of biofuel in Mozambique), Faculty of Agronomy and Forestry, Eduardo Mondlane University

- Task
  - Submit paper and present orally on the research undertaken under the FACT/ADPP Jatropha project in Cabo Delgado

14 to 25 September

Course on Jatropha production, Bilibiza, Cabo Delgado.

- Tasks:
  - Teach and make training material for the course.

11 to 25 September

A number of research tasks were planned too.

- Tasks:
  - Follow up on trials, including inspection and weighing of harvested seeds.
  - Obtain rainfall data from the meteorological station, Bilibiza.
  - Forecast Jatropha production for 10 years.
  - Forecast transport needs for collecting Jatropha seeds from the project area.
  - Interview farmers about labour allocation during the rainy season.

28 September til 1 October

- Task
  - Submit paper and present orally on the viability of using Jatropha for local development based on the experience from the FACT/ADPP Jatropha project in Cabo Delgado

Seminar: Production of biofuel in Mozambique

The seminar brought together various actors in biofuels in Mozambique but with a overweight of representatives from GALP Energy and Wageningen University. The national agricultural research system, IIAM, had very little to present. A field-trip to the Energem Jatropha project in Bilene was included in the program.

It was apparent that the FACT/ADPP project is relatively advanced compared to other projects in Mozambique but that the extensive research programs undertaken by commercial operators like GALP and Energem will soon be dwarfing the FACT/ADPP projects effort. However, the

commercial research is focused on medium to high input plantation agriculture with extensive mechanisation. There is therefore still an important niche for research focused on small scale farmers. In some cases there are overlapping interests. For instance a discussion with Energem revealed that they have big problems with flea beetles and see IPM as a long term solution. I am currently organising collaborative research on IPM for flea beetle control with Energem, UEM, and Wageningen University.

The willingness by GALP and Energem to share their research findings is very much appreciated. Sun Biofuels was noticeable absent. The reason is not known to me.

Course on Jatropha curcas Production

It was the first time we organised the course and it worked out surprisingly well. The participants were highly motivated and knowledgeable. Our knowledge about Jatropha has increased much over the last few years and it was no problem filling the two week program. It may be worth considering a three-week program next time. However, some organisations may find it too long for their staff to be absent and the burden on the Jatropha project staff should be considered too. They are just a few people and had to perform all their normal tasks beside running the course.

I prepared and gave presentations on:

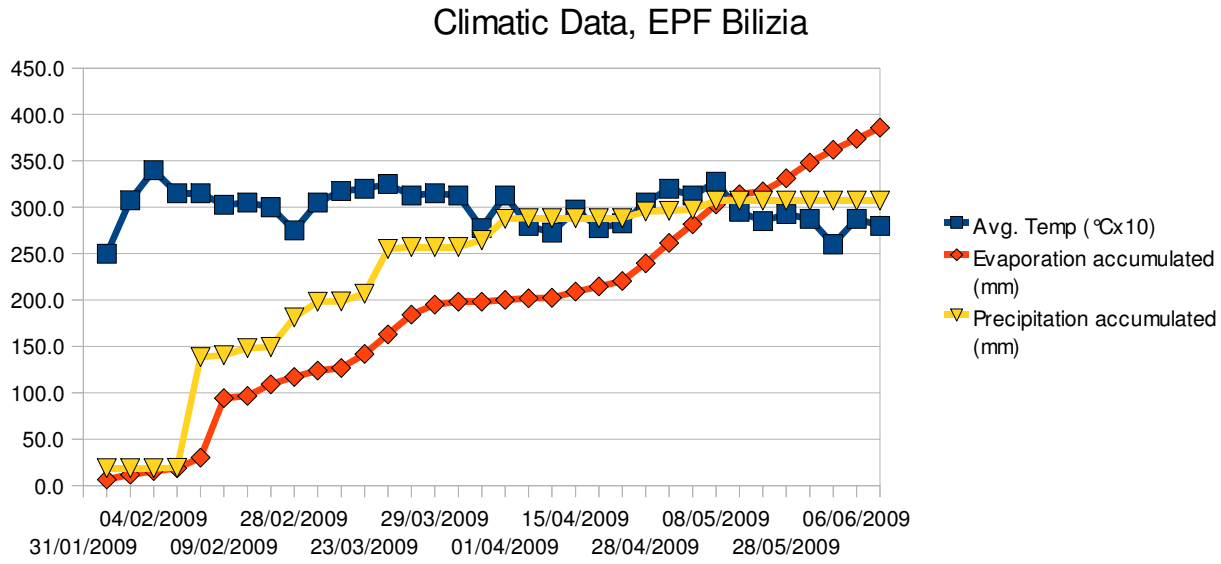
- Introduction to Biofuels
- Establishing Jatropha
- Misc. including yield versus rainfall and age, seed weight versus germination, mycorrhiza
- Pruning of Jatropha
- Pest and diseases of Jatropha and their control

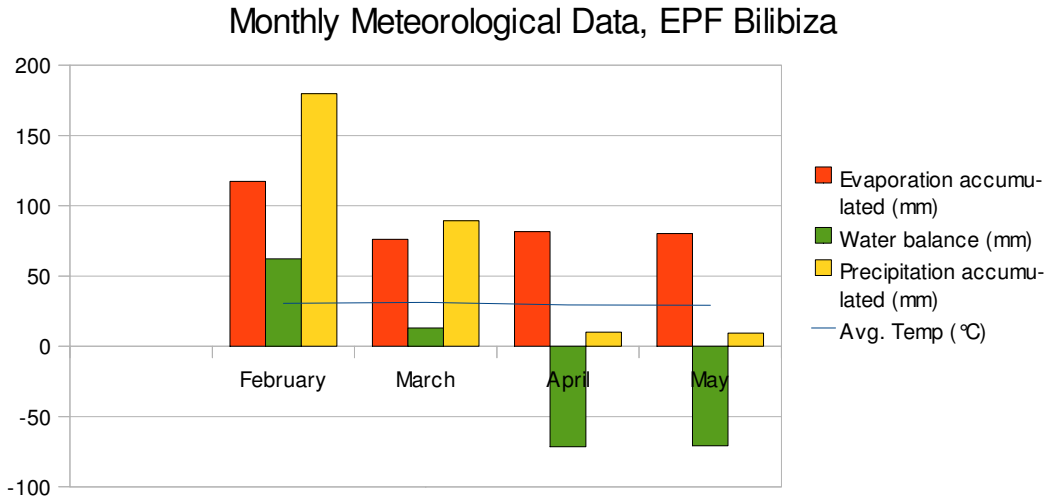
The presentations were given to the participants on a CD. GAIA Movement will be asked to translate the material into Portuguese.

Meteorological Data

At Bilibiza EPF there is a government meteorological station. I have tried previously in vain to get data from the station but this time with the help of Bachir data starting January this year were obtained. Since the station is located just 200 m from our trials the data will be very valuable for the analysis of the trial data when longer time series are available.

The meteorological data was found to be collected inconsistently, i.e. sometimes every day but often with gaps of four days or more. Some data was clearly inconsistent like minimum temperatures listed as higher than maximum temperatures. The data on evaporation, minimum and maximum temperature and precipitation was entered in a spreadsheet. Ineligible data was omitted. Where minimum and maximum data appeared to have been switched they were reversed. The figures below shows the main data.





Agronomic Trials

Yield Forecast

Objective

As part of the development of a business plan for the Bilibiza Biofuel Centre (BBC) it is important to have yield fore cast for Jatropha. The first part of this document will assess the

- Expected yield over the next 10 years of Jatropha planted in the project area with the current plantings of 250,000 plants kept constant
- Expected yield over the next 10 years with and annual expansion of the area planted with Jatropha of 25ha. Currently the equivalent of 250 ha has been planted.

Next the maximum Jatropha production per household will be assessed under the assumption that farmers continue to prioritise production of food for own consumption and only use surplus labour on Jatropha.

Next the geographical distribution of Jatropha production will be assessed using different scenarios:

- The Jatropha plantings remain constant
- Jatropha cultivation is expanded with 25ha per year
- Jatropha cultivation is expanded at each locality to the maximum.

10 Year Yield Prediction with Constant Area

Multiple Regression

An attempt was made to create a regression equation for yield.

Date for Jatropha yield based in relation to age and rainfall data was extracted from Figure 2 in:

Achten WMJ, Verchot L, Franken YJ, Mathijs E, Singh VP, Aerts R, et al. Jatropha biodiesel production and use. Biomass and Bioenergy (2008), doi:10.1016/j.biombioe.2008.03.003

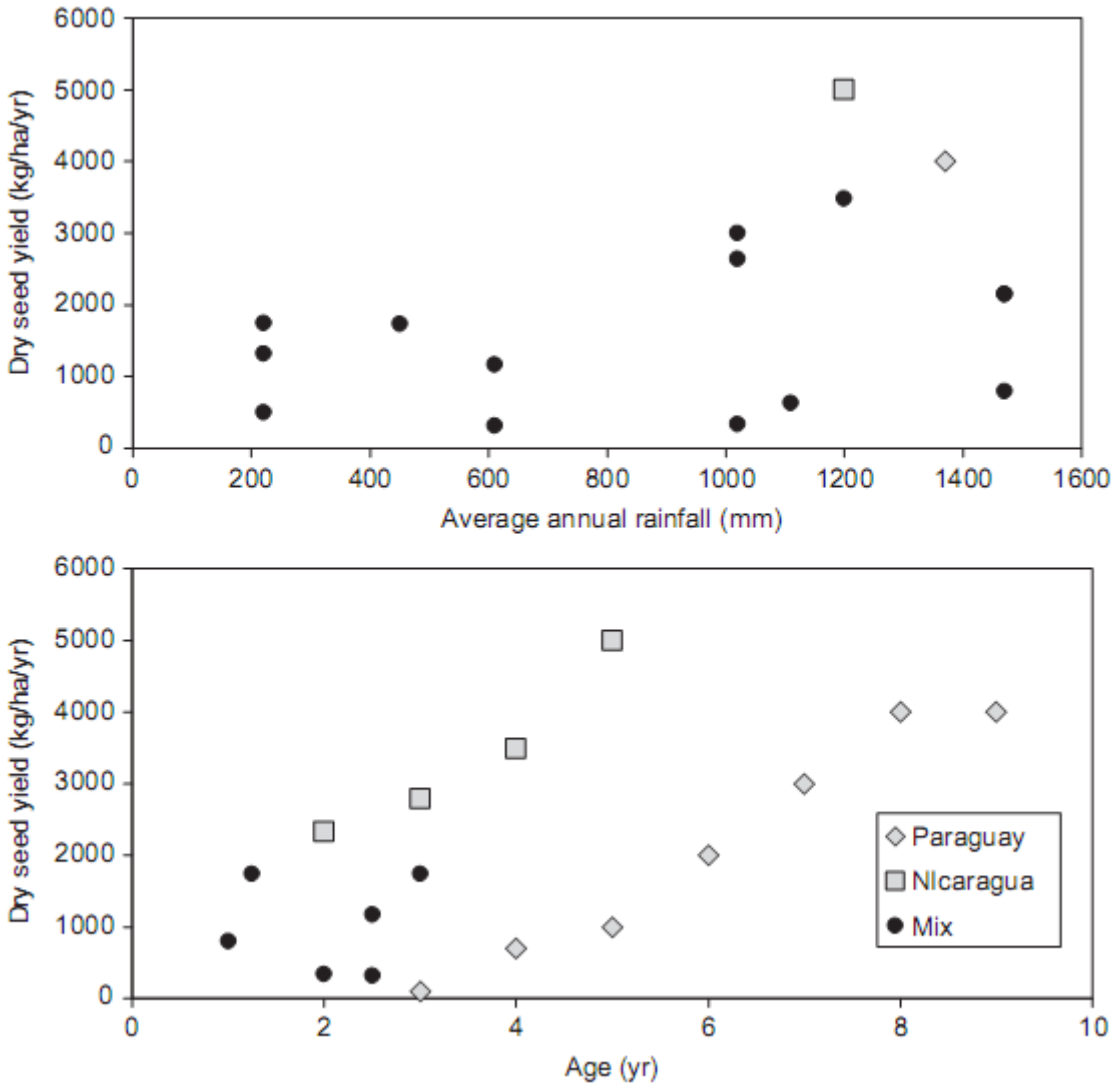


Illustration 1: From Achten et al 2008: "Fig.2–Dry seed yield in relation to average annual rainfall (mm) and age of the JCL crop. The plotted points represent a mix of provenances, site conditions and plantage or average annual rainfall. Sources: [9,11,13,52,53,56] and personal communication: Kumar, 2005 and Buisman, 2005."

The article is available in pdf format and the data is not in table form but only in two graphs in Figure 2. To extract the numeric values from the graphs a screen dump was saved as a bmp file.

The Enguage Digitizer was used to obtain numeric values from the screen dump. Comparison of values extracted from the two graphs showed a difference of max ±2%. The imprecision is likely caused by the limited screen resolution.

Matching of data from the two graphs was done manually in OpenOffice Calc and the data was saved in ASCII file named 2009-09_Yield_data.txt:

```
age   yield rain  locality
NA    1318.1      219.22      NA
NA    502.57      219.41      NA
NA    3013.24     1018.11     NA
NA    2652.07     1018.2      NA
NA    637.2 1108.73     NA
NA    3492.21     1196.72     NA
NA    2166.03     1468.62     NA
1     811.22      1468.94     NA
1.24  1750.98     219.12      NA
1.99  357.46      1018.74     NA
2.5   1180.85     609.05      NA
2.5   333.65      609.25      NA
3     1748.94     448.49      NA
3.02  66.13       1369.68     ”Paraguay”
4.01  668.46      1369.68     ”Paraguay”
5.02  957.43      1369.68     ”Paraguay”
6.01  1965.94     1369.68     ”Paraguay”
7.01  2951.24     1369.68     ”Paraguay”
8.01  3959.75     1369.68     ”Paraguay”
9.01  3946.99     1369.68     ”Paraguay”
1.99  2330.38     1197.77     ”Nicaragua”
3     2781.81     1197.77     ”Nicaragua”
3.99  3476.99     1197.77     ”Nicaragua”
4.99  4984.53     1197.77     ”Nicaragua”
```

Further analysis was done in R. To import the data file:

```
Jatropha <- read.table("2009-09_Yield_data.txt", header=TRUE)
```

Misc. commands for data exploration:

```
hist(Jatropha$age)
hist(Jatropha$yield)
hist(Jatropha$rain)
levels(Jatropha$locality)
plot(Jatropha$age, Jatropha$yield)
plot(Jatropha$rain, Jatropha$yield)

A linear multiple regression model is fitted:

mreg <- lm(yield ~ age + rain, data = Jatropha)
```

Different sub-sets of the data was used but no sensible regression equation could be obtained. There are several reasons for this. First of all some of the data from areas with very low rainfall (< 600 mm) have high yields. Since Jatropha usually does not yield when the rainfall is below 600 mm those data must be from areas where Jatropha relies on water from other source, be it irrigation or high ground water tables.

Other data is problematic too. In the graph on yield by rainfall the peak yield has been used for Nicaragua and Paraguay. Other data from high rainfall area are very low but the age of the plants is not known.

Excluding all outliers leaves us with mainly the two most complete datasets namely the Nicaragua and the Paraguay data series. The rainfall is higher in Paraguay than in Nicaragua but the yield is lower. A regression equation based on these data alone will therefore predict higher yield with decreasing rainfall, i.e. grossly over-estimate the yield for the Bilibiza area.

The multiple regression method is therefore not appropriate with the current data set.

Generalised Logistic (Richard's) Curve

The longest data serie from Paraguay shows the S-curve shape that is characteristic for many yield curves. It can often be described with the generalised logistic curve, also called Richard's curve:

$$Y = A + \frac{(C - A)}{(1 + Te^{-B(x-M)})^{1/T}}$$

Where Y is the yield and T is the year. The five parameters are:

A, the lower asymptote;

C, the upper asymptote, i.e. the maximum yield

M, the time of maximum growth;

B, the growth rate;

T, near which asymptote maximum growth occurs.

The Paraguay data series was entered in a spreadsheet and visual curve fitting was done resulting in the following values:

A	0
C	3947
M	6.9
B	4
T	7

The model values are compared with the Parauay data set in Illustration 2.

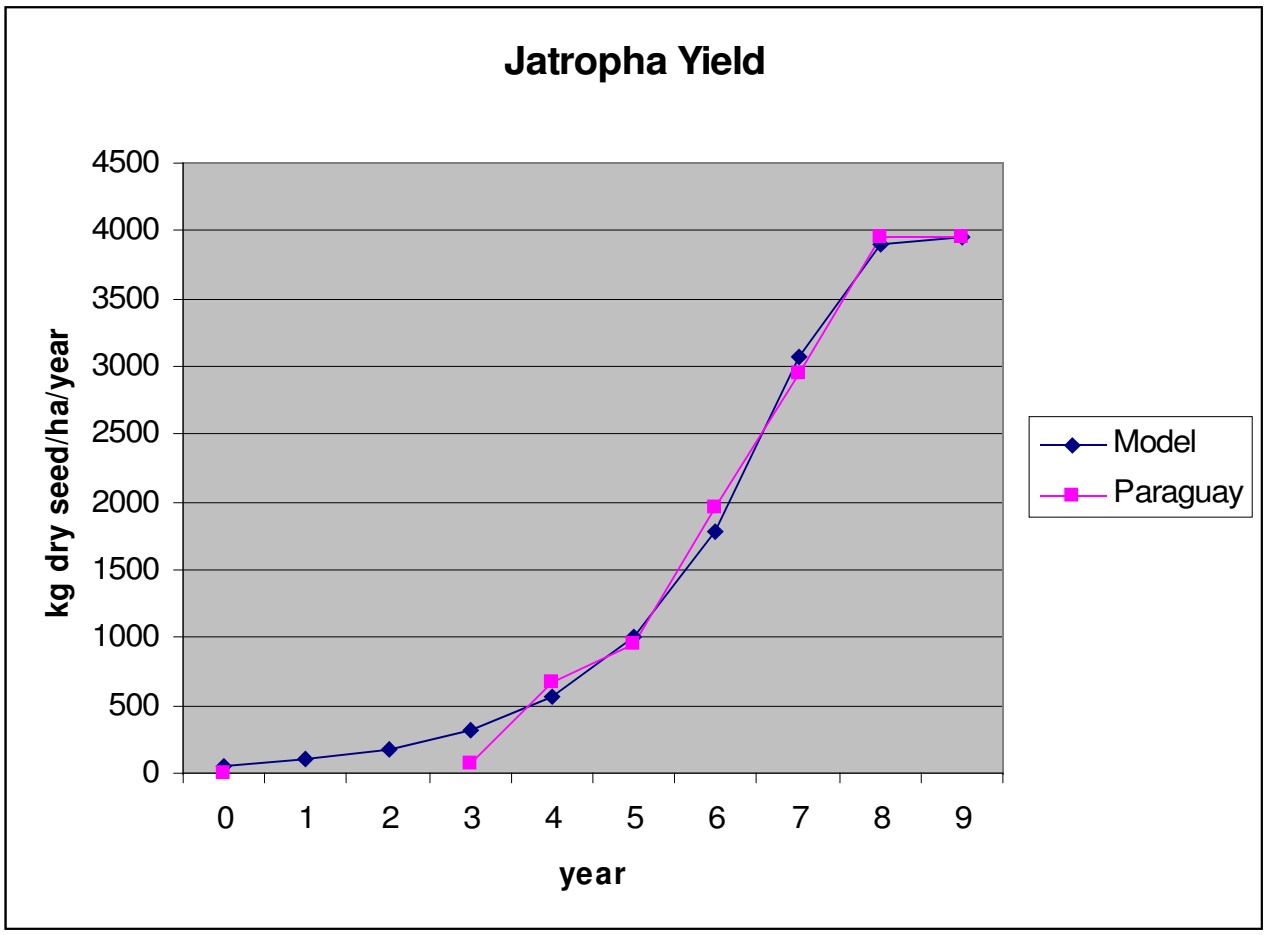


Illustration 2: Richards'curve fitted to imperical Jatropha yield data from Paraguay

The average yield in the project area is estimated to be peak around 800 kg/ha. This may appear low considering the data in Illustration 1. However, poor management including poor pruning practise makes it unlikely that higher yields will be achieved.

Using the above mentioned parameters for the Richards' curve but with maximum yield set to 800 kg result in the following yield figures.

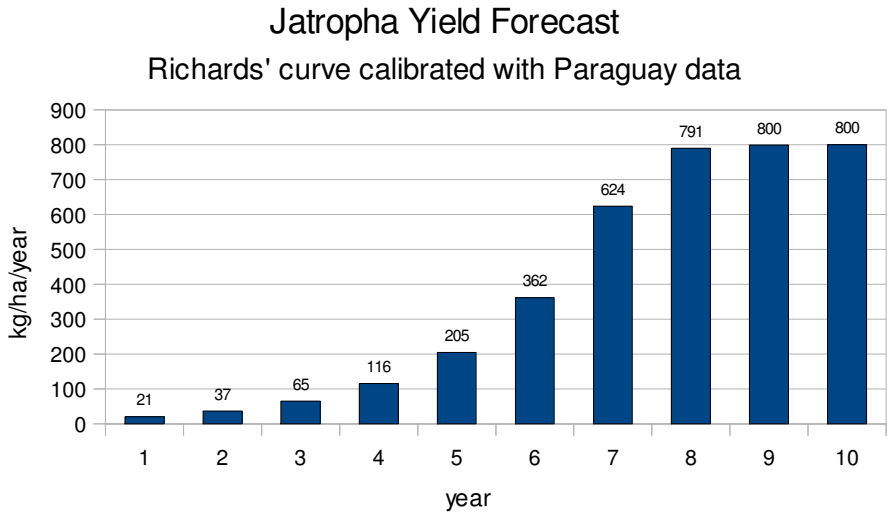


Illustration 3: Jatropha yield forecast for the project area (kg/ha)

Currently the equivalent of 250 ha have been planted. Below the total harvest from the project area is forecast for two scenarios:

- The area with Jatropha is kept constant at the current level of 250 ha;
- Farmers expand the area under Jatropha with 25 ha every year.

The two scenarios result in the following harvest forecast.

	Harvest from 250 ha	**Harvest from 250 ha + 25 ha expansion/year**	
year	**t**	**t**	**ha**
1	5	6	275
2	9	11	300
3	16	19	325
4	29	35	350
5	51	62	375
6	91	111	400
7	156	192	425
8	198	253	450
9	200	275	475
10	200	295	500
11	200	315	525
12	200	335	550
13	200	355	575
14	200	375	600
15	200	395	625
16	200	415	650
17	200	435	675
18	200	455	700
19	200	475	725
20	200	495	750

Table 1: Harvest forecast for the project area under two scenarios

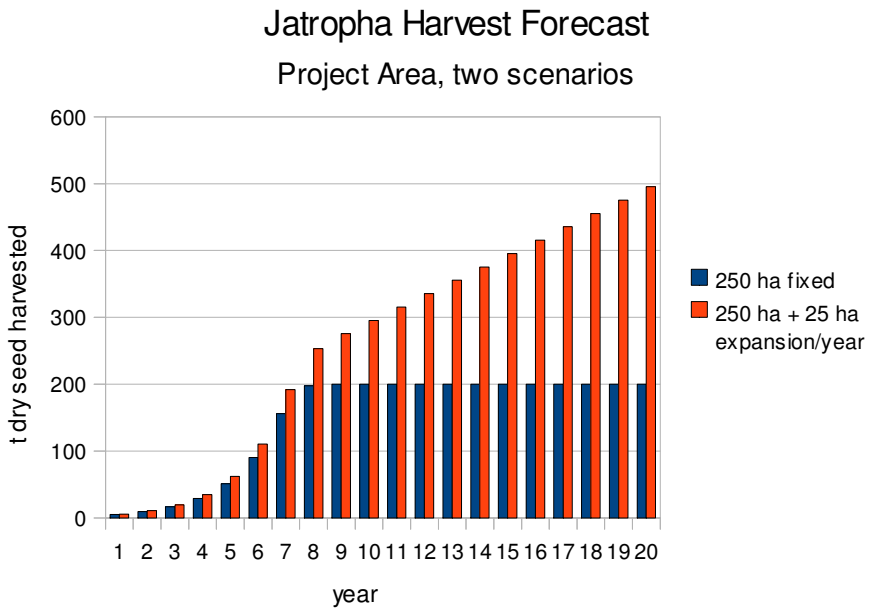


Illustration 4: Harvest forecast for the project area under two scenarios