Intercropping

Noviria Syifaun Nafsi, Sang Hyo Moon, Sineenad Kongtonkun

Module: Crop and Ecosystem Analysis and Modelling
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UNIVERSITÄT BONN

What is intercropping?

Intercropping is the practice of growing two or more crops in proximity. The most common goal of intercropping is to produce a greater yield on a given piece of land by making use of resources that would otherwise not be utilized by a single crop. Examples of intercropping strategies are planting a deep-rooted crop with a shallow-rooted crop, or planting a tall crop with a shorter crop that requires partial shade. Numerous types of intercropping, all of which vary the temporal and spatial mixture to some degree, have been identified: mixed intercropping, row cropping, relay cropping, etc.

Source : a5 - intercropping.pdf (nwrm.eu)

Figure1: Maize/soybean strip intercropping

Source : Frontiers | Maize/soybean strip intercropping produces higher crop yields and saves water under semi-arid conditions (frontiersin.org)

Introduction of the project

- **Objective**
  Compare LER (Land Equivalent Ration) results of intercropping model with single-crop model results.

- **Material**
  - Use the modeling framework **Simplace** to run the crop model Lintul5.
  - It calculates potential yield (no water or nutrient limitations)

- **Methods**
  - Run a crop model with two sole crop (maize & groundnut) and with intercropping in two different locations (Sevilla vs. Wageningen).
  - Run different intercropping scenarios by varying emergence (sowing) dates and strip widths.
  - Compare the yield of intercropping vs. Sole cropping.
  - Find a combination that maximize the LER (land equivalence ratio)

Intercropping: Nafsi, Moon, Kongtonkun

LER (Land Equivalent Ratio)

$$LER = LER_M + LER_G = \frac{Y_M}{M_M} + \frac{Y_G}{M_G}$$

- Y_M & Y_G: the yields for each crop in the intercrop
- M_M & M_G: yields for each crop in sole crops.
- LER_M& LER_G: partial LERs for each species.
- Yield: g/m^2

- An LER of 1.0 indicates the same land productivity for intercropping and sole crops, whereas values greater that 1.0 indicate a land use advantage for intercropping while values smaller that n1.0 indicate a disadvantage for intercropping.

4

Intercropping: Nafsi, Moon, Kongtonkun

The land equivalent ratio (LER) is a measure of the relative productivity of intercropping compared to sole cropping. It is defined as the ratio of the area under sole cropping to the area under intercropping needed to give equal amounts of yield at the same management level[1]. The higher the LER, the more productive the intercropping system is compared to sole cropping.

If LER is 1.22, that means 22% more yield in intercropping

Location 1: Wageningen

Climate Kondition in Wageningen in 1987

- Mean temperature 8.7 °C
- Mean Precipitation change 879 mm

Present soil types:

- Eutric Cambisols
- Gleysols
- Fluvisols

5

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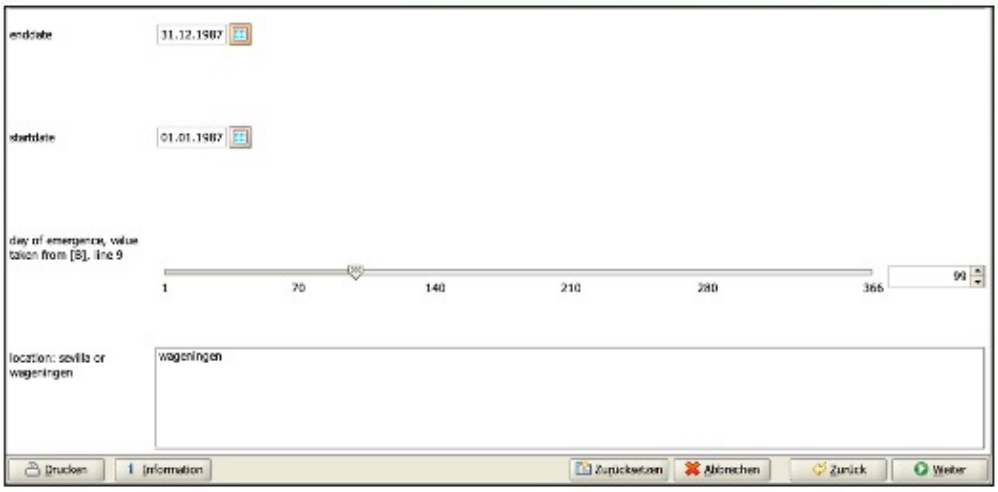
- Eutric cambisols (loam, clay loam, silty clay loam and silty clay)
- Gleysols (consist mostly of clay)
- Fluvisols. These soils are flooded for a few weeks almost every year. Most of the soils show stratification at shallow depth and therefore are classified as Fluvisols (WRB) or Udifluvent (Soil Taxonomy, if well drained) or Fluvaquent (Soil Taxonomy, if poorly drained). However, some soils of the forelands, notably those which have a relatively high position in the landscape, show a clearly developed cambic horizon with a welldeveloped subangular blocky structure

The weather is similier like in bonn.

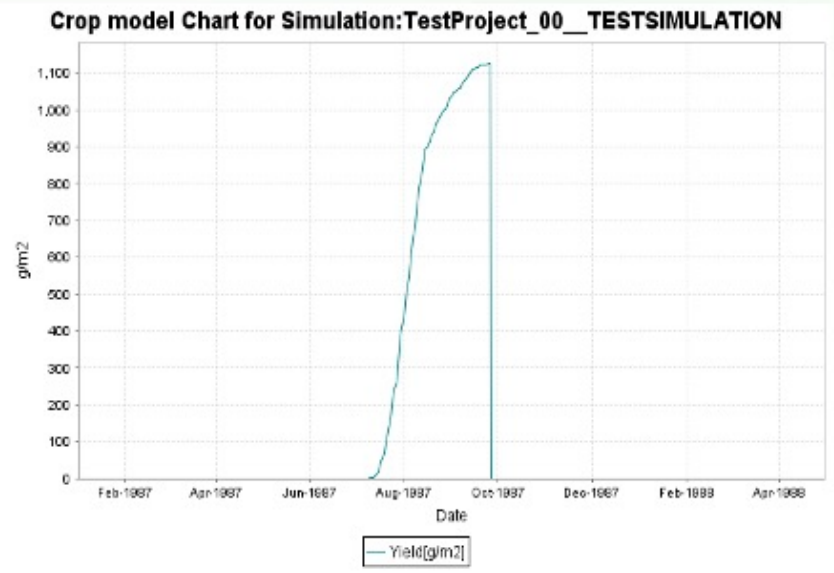
Sole cropping in Wageningen

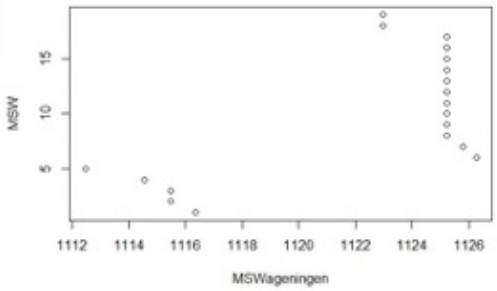


Setting:

- Crop: Maize or Groundnut
- Day of emergence
- Location

Sole crop 1: Maize in Wageningen





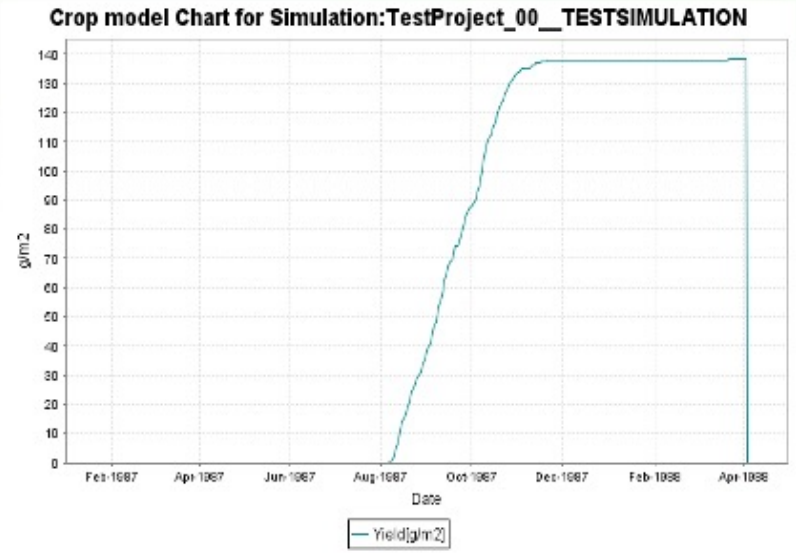
Day of emergence: 29
Yield: 1126 g/m^2

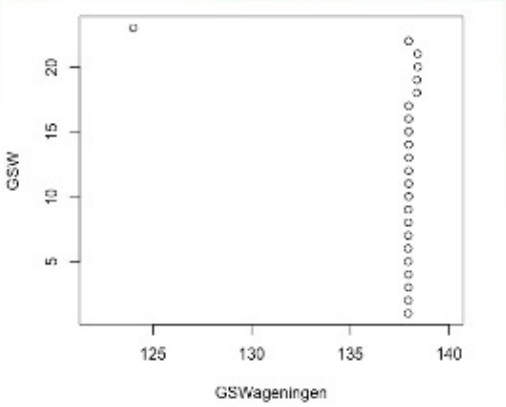
7

Intercropping: Nafsi, Moon, Kongtonkun

Simulated for 19 times, the highest is at the emergence day of 29 with a yield of 1126.267. The simulation before and after day 29 showed lower yield.

Sole crop 2: Groundnut in Wageningen





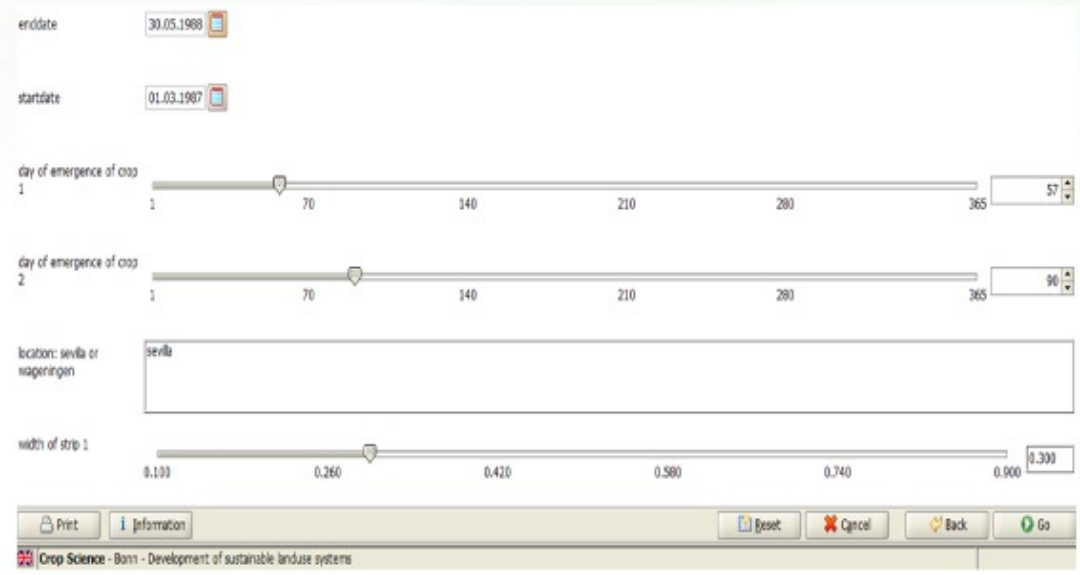
Day of emergence: 95
Yield: 138 g/m^2

8

Intercropping: Nafsi, Moon, Kongtonkun

We simulated 23 times and lot of them shows around 137 g/m2 and the best was 138.4 from the groundnut with the day of emergence 94 and 95

Intercropping in Wageningen



Setting:

Day of emergence:
- Crop 1 : Maize
- Crop 2 : Groundnut

Width of Strip:
- Maize: 30%
- Groundnut: 70%

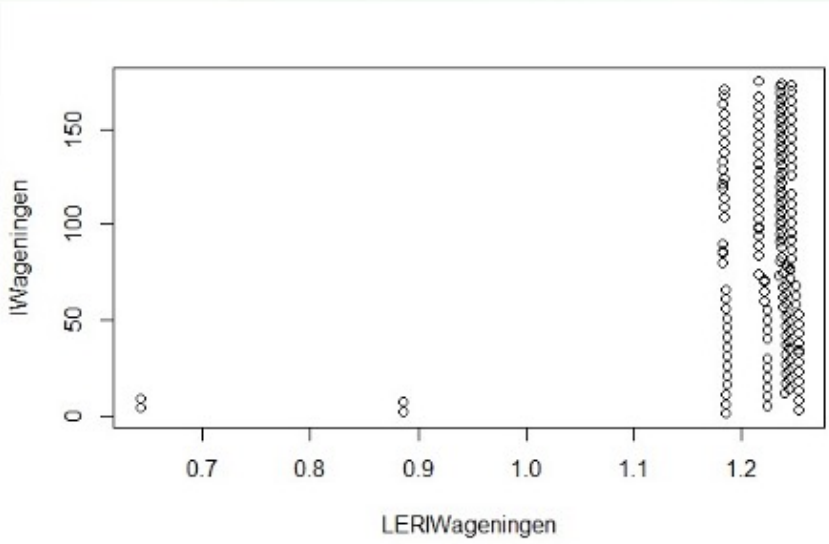
9

Intercropping: Nafsi, Moon, Kongtonkun

To simulate for intercropping we could set
1. Start and End date
2. The Days of emergence of both crops
3. Location
4. Width of strip of crop 1 which is Maize

So we simulated around 180 times with different parameters
And calculated with R
(first, we tried to use maunal however with the huge numbers of files we changed that we use R)

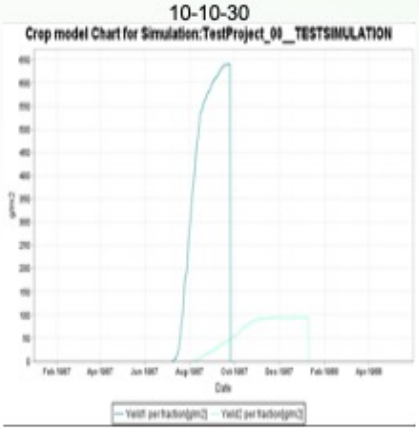
Total yield intercropping in Wageningen



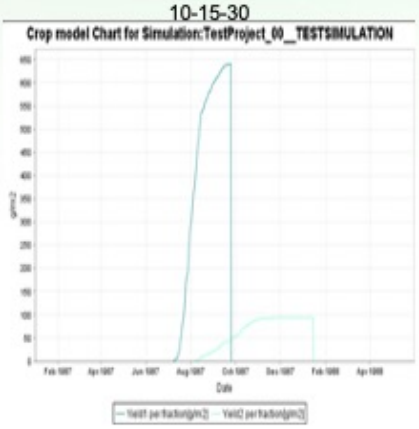
Here we see the LER values which we simulated
it shows that the majors are over 1.1, which means
However there are also under 1. which means less yield at intercroppping than sole crop.

Total yield intercropping in Wageningen

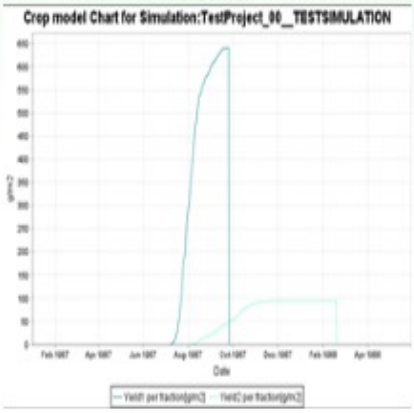
10-10-30



10-15-30



10-50-30



Day of emergence:
- Maize: 10
- Groundnut: 10, 15, 50

Width of strip for Maize: 30%

Yield:
- Maize: 640.559 g/m^2
- Groundnut: 93.610 g/m^2

LER: 1.25245

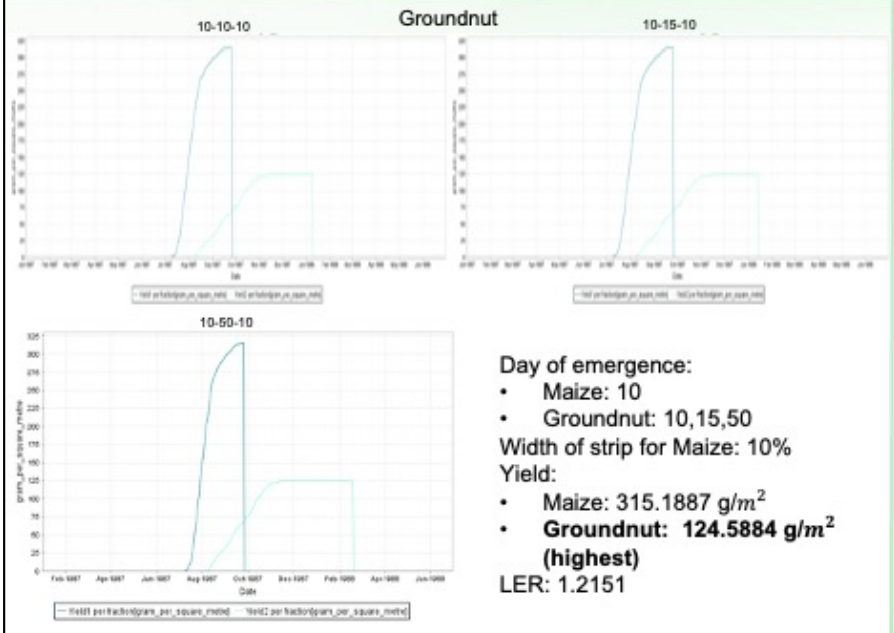
11

Intercropping: Nafsi, Moon, Kongtonkun

These graphs show the total yield of intercropping
the day of emergence of maize 10 with the day of emergence groundnut 10, 15 and 50
With width of strip for Maize 30% has same LER

So here we need to know that the LER is calculated with the Yield of fraction.
Which means 30% of field is used for Maize. And rest for groundnut

Highest yield of maize and groundnut in intercropping in Wageningen



Day of emergence:
- Maize: 10
- Groundnut: 10,15,50

Width of strip for Maize: 10%
Yield:
- Maize: 315.1887 g/m^2
- **Groundnut: 124.5884 g/m^2 (highest)**

LER: 1.2151

Day of emergence:
- Maize: 29
- Groundnut: 95

Width of strip for maize: 50%
Yield:
- **Maize: 849.6364 g/m^2 (highest)**
- Groundnut: 63.7876 g/m^2

LER: 1.2151

12

Intercropping: Nafsi, Moon, Kongtonkun

Now i show you the highest yield of Maize and Groundnut
first for Groundnut, the highest yield (124.59 g/m2)was shown by the day of emergence
of Maize 10 and Groundnut 10,15,50 with 10% of Width of Maize strip.

And for Maize, the highest yield(849.63) was shown by the day of emergence of Maize 29 and Groundnut 95 with 50% Width of Maize strip.

Why same yield of Groundnut??... !! Same strip?

Result in Wageningen

Emergence day		Width of strip (%)	Yield per-fraction		LER
Maize	Groundnut		Maize	Groundnut	
29	-	Sole crop	1126		-
-	95	Sole crop		138	-
10	10	10	315.1887	**124.5884**	1.2151
	15				
	50				
10	10	30	640.559	93.610	**1.25245**
	15				
	50				
29	95	50	**849.6364**	63.7876	1.2151

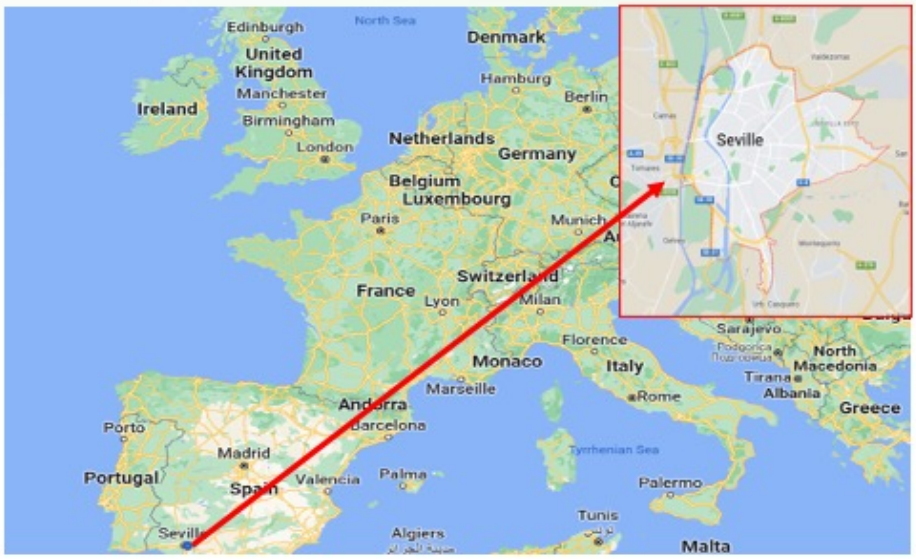
13

Intercropping: Nafsi, Moon, Kongtonkun

As we see here, the highest yield of Maize or Groundnut means not the highest LER.
So the balance of the parameters are important to get highest LER.

Next Novi next Location and Summary

Location 2: Sevilla



Climate condition in Sevilla in 1987:

- Mean temperature 18.5 °C
- Mean Precipitation change 684.4 mm

Soil type:

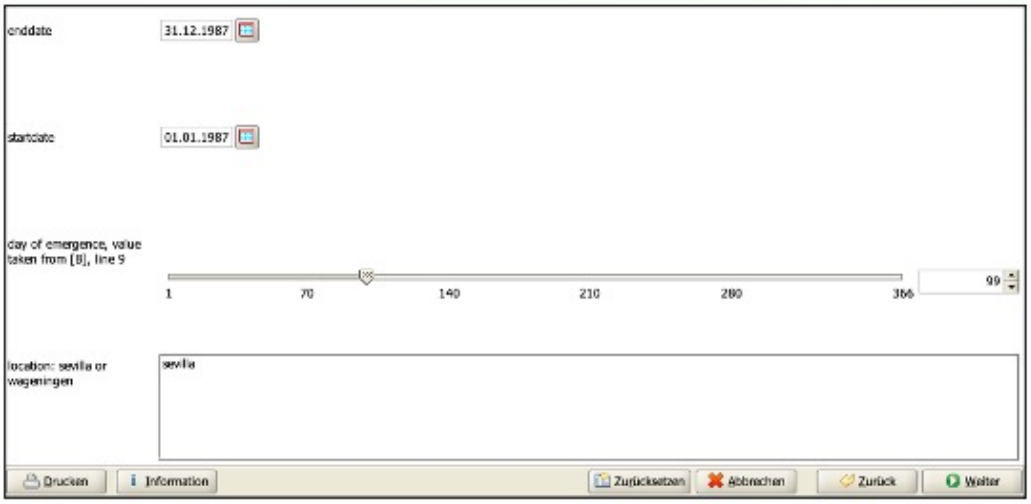
- Luvisols
- Vertisols

14

Intercropping: Nafsi, Moon, Kongtonkun

- Soil: Moderately well drained; medium or high runoff; slow permeability above the duripan, very slow in the duripan, and moderately rapid below the duripan.

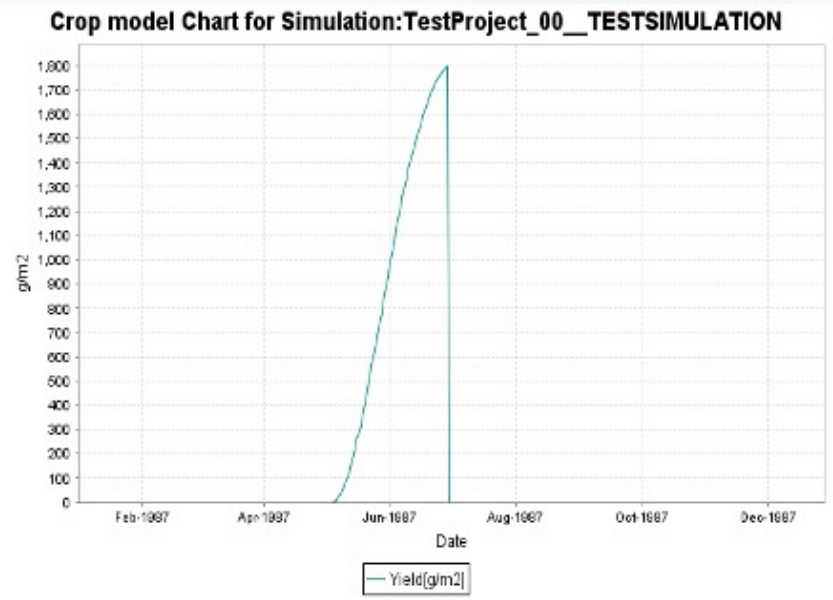
Sole cropping in Sevilla

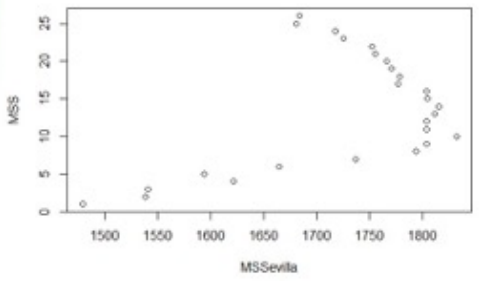


Setting:

- Crop: Maize or Groundnut
- Day of emergence
- Location

Sole Crop 1: Maize in Sevilla





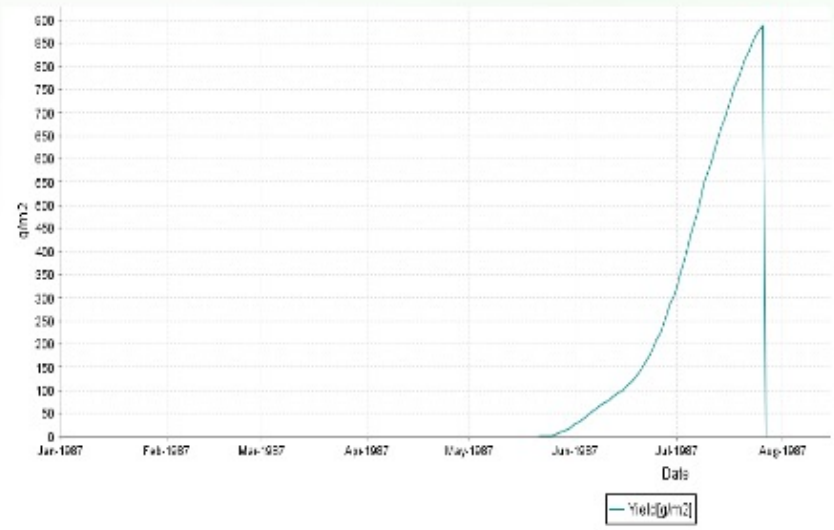
Day of emergence: 50
Yield: 1832.038 g/m^2

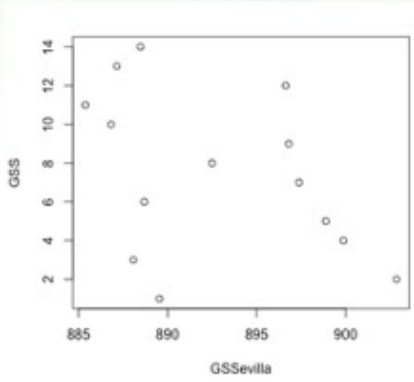
16

Intercropping: Nafsi, Moon, Kongtonkun

We simulated 26 times, the highest yield is 1832.038 by the emergence day 50.

Sole crop 2: Groundnut in Sevilla



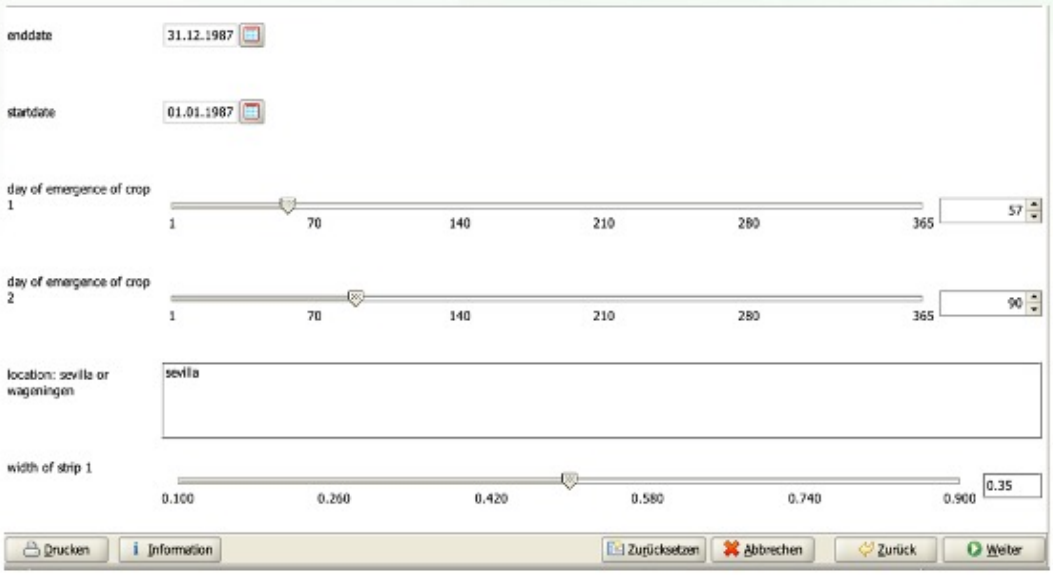


Day of emergence: 15
Yield: 902.8626 g/m^2

Intercropping: Nafsi, Moon, Kongtonkun

We simulated 14 times, the highest yield is 902.8626 by the emergence day 15.

Intercropping in Sevilla

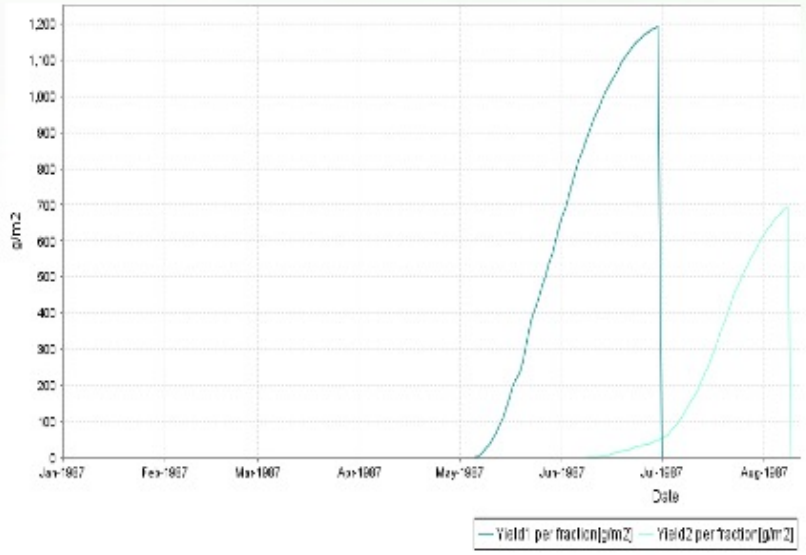


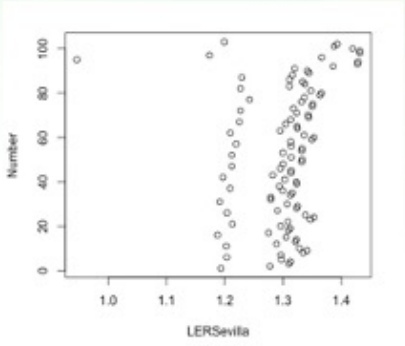
Setting:

Day of emergence:
- Crop 1 : Maize
- Crop 2 : Groundnut

Width of Strip:
- Maize: 35%
- Groundnut: 65%

Total yield intercropping in Sevilla





Day of emergence:
- Maize: 57
- Groundnut: 90

Width of strip for maize: 35%

Yield:
- Maize: 3406.649 g/m^2
- Groundnut: 694.6318 g/m^2

LER: 1.431764

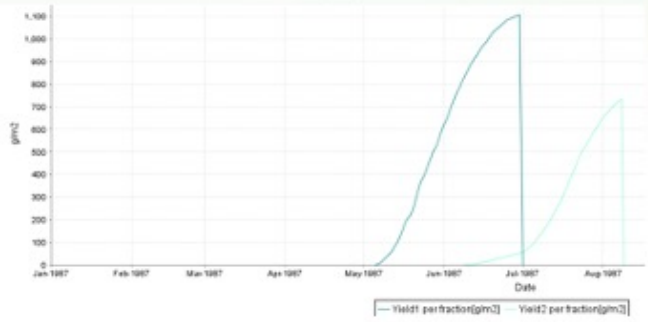
19

Intercropping: Nafsi, Moon, Kongtonkun

We simulated for 103 times with different parameters, with the highest LER is 1.43, which means 43% higher yield than in sole crop

Highest yield of maize and groundnut in intercropping in Sevilla

Maize



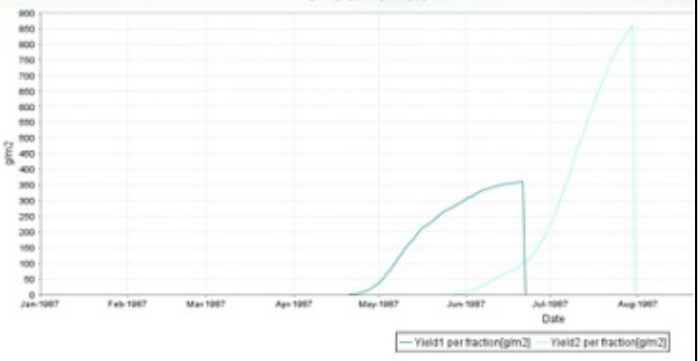
Day of emergence:
- **Maize: 57**
- Groundnut: 90

Width of strip for Maize: 30%

Yield:
- **Maize: 3692.98 g/m^2 (highest)**
- Groundnut: 732.88 g/m^2

LER: 1.427721

Groundnut



Day of emergence:
- Maize: 10
- **Groundnut: 50**
- Width of strip for maize: 10%

Yield:
- Maize: 361.28 g/m^2
- **Groundnut: 860.21 g/m^2 (highest)**

LER: 1.203444

Intercropping: Nafsi, Moon, Kongtonkun

Result in Sevilla

Emergence day		Width of strip (%)	Yield per-fraction		LER
Maize	Groundnut		Maize	Groundnut	
50	-	Sole crop	1832.038	-	-
-	15	Sole crop	-	902.8626	-
10	50	10	361.2794	**860.2163**	1.203444
57	90	30	**3692.982**	732.8863	1.427721
57	90	35	3406.649	694.6318	**1.431764**

Summary

	Emergence day		Width of strip (%)	Yield per-fraction		LER
	Maize	Groundnut		Maize	Groundnut	
Wageningen	29	-	Sole crop	1126		-
	-	95	Sole crop		138	-
	10	10	10	315.1887	**124.5884**	1.2151
		15				
		50				
	10	10	30	640.559	93.610	**1.25245**
		15				
		50				
	29	95	50	**849.6364**	63.7876	1.2151
Sevilla	50	-	Sole crop	1832.038	-	-
	-	15	Sole crop	-	902.8626	-
	10	50	10	361.2794	**860.2163**	1.203444
	57	90	30	**3692.982**	732.8863	1.427721
	57	90	35	3406.649	694.6318	**1.431764**

Intercropping: Nafsi, Moon, Kongtonkun

Conclusion

- Highest yield for sole crop in Wageningen is found for maize (1126 g/m2) at the emergence day of 29 and groundnut (138 g/m2) at the emergence day of 95.
- Highest yield for sole crop in Sevilla is found for maize (1832 g/m2) at the emergence day of 50 and groundnut (903 g/m2) at the emergence day of 15.
- Highest LER (1.25) for intercropping maize and groundnut in Wageningen is found at the emergence day of 10 (maize) and 10/15/50 (groundnut) with a width of strip of 30%.
- Highest LER (1.43) for intercropping maize and groundnut in Sevilla is found at the emergence day of 57 (maize) and 90 (groundnut) with a width of strip of 35%.
- **The emergence day that gives the highest yield in sole crop does not affect to highest LER at the same emergence day in intercropping.**
- **Maize and groundnut both for sole crop and strip intercropping in Sevilla is better than in Wageningen.**