

Climate change sensitivity of multi-species afforestation in semi-arid Benin

Supplementary Materials

Table S1. Tree parameters used for simulating the growth of *Jatropha curcas* L. in WaNuLCAS. C = calibrated values; L = values from literature; M = measured values; D = default values from the “WaNuLCAS tree parametrization” Excel file, except for default values of root parameters which were derived from the “WaNuLCAS” Excel file

Parameter	Description	Units	<i>Jatropha curcas</i>		
			Default value	Value used in the simulation	Determination
Growth Stage	Length of vegetative cycle	days	365	365	D
	Length of generative cycle	days	90	90	D
	Earliest day to flower in a year	Julian day	305	305	D
	Latest day to flower in a year	Julian day	195	195	D
	Initial stage	-	0.10	0.10	D
	Stage after pruning	-	0.15	1.00	L
Growth	Max. growth rate	kg m ⁻²	0.02	0.007	C
	Fraction of growth reserve	-	0.025	0.025	D
	Leaf weight ratio	-	0.70	0.50	M
	Specific leaf area	m ² kg ⁻¹	7.00	25.40	M
	Water requirement for dry matter production	l kg ⁻¹	300	300	D
	Tree growth follows Rubber tree rules?	-	0.00	0.00	D
Fruit	Fruit growth follows oil palm rules?	-	0.00	0.00	D
	Fraction biomass allocated to fruit	-	0.25	0.08	L
Canopy	Max. canopy height above bare stem	m	1.50	1.76	M
	Ratio between canopy width and height	-	0.50	0.48	C
	Max. canopy radius	m	1.50	1.62	M

Parameter	Description	Units	<i>Jatropha curcas</i>		
			Default value	Value used in the simulation	Determination
	Maximum leaf area index	-	5.33	3.00	C
	Ratio leaf area index min. and max.	-	0.50	0.36	L
Light capture	Relative light intensity at which shading starts to affect tree growth	-	0.50	0.50	D
	Extinction light coefficient	-	0.70	0.50	C
Rain interception	Rainfall water stored at leaf surface	mm	1.00	1.00	D
Tree Water	Coefficient related to tree root conductivity	cm day ⁻¹	0.00002	0.00002	D
	Plant potential for max. transpiration	cm	-1500	-1500	D
	Plant potential for min. transpiration	cm	-4500	-4500	D
N ₂ Fixation	Type of N ₂ fixation	-	0.00	0.00	D
	Proportion of N from atmosphere	-	0.00	0.00	D
	Fraction of reserve pool for N ₂ fixation	-	0.00	0.00	D
	Dry weight cost for N ₂ fixation	-	0.005	0.005	D
	Responsiveness of N ₂ fixation to N stress	-	0.00	0.00	D
N Concentration	N concentration in carbohydrate reserves	g g ⁻¹	0.11	0.11	D
	N concentration in leaf component	g g ⁻¹	0.025	0.0099	M
	N concentration in twig component	g g ⁻¹	0.008	0.0158	M
	N concentration in wood component	g g ⁻¹	0.005	0.0175	M
	N concentration in fruit component	g g ⁻¹	0.015	0.015	D
	N concentration in root component	g g ⁻¹	0.01	0.0142	M
P Concentration	P concentration in carbohydrate reserves	g g ⁻¹	0.0055	0.01	C
	P concentration in leaf component	g g ⁻¹	0.001	0.0004	L
	P concentration in twig component	g g ⁻¹	0.00	0.0038	L

Parameter	Description	Units	<i>Jatropha curcas</i>		
			Default value	Value used in the simulation	Determination
	P concentration in wood component	g g ⁻¹	0.00	0.0019	L
	P concentration in fruit component	g g ⁻¹	0.001	0.0047	L
	P concentration in root component	g g ⁻¹	0.001	0.0014	L
Litterfall	Litterfall caused by drought	day ⁻¹	0.10	0.008	C
	Threshold value for litterfall due to drought	-	0.70	0.70	D
	Reducing factor for N of litterfall	-	0.85	0.85	D
	Reducing factor for P of litterfall	-	0.85	0.85	D
Litter quality	Lignin fraction of litterfall	-	0.20	0.1584	L
	Lignin fraction of pruned biomass	-	0.20	0.1683	L
	Lignin fraction of root	-	0.20	0.1395	L
	Polyphenol fraction of litterfall	-	0.05	0.0371	L
	Polyphenol fraction of pruned biomass	-	0.05	0.0314	L
	Polyphenol fraction of root	-	0.05	0.0968	L
Allometric Branching (Aboveground)	Apply allometric equation?	-	1.00	1.00	-
	Intercept for total biomass equation	kg	0.012	0.004	M
	Power for total biomass equation	cm ⁻¹	2.336	2.930	M
	Intercept for branch biomass equation	kg	0.008	0.004	M
	Power for branch biomass equation	cm ⁻¹	2.315	2.740	M
	Intercept for Leaf and twig biomass equation	kg	0.004	0.003	M
	Power for leaf and twig biomass equation	cm ⁻¹	2.373	2.480	M
	Intercept for litterfall equation	kg	0.03	0.000	D
	Power for litterfall equation	cm ⁻¹	3.094	3.290	D
	Wood density	kg m ⁻³	336.3	336.3	L

Parameter	Description	Units	<i>Jatropha curcas</i>		
			Default value	Value used in the simulation	Determination
Roots	Root tip diameter	cm	0.10	0.10	D
	Max. root length density in layer1-zone1	cm cm ⁻³	2.00	0.035637	L
	Max. root length density in layer1-zone2	cm cm ⁻³	1.20	0.907471	L
	Max. root length density in layer1-zone3	cm cm ⁻³	0.72	0.787833	L
	Max. root length density in layer1-zone4	cm cm ⁻³	0.00	0.001	L
	Max. root length density in layer2-zone1	cm cm ⁻³	1.50	0.001	L
	Max. root length density in layer2-zone2	cm cm ⁻³	0.90	0.196004	L
	Max. root length density in layer2-zone3	cm cm ⁻³	0.54	0.496373	L
	Max. root length density in layer2-zone4	cm cm ⁻³	0.00	0.001	L
	Max. root length density in layer3-zone1	cm cm ⁻³	0.60	0.001	L
	Max. root length density in layer3-zone2	cm cm ⁻³	0.36	0.085274	L
	Max. root length density in layer3-zone3	cm cm ⁻³	0.216	0.081456	L
	Max. root length density in layer3-zone4	cm cm ⁻³	0.00	0.001	L
	Max. root length density in layer4-zone1	cm cm ⁻³	0.20	0.001	L
	Max. root length density in layer4-zone2	cm cm ⁻³	0.12	0.001	L
	Max. root length density in layer4-zone3	cm cm ⁻³	0.072	0.038183	L
	Max. root length density in layer4-zone4	cm cm ⁻³	0.00	0.001	L

Note: Literature values were derived from Tjeuw (2017)

Table S2. Tree parameters used for simulating the growth of *Moringa oleifera* Lam. in WaNuLCAS. C = calibrated values; L = values from literature; M = measured values; D = default values from the “WaNuLCAS tree parametrization” Excel file, except for default values of root parameters which were derived from the “WaNuLCAS” Excel file

Parameter	Description	Units	<i>Moringa oleifera</i>		
			Default value	Value used in the simulation	Determination
Growth Stage	Length of vegetative cycle	days	183	183	D
	Length of generative cycle	days	90	90	D
	Earliest day to flower in a year	Julian day	210	210	D
	Latest day to flower in a year	Julian day	360	360	D
	Initial stage	-	0.10	0.10	D
	Stage after pruning	-	0.10	0.10	D
Growth	Max. growth rate	kg m ⁻²	0.036	0.008	C
	Fraction of growth reserve	-	0.025	0.025	D
	Leaf weight ratio	-	0.70	0.50	M
	Specific leaf area	m ² kg ⁻¹	10.5	16	C
	Water requirement for dry matter production	l kg ⁻¹	300	300	D
	Tree growth follows Rubber tree rules?	-	0.00	0.00	D
Fruit	Fruit growth follows oil palm rules?	-	0.00	0.00	D
	Fraction biomass allocated to fruit	-	0.080	0.08	D
Canopy	Max. canopy height above bare stem	m	3.30	3.30	D
	Ratio between canopy width and height	-	0.50	0.23	C
	Max. canopy radius	m	2.00	2.00	D
	Maximum leaf area index	-	3.00	3.00	C
	Ratio leaf area index min. and max.	-	0.50	0.33	C

Parameter	Description	Units	<i>Moinga oleifera</i>		
			Default value	Value used in the simulation	Determination
Light capture	Relative light intensity at which shading starts to affect tree growth	-	0.80	0.80	D
	Extinction light coefficient	-	0.86	0.86	D
Rain interception	Rainfall water stored at leaf surface	mm	1.00	1.00	D
Tree water	Coefficient related to tree root conductivity	cm day ⁻¹	0.00002	0.00002	D
	Plant potential for max. transpiration	cm	-1500	-1500	D
	Plant potential for min. transpiration	cm	-4500	-4500	D
N ₂ Fixation	Type of N ₂ fixation	-	0.00	0.00	D
	Proportion of N from atmosphere	-	0.00	0.00	D
	Fraction of reserve pool for N ₂ fixation	-	0.00	0.00	D
	Dry weight cost for N ₂ fixation	-	0.00	0.00	D
	Responsiveness of N ₂ fixation to N stress	-	0.00	0.00	D
N Concentration	N concentration in carbohydrate reserves	g g ⁻¹	0.22	0.22	D
	N concentration in leaf component	g g ⁻¹	0.025	0.013	M
	N concentration in twig component	g g ⁻¹	0.015	0.020	M
	N concentration in wood component	g g ⁻¹	0.01	0.015	M
	N concentration in fruit component	g g ⁻¹	0.023	0.023	D
	N concentration in root component	g g ⁻¹	0.01	0.011	M
P Concentration	P concentration in carbohydrate reserves	g g ⁻¹	0.022	0.022	D
	P concentration in leaf component	g g ⁻¹	0.003	0.003	D
	P concentration in twig component	g g ⁻¹	0.002	0.002	D
	P concentration in wood component	g g ⁻¹	0.001	0.001	D
	P concentration in fruit component	g g ⁻¹	0.002	0.002	D
	P concentration in root component	g g ⁻¹	0.001	0.001	D

Parameter	Description	Units	<i>Moinga oleifera</i>		
			Default value	Value used in the simulation	Determination
Litterfall	Litterfall caused by drought	day ⁻¹	0.100	0.008	C
	Treeshold value for litterfall due to drought	-	0.90	0.70	C
	Reducing factor for N of litterfall	-	0.85	0.85	D
	Reducing factor for P of litterfall	-	0.85	0.85	D
Litter quality	Lignin fraction of litterfall	-	0.20	0.20	D
	Lignin fraction of pruned biomass	-	0.20	0.20	D
	Lignin fraction of root	-	0.20	0.20	D
	Polyphenol fraction of litterfall	-	0.05	0.05	D
	Polyphenol fraction of pruned biomass	-	0.05	0.05	D
	Polyphenol fraction of root	-	0.05	0.05	D
Allometric Branching (Aboveground)	Apply allometric equation?	-	1.00	1.00	-
	Intercept for total biomass equation	kg	0.010	0.010	M
	Power for total biomass equation	cm ⁻¹	2.360	2.360	M
	Intercept for branch biomass equation	kg	0.008	0.008	M
	Power for branch biomass equation	cm ⁻¹	2.380	2.380	M
	Intercept for leaf & twig biomass equation	kg	0.010	0.010	M
	Power for leaf & twig biomass equation	cm ⁻¹	1.490	1.490	M
	Intercept for litterfall equation	kg	0.000	0.000	D
	Power for litterfall equation	cm ⁻¹	3.290	3.290	D
	Wood density	kg m ⁻³	262	262	D
Roots	Root tip diameter	cm	0.10	2.00	D
	Max. root length density in layer1-zone1	cm cm ⁻³	2.00	2.00	D
	Max. root length density in layer1-zone2	cm cm ⁻³	1.20	1.20	D

Parameter	Description	Units	<i>Moinga oleifera</i>		
			Default value	Value used in the simulation	Determination
	Max. root length density in layer1-zone3	cm cm ⁻³	0.72	0.72	D
	Max. root length density in layer1-zone4	cm cm ⁻³	0.00	0.00	D
	Max. root length density in layer2-zone1	cm cm ⁻³	1.50	1.50	D
	Max. root length density in layer2-zone2	cm cm ⁻³	0.90	0.90	D
	Max. root length density in layer2-zone3	cm cm ⁻³	0.54	0.54	D
	Max. root length density in layer2-zone4	cm cm ⁻³	0.00	0.00	D
	Max. root length density in layer3-zone1	cm cm ⁻³	0.60	0.60	D
	Max. root length density in layer3-zone2	cm cm ⁻³	0.36	0.36	D
	Max. root length density in layer3-zone3	cm cm ⁻³	0.216	0.216	D
	Max. root length density in layer3-zone4	cm cm ⁻³	0.00	0.00	D
	Max. root length density in layer4-zone1	cm cm ⁻³	0.20	0.20	D
	Max. root length density in layer4-zone2	cm cm ⁻³	0.12	0.12	D
	Max. root length density in layer4-zone3	cm cm ⁻³	0.072	0.072	D
	Max. root length density in layer4-zone4	cm cm ⁻³	0.00	0.00	D

Table S3. Relative increment in height (H, m), diameter (D, cm), and aboveground biomass (ABG, kg m⁻²) in response to fertilization (F), irrigation (I) and fertilization plus irrigation (IF) as observed and as simulated by WaNuLCAS. The average values of the three harvest times are presented

Treatment effects	Height (H, m)		Diameter (D, cm)		Aboveground biomass (AGB, kg m ⁻²)	
	Measured	Simulated	Measured	Simulated	Measured	Simulated
<i>Jatropha curcas</i>						
Fertilization (F)	0.10	0.10	0.48	0.54	0.13	0.12
Irrigation(I)	0.08	0.02	0.30	0.05	0.09	0.01
Irrigation plus fertilization (IF)	0.13	0.15	0.53	0.81	0.18	0.17
<i>Moringa oleifera</i>						
Fertilization (F)	0.03	0.15	0.51	0.37	0.07	0.03
Irrigation(I)	0.00	0.06	0.15	0.12	0.01	0.02
Irrigation plus fertilization (IF)	0.08	0.11	0.61	0.29	0.07	0.17

Reference

1. Tjeuw J (2017) Is there life after hype for Jatropha? Exploring growth and yield in Indonesia. Doctoral dissertation, Wageningen University