Pecan tree irrigation-fertilization management model

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Pecan water and fertilizer use

• Pecan ET can be 1.4 m a year, and irrigation is about 2 m.

• Annual nitrogen use is about 200 kg/ha (100 trees), and fertilization is about 350 N kg/ha.
Objective

• Develop a pecan irrigation-fertilization scheduling model
Start

Day=0

Day=1+Day

Day>total simulation days

Y

End

N

Input weather data, irrigation, fertilization, and pruning data

Irrigation object

Fertilization object

Biomass allocation ratio object

Alternate bearing object

Pruning object

Growth of nut, branches, leaves and carbohydrate
\[ K_c = 0.286 + 0.003GDD_i - 3.02 \times 10^{-6} \times GDD_i^2 + 1.4 \times 10^{-9} \times GDD_i^3 \\
- 2.28 \times 10^{-13} \times GDD_i^4 \]
Organic N=f (fallen leaves, pruned branch chips)

Leached nitrate=f (drainage, N concentration)

Input weather and environmental data

Root zone moisture=f (irrigation, rain, drainage, ET)

Plant uptake=f (leaf, branch, reproductive)

Elsia 2003

Kn (stress)=f (N concentration)

Smith et al., 1985

Mineralized ammonium =f (soil temperature and moisture, organic N)

Asare, 1990

Nitrified nitrate=f (soil temperature and moisture, ammonium)

Asare, 1990

Denitrified nitrate=f (soil temperature and moisture, ammonium)

Asare, 1990

N stressed?

Y

Apply fertilizer

N

Fertilization object

0.7

0.75

0.8

0.85

0.9

0.95

1

0 0.005 0.01 0.015 0.02 0.025 0.03 0.035 0.04 0.045 0.05

N concentration at root zone (mg N/kg H2o)

N stress
Alternative bearing object

Start

Find winter CHO reserve amount in current year

\[ RR_i = \frac{\text{CHO Winter}}{\text{CHO OPT}} \]

Pruned?

\( Y \)

Adjust \( RR_i \) by pruning coefficient

\( N \)

End
Biomass allocation object

Start

Assign each level branch length, diameter and number

Potential yearly growth for each level branches

Allocation ratios = $f(\text{potential yearly growth})$

End
Remove branches smaller than or equal to the input diameter at the corresponding sides.

Inform irrigation object to adjust canopy coefficient.
Inform fertilization object to adjust N uptake for branches.
Pruning coefficient = f (pruning amount)
Inform alternative bearing object to adjust RRi
Inform growth object to adjust branch number.

Pruning object

<table>
<thead>
<tr>
<th>Pruning coefficient</th>
<th>Pruned biomass ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0.1</td>
<td>0.9</td>
</tr>
<tr>
<td>0.2</td>
<td>0.8</td>
</tr>
<tr>
<td>0.3</td>
<td>0.7</td>
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<td>0.4</td>
<td>0.6</td>
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<td>0.5</td>
<td>0.5</td>
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<td>0.6</td>
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<tr>
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<td>0.3</td>
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<tr>
<td>0.8</td>
<td>0.2</td>
</tr>
<tr>
<td>0.9</td>
<td>0.1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

End
Growth object

Start

Input ET, allocation ratios, RR_i, branch numbers after pruning

Bud break?

N

Y

Leaf fall ?

Y

Leaf full Expansion?

N

Y

Calculate needed CHO reserve

Leaf and bud growth

Nut growth scaled by RR_i

CHO reserve growth

Biomass allocation to shoots

Branch diameter and length growth

Root biomass growth = 0.34 × above ground growth

Go to main program next day

End
ET and Co2 flux measurement
Leaf and nut growth measurement
Shoot growth measurement

9605 Sensor

C-clamp

3 wires to Campbell CR23X data logger
Results

Branch diameter growth

<table>
<thead>
<tr>
<th>Time (days)</th>
<th>Diameter (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/15/01</td>
<td>0.15</td>
</tr>
<tr>
<td>03/15/02</td>
<td>0.20</td>
</tr>
<tr>
<td>06/13/02</td>
<td>0.25</td>
</tr>
<tr>
<td>09/11/02</td>
<td>0.30</td>
</tr>
<tr>
<td>12/10/02</td>
<td>0.35</td>
</tr>
<tr>
<td>03/10/03</td>
<td></td>
</tr>
<tr>
<td>06/08/03</td>
<td></td>
</tr>
<tr>
<td>09/06/03</td>
<td></td>
</tr>
<tr>
<td>12/05/03</td>
<td></td>
</tr>
<tr>
<td>03/04/04</td>
<td></td>
</tr>
<tr>
<td>06/02/04</td>
<td></td>
</tr>
<tr>
<td>08/31/04</td>
<td></td>
</tr>
<tr>
<td>11/29/04</td>
<td></td>
</tr>
</tbody>
</table>

Legend:
- Level 1 trunk simulation
- Level 1 trunk observation
- Level 2 branch simulation
- Level 2 branch observation
- Level 3 branch simulation
- Level 3 branch observation
Branch weight growth

- Level 1 trunk simulation
- Level 1 trunk observation
- Level 2 branch simulation
- Level 2 branch observation
- Level 3 branch simulation
- Level 3 branch observation
Simulation vs. observation of biomass production

Cumulated biomass production (kg)

Time (day)

Simulation
Observation
Nut yield

Nut growth (kg/ha)

Simulation
Observation

Time (days)

Nut yield chart showing the growth of nuts over time, comparing simulation and observation data. The chart includes specific dates for data points, ranging from 12/15/01 to 11/29/04.
Model scheduling
Scheduled irrigation
Model scheduled annual irrigation amount compared to farming practice

![Bar chart showing model scheduled annual irrigation amount compared to farming practice for the years 2002, 2003, and 2004. The chart displays the irrigation amount in centimeters for each year. In 2002, the scheduled irrigation is slightly lower than the farmer practice. In 2003, the scheduled irrigation is much higher, almost three times the farmer practice. In 2004, the scheduled irrigation is still higher than the farmer practice, but not as much as in 2003.]
Scheduled fertilization

Date

Nitrogen (kg/ha)
Model scheduled annual fertilization amount compared to farming practice
Conclusion

• This model can be used for pecan irrigation-fertilization scheduling.
Future work

- More tests on this model
Thank You!