Preliminary Version of Tomato Production Simulation Software with probabilistic inputs and outputs

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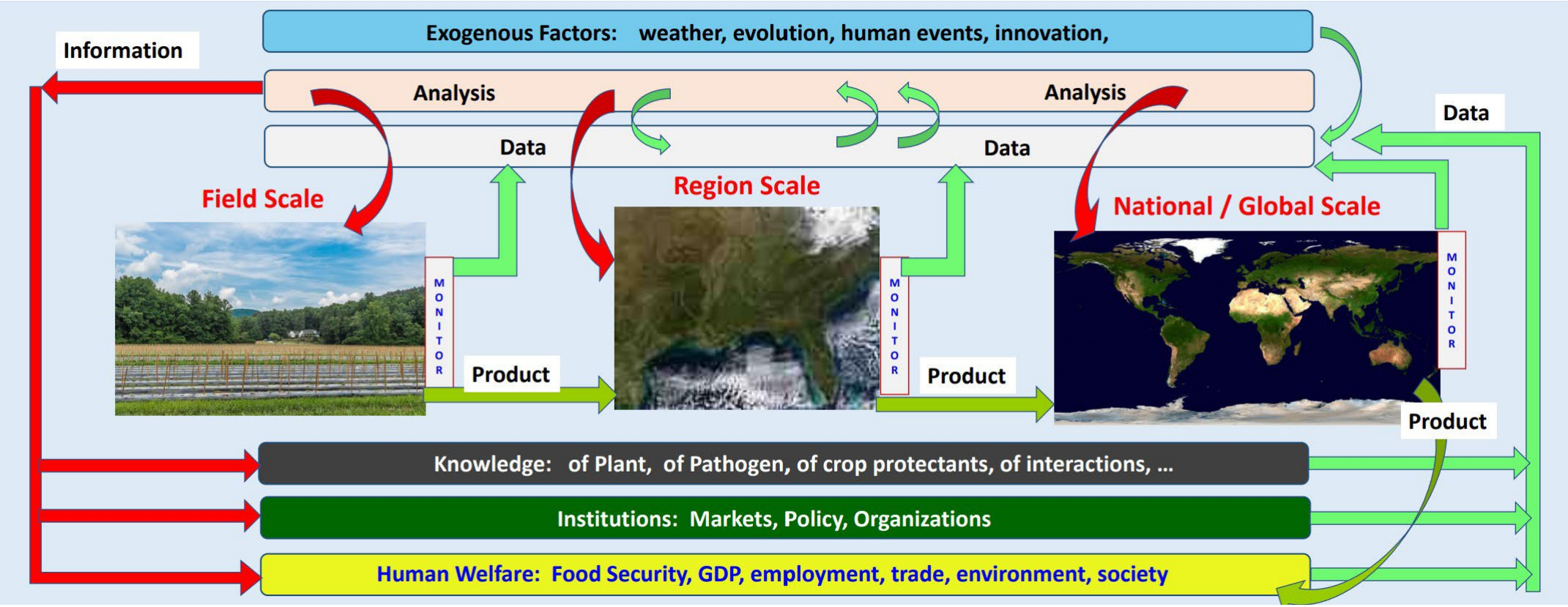
NC STATE UNIVERSITY

PIPP Phase 1

Background

The NSF Predictive Intelligence for Pandemic Prevention (PIPP) program: 'tackle … infectious disease pandemics through prediction and prevention'.

This work is part of a PIPP Phase 1 project titled "Real-time Analytics to Monitor and Predict Emerging Plant Disease", Ristaino et al.



Zering and Lee are working to develop selected economic models on a range of scales that together, model a dynamic plant disease pandemic control system.

Objective and First Model

Develop selected economic models on a range of scales that together, model a dynamic plant disease pandemic control system.

Identify data streams needed for those models, and work with PIPP team members and stakeholders to integrate models, programs, and data streams.

Begin with models of tomato production, late blight, pathogen detection and control, tomato supply chain, consumer and producer welfare (supply and demand based), and selected institutions.

Lee and Zering are in the early stages of developing a tomato production simulation model.

The purpose of the model is to generate realistic predictions of production practices, yields, resource use, costs and returns at a field scale.

Design criteria include:

1) detailed inclusion of practices, inputs, products, prices, costs and revenues and generate predicted outcomes;

2) practical inclusion of disease effects on products, management response to disease, and key factors related to disease;

3) Capacity for probabilistic data input and outcomes; and

4.) Capacity to receive and generate streaming data

We build on a traditional Enterprise Budget:

Tomato, Budget - 2021

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ESTIMATED COSTS AND RETURNS PER ACRE, 2021
Yeild 42,000 lbs per acre, 5' rows on center and 18" plant spacing
1 box of Tomatoes = 25lbs

	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER ACRE	YOUR FARM
1. GROSS RECEIPTS					
Projected Yields =%80 base yeild:					
Jumbo and XL Fruit (40%)	LBS	16800.00	$0.48	$8,064.00	
Large (40%)	LBS	16800.00	$0.46	$7,728.00	
Medium and Small (20%)	LBS	8400.00	$0.44	$3,696.00	
AVERAGE:					
TOTAL RECEIPTS:		42,000.00	$0.46	**$19,488.00**	
2. VARIABLE COSTS					
TOMATO TRANSPLANTS (FLAT OF 72)	EACH	67.00	$10.35	$693.45	
FERTILIZER					
6-3-18	LBS	800.00	$0.13	$104.00	
13-0-44 POTASSIUM NITRATE	LBS	275.00	$0.51	$140.25	
CN-9 9-0-0	GAL	40.00	$1.78	$71.20	
LIME SPREAD	TON	1.50	$54.50	$81.75	
HERBICIDES	ACRE	1.00	$159.25	$159.25	
INSECTICIDES	ACRE	1.00	$76.88	$76.88	
FUNGICIDES	ACRE	1.00	$568.67	$568.67	
HAULING	LBS	0.00	$0.000	$0.00	
COVER CROP- RYE	BU.	1.50	$19.500	$29.25	
PLASTIC WITH IRRIGATION	FOOT	8405.00	$0.09	$756.45	
REPLACEMENT STAKES*	STAKE	550.00	$0.66	$363.00	
STRING/TWINE	BOX	2.00	$5.900	$11.80	
TOMATO 25 LB. BOX*	BOX	1680.00	$1.500	$2,520.00	
CROP INSURANCE	ACRE	1.00	$588.00	$588.00	
GROWER INCOME INSURANCE	ACRE	1.00	$30.00	$30.00	
TRACTOR/MACHINERY	ACRE	1.00	$84.42	$84.42	
LABOR					
Drip Irrigation	HRS	3.00	$12.67	$38.01	
Planting	HRS	16.00	$12.67	$202.72	
Staking	HRS	14.00	$12.67	$177.38	
Stringing	HRS	25.00	$12.67	$316.75	
Backpack spraying	HRS	6.00	$12.67	$76.02	
Pruning/Suckering	HRS	15.00	$12.67	$190.05	
Picking	BOX	1680.00	$2.50	$4,200.00	
Packing	HRS	170.00	$12.67	$2,153.90	
Post-Harvest Clean Up	CONTRACT	1.00	$400.00	$400.00	
INTEREST ON OP. CAP.	DOL.	$5,042.16	2.7%	$137.15	
TOTAL VARIABLE COSTS:				**$14,170.35**	
3. INCOME ABOVE VARIABLE COSTS:				**$5,317.65**	
4. FIXED COSTS					
TRACTOR/MACHINERY	ACRE	1.00	$131.11	$131.11	
IRRIGATION	ACRE	1.00	$63.50	$63.50	
H2A OVERHEAD	ACRE	1.00	$206.00	$206.00	
GENERAL OVERHEAD	DOL.	$14,170.35	7.0%	$991.92	
TOTAL FIXED COSTS:				**$1,392.53**	
6. TOTAL COSTS:				**$15,562.88**	
7. NET RETURNS TO LAND, RISK, AND MANAGEMENT:				**$3,925.12**	

BREAK-EVEN YIELD		BREAK-EVEN PRICE	
VARIABLE COSTS	30539.55	VARIABLE COSTS	$0.34
TOTAL COSTS	33540.69	TOTAL COSTS	$0.37

* PLEASE NOTE: THIS BUDGET IS FOR PLANNING PURPOSES ONLY, IT DOES NOT INCLUDE LAND RENT
*Stake cost does not include initial fixed cost of stakes
* Tomatoes will be packaged in 25 lb. box. Cannot reuse old boxes.

Credit ARE and other CALS folks and tomato producers for creating the detailed Enterprise Budget

This is page 1 summarizing inputs and products by type, quantity, price, cost and revenue, and net returns

Purposes: provide a general prediction of costs, revenues, net returns to assist in farm planning, provide a framework for users to adapt to their own situation.

Sources: https://cals.ncsu.edu/are-extension/business-planning-and-operations/enterprise-budgets/
https://cals.ncsu.edu/are-extension/wp-content/uploads/sites/27/2021/06/Tomato-Budget-2021.pdf

We build on a traditional Enterprise Budget (cont.):

INCOME ABOVE VARIABLE COSTS AT DIFFERING YIELDS AND PRICES

PRICES RECEIVED	$0.32	$0.39	$0.46	$0.53	$0.60
LBS TOMATOS PER ACRE					
29400.00	$ (1,959.06)	$ 87.18	$ 2,133.42	$ 4,179.66	$ 6,225.90
35700.00	$ (1,243.91)	$ 1,240.82	$ 3,725.54	$ 6,210.26	$ 8,694.98
42000.00	$ (528.75)	$ 2,394.45	$ 5,317.65	$ 8,240.85	$ 11,164.05
48300.00	$ 186.40	$ 3,548.09	$ 6,909.77	$ 10,271.45	$ 13,633.13
54600.00	$ 901.56	$ 4,701.72	$ 8,501.88	$ 12,302.04	$ 16,102.20

TOMATO - HAND HARVEST

PER ACRE MACHINERY AND LABOR REQUIREMENTS FOR HAND HARVEST TOMATO

MONTH	OPERATION	TIMES OVER	LABOR HOURS	MACHINE HOURS	VARIABLE COSTS	FIXED COSTS
3,11	HEAVY DISK 13'	3.00	0.56	0.51	$11.91	$14.28
3	1-BOTTOM PLOW	1.00	0.55	0.50	$7.43	$7.02
3	MULCH BEDDER-LAYER W/ FUMIGANT	1.00	0.57	0.52	$10.50	$13.59
3 thru 8	TRACTOR MTD SPRAYER PROD 3-ROW	16.00	1.36	2.40	$39.68	$73.76
3	TRACTOR MTD SPRAYER 30 FT	1.00	1.36	0.08	$2.41	$6.64
3 thru 8	24 FOOT BOX TRUCK	1.00	0.48	0.44	$3.92	$6.18
9	MULCH LIFTER	1.00	0.57	0.52	$6.65	$7.54
9	SPREADER/SEEDER 3PH	2.00	0.22	0.20	$1.92	$2.10
PER ACRE TOTALS FOR SELECTED OPERATIONS			5.67	5.17	$84.42	$131.11

CHEMICAL USE ASSUMPTIONS FOR HAND HARVEST TOMATO

	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER ACRE	MONTH
HERBICIDES					
metribuzin (Sencor)	LB	2.00	$66.48	$132.96	MAR
Fomasafen (Reflex)	PT	1.00	$8.88	$8.88	MAR
metolachlor (Dual)	PT	1.33	$13.09	$17.41	MAR
INSECTICIDES:					
imidacloprid (Admire Pro)	OZ	9.00	$1.00	$9.00	2 X (MAR & MAY)
dicofol	PT	1.50	$4.56	$6.83	MAY
spinetoram (Radiant)	OZ	5.00	$5.90	$29.49	JUNE
rynaxapyr (Coragen)	OZ	3.50	$7.84	$27.44	JUNE
pyrethroid (bifenthrin)	OZ	5.00	$0.82	$4.12	JULY
FUNGICIDES:					
copper diammonia diacetate (copper)	PT	15.00	$2.50	$37.50	5 X (MAR-JUL)
mancozeb (Manzate)	LB	12.00	$3.04	$36.48	8 X (MAR-JUL)
acibenzolar (actiguard)	OZ	2.00	$55.00	$110.00	4 X (MAR-JUL)
azoxystrobin (Quadris)	OZ	18.60	$3.01	$55.96	3 X (MAR-SEP)
difenoconazole, cyprodinil (Inspire Super)	OZ	54.00	$2.48	$133.73	3 X (MAR-SEP)
penthiopyrad (Fontelis)	OZ	48.00	$1.86	$89.25	3 X (MAR-SEP)
cyazofamid (ranman)	OZ	7.50	$10.00	$75.00	3 X (JUN- SEP)
chlorothalonil (Bravo)	PT	6.00	$5.13	$30.75	3 X (JUN- SEP)
FUMIGANTS:					
chloropicrin (Chlor-O-Pic)	LB	264.00	$1.87	$493.68	MAR
TOTAL:				$1,298.48	

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Page 2 provides a "what-if" table with calculated Returns Above Variable Costs at Selected Prices and Yields around the assumed values.

Another table presents machinery and equipment used by type, months used, costs of use, and number of passes over the field.

A third table lists crop protectants used, prices, quantities, and number of applications.

Note: Traditional enterprise budgets are a 'snapshot' or a single point on a very complex production function.

They represent a single set of quantities and prices among many possible.

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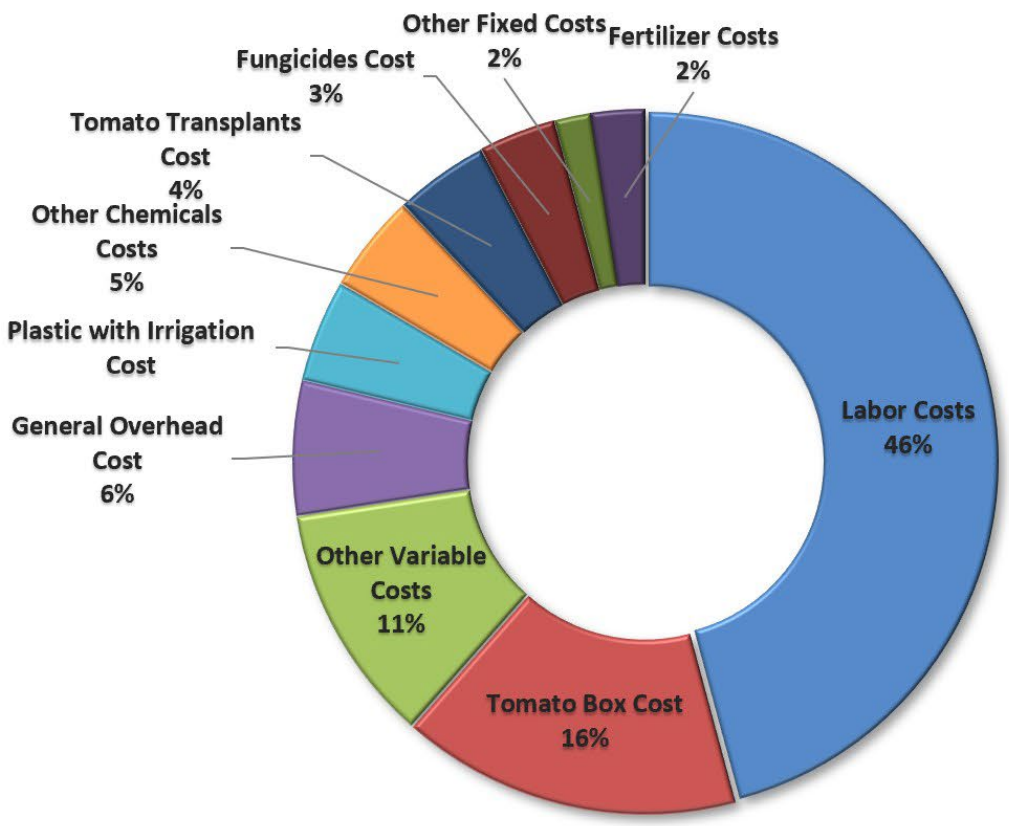
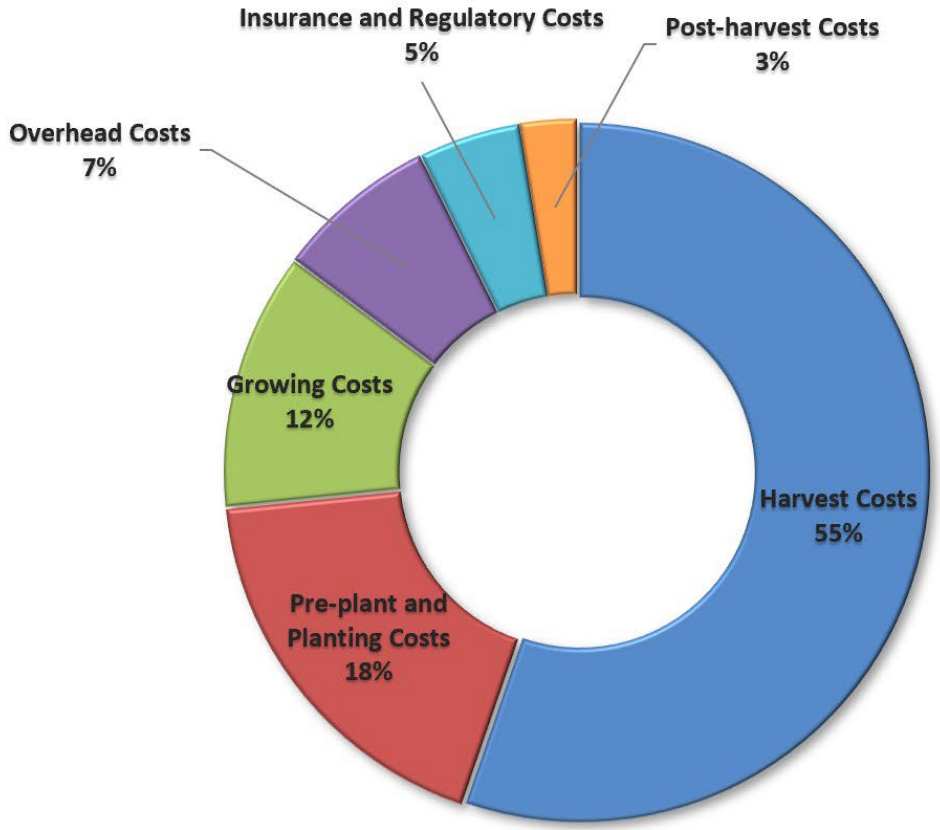
Two Summaries of Tomato Production Costs: by Input Type and by Production Phase





Extract Estimated Cost of Spraying one acre one time for late blight prevention:

(to be validated!)

10 minutes machine time + 18 minutes labor + $10 to $25 fungicide = $21 to $36 /acre

We are integrating disease effects:

on products, management response to disease, and key factors related to disease. Our first case is late blight in North Carolina field tomatoes.

We are grateful for guidance to the literature shared by Inga Meadows and Jean Ristaino.

We use results from Liu et al. to expand the model.

Yangxuan Liu, Michael R. Langemeier, Ian M. Small, Laura Joseph, William E. Fry, Jean B. Ristaino, Amanda Saville, Benjamin M. Gramig, and Paul V. Preckel. A Risk Analysis of Precision Agriculture Technology to Manage Tomato Late Blight. *Sustainability* 2018, 10, 3108; doi:10.3390/su10093108

Integrating disease effects:

Four or more variables to add to the model: (based on Liu et al)

AUDPC area under the disease progress curve.

Potential Damage: affect on yield of the Control (no-spray)

e.g. Marketable Yield 0.71 to 2.49 tons/acre Control
11.41 to 14.30 " " Calendar spraying

Variety Susceptibility: Susceptible, Moderately Susceptible, and Moderately Unsusceptible,

Date of First Detection, AUDPC Score at First Detection, Delayed Spray Days

Capacity for probabilistic data input and outcomes

We are using @Risk to make selected variables stochastic.

- an add-on to EXCEL

- offers multiple probability distributions
  and multivariate probability distributions

- runs Monte Carlo simulation to generate outcome
  probability distributions

- creates Dashboards for User friendly interfaces

Capacity to receive and generate streaming data

We will add capacity to receive data from programs such as PoPS to create near-real time updating of projected probabilistic production, costs, and revenues.

We will also consider adding real time updating of prices and of disease and protectant characteristics.

Projected outcomes will be updating and may be streamed.

Regional projections will be updated based on updated results of field scale models.

Questions?

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