Predicting Fruitset Model

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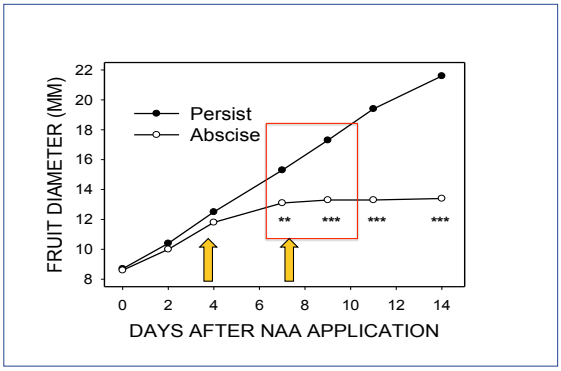
Chemical thinning is the most critical annual apple orchard practice. Yet chemical thinning is the most stressful and difficult practice to implement. Over time, new approaches to cropload management have been developed. The most recent approach involves the use of a spreadsheet tool called Predicting Fruitset. This model will allow growers to evaluate ongoing fruitset and/or help to access the effectiveness of their chemical thinning applications. This model is based on the assumption that setting fruitlets grow faster than abscising fruitlets (Table 1).

Table 1. Fruitset prediction hypothesis.

Fruitlet Fate	Prediction
Persist	A fruit is predicted to persist if the growth rate over the measurement period was at least 50% or greater of the fastest growing fruit.
Abscise	A fruit is predicted to abscise if the growth rate of the fruit slowed to 50% or less of the growth rate of the fastest growing fruit.

Figure 1. Typical growth pattern of persisting and abscising fruitlets.



Abscising fruitlets will stop growing many days before they will drop. A typical growth pattern is clearly visible in Figure 1. Abscising fruit slow down growth in three to four days and stop growth within a four to six days following a thinning application. This slowing of growth is temperature dependent, warmer temperatures will hasten the stopping and cold temperatures will delay the stopping of growth. The growth rate difference between setting fruitlets (fast growing) and dropping fruitlets (slow growing) is all that is needed to predict fruitset. Two measurements usually will suffice to predict set. The first diameter measurement should be performed three days after the time of a thinning application or no earlier than the 6 mm stage. The second diameter measurement should be performed three to four days later as indicated in Figure 1. This will maximize the difference in growth rates. The slowing fruitlets will reveal themselves as abscising fruitlets. The model calculates the growth rates and predicts set.

This model starts you planning your thinning program early. It encourages a more precise approach to cropload management. It also gives you confidence to strategize, evaluate and achieve a successful thinning plan. The model will encourage appropriate actions based on the predictions. The predictions may require additional thinning applications to reduce cropload.

Predicting Fruitset Model

This model was developed by Dr. Duane Greene, of UMASS and the downloadable (Table 2) Excel spreadsheet was designed by Philip Schwallier, MSU.

Table 2. Predicting Fruitset Model Download sites.

This model can be downloaded at:	
1	Apples.msu.edu
2	http://www.glexpo.com/summaries/2013summaries
3	http://extension.umass.edu/fruitadvisor/resources/clements-corner

Figure 2. Marked Flower Cluster.

Growth diameter rate disparity is the earliest indication of abscising and persisting fruitlets during the fruitset period (30 DAFB). Fruitlets that are abscising either on their own or due to the chemical thinning stress are the one's growing at less than half the diameter of the fastest growing fruitlets (Table 1). Table 3 lists the basic steps needed to use the Predicting Fruitset Model.

Abscising fruitlets will normally start slowing their growth rate four or five days after a thinner application. Abscising slow growing fruitlets at day seven stop growing all together. The abscising fruitlets appear normal until a few days later when they start turning an off color (dark green or yellow). This is the first visible evidence that fruitlets are going to abscise. Dropping fruitlets will have sepals that fold outward and setting fruitlets will have sepals that fold closed inward over the calyx. Seeds will sometimes turn an off color, but all these visible symptoms are inconsistent and can be misleading. The Predicting Fruitset Model will predict fruitset based on the diameter growth disparity of fruitlets. It is quite accurate.

This model keeps track of measurements of fruitlet growth and predicts set. We suggest that 75 representative flower clusters should be marked (Figure 2) and the diameter measured every three to four days. An outline of the basic steps for this model is listed in Table 3. The steps include 1) evaluate bloom, 2) select representative clusters, 3) mark and measure fruitlets and 4) evaluate predictions. When measuring fruitlets, measure the diameter on the dots or numbers on the fruit. Most fruit are asymmetrical and doing this removes quite a bit of variability. The directions for the details of the model are listed in the model spreadsheet and in Table 4. A guide to help determine target cropload density is presented in Table 6.

Predicting Percent Fruitset Summary Sheet

This sheet summarizes the data of all your input measurements. The summary sheet includes all the data from the other sheets. The Target Number of Fruit and the Target Percent Fruitset are grower defined on the Setup Sheet. Macro's sorts out the 20 fastest growing fruitlets and calculates their diameter growth rate. All other fruitlets are compared to the 50% average of the 20 fastest fruitlet diameter growth rate. It counts the number of the fastest growing fruitlets and the slowest (<50% the rate of the fastest growing fruitlets) growing fruitlets. These numbers and

percent's are listed on the Summary Sheet and are plotted on the two charts. This is repeated as many times as the fruitlets are measured. If after the prediction is calculated, there is a significant difference between the predicted set and the target set, an additional chemical thinning application is necessary. If there is only a small difference between the prediction and the target set, chemical thinning is complete. For example, if the "Target" and the "Predicted" percent fruitset are close (say 5 to 8%), then chemical thinning is over.

Table 3. Predicting Fruitset Model Steps Outline.

	Data Needed	Example
Evaluate Bloom		
Estimate flower cluster numbers per tree; (count if small trees).		Do at Pink to Full Bloom.
1.	Flower clusters/tree (or per tree canopy measured).	400 clusters/tree (typical Tall Spindle tree).
2.	Use Method 1 or 2. Tree trunk cross-sectional area; (see Table 6 or 7).	2" diameter trunk = (20^2 cm)
3.	Use Method 1 or 2. Determine target cropload, (see Table 6 or 7).	100 to 200 fruits/2" diameter trunk (100 for trays, 200 for bags).
Select representative flower clusters.		
1.	Mark 75 flower clusters/block minimum.	Mark 15 clusters on 5 trees, number from 1 to 75.
Mark and Measure Fruitlets (Figure 2).		
1.	Take the first measurement 3 to 4 days after a thinning treatment or not before the 6 mm stage.	Number fruitlets within cluster, King=1, Laterals=2 to 5.
2.	Enter measurement data into the model.	
3.	Make second measurement in 4 to 5 days and enter data.	
Evaluate Predictions		
1.	The model predicts percent fruitset. If the prediction is close to your target, you are done.	If the target set = 10% and the Model predict 8 to 15% set, do no more chemical thinning.
2.	If still too many fruit, thin again.	If the target set = 10% and the Model predict >20% set, another chemical thinning is needed.

Example from Table 4:

On 5-1, 505 fruitlets were measured. The target fruit number for this blocks measured trees was determined to be 35 fruit or 7% of the 505 fruitlets. On 5-4, three days later, only 483 fruitlets were measured and the model calculated the 20 fastest growing fruitlets grew 3.54 mm in those three days. Fruitlets growing faster than 1.77 mm (50% of 3.54) were 64 (12.7%) of the original 505 fruitlets. On 5-4 the model predicted 483 fruitlets were not setting. It predicted 12.7% fruitset. This 12.7% is close to the target (7%); therefore no more chemical thinning is warranted. On 5-7, six days after the first measurement, the predicted percent set was 9.9%, a more accurate prediction.

Table 4. Predicting Percent Fruitset Summary Sheet Example.

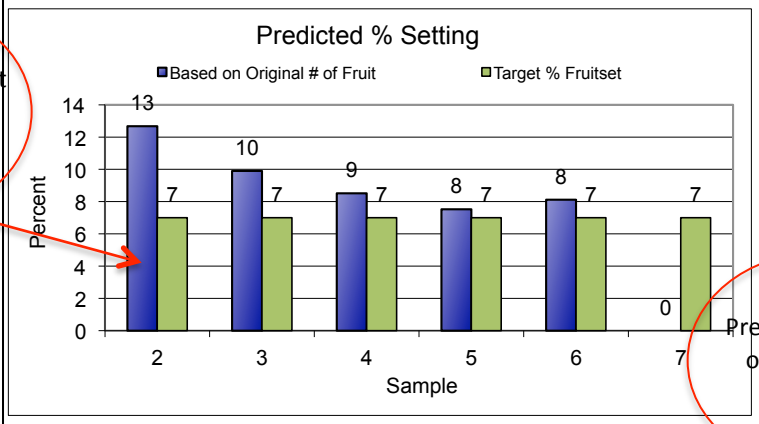
Predicted number of fast growing fruit

Target number of fruit and target percent.

Number of fruit originally marked and measured.

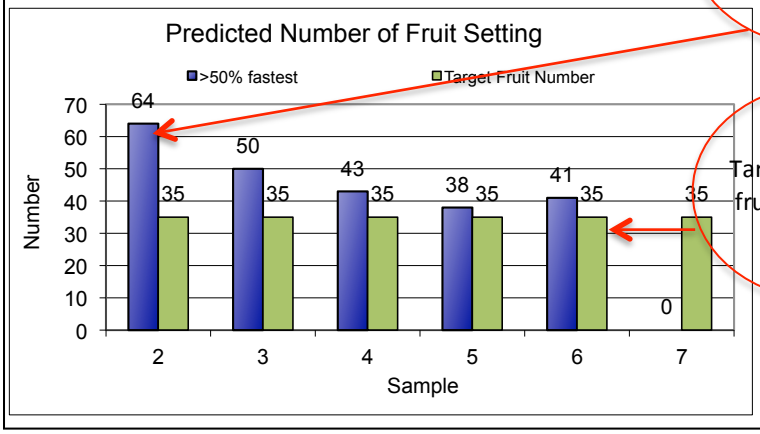
Predicted % fruitset of the original measured fruitlets.

Summary Sheet			Farm: TestData Farm		Block: Test Block						
Target Fruit Number			35		Target % Fruitset					7%	
Sampling			Diameter (mm)		Diameter Growth (mm)		Number of Fruit			Predicted % Setting	
Number	Date	Days between sample dates	Mean of 20 largest fruitlets	Mean of all fruitlets	Mean of up to 20 fastest growing fruitlets	50% fastest growing fruitlets	>50% fastest	<50% fastest	Measured	Based on Original # of Fruit	
1	5/1	0	10.05	7.04					505		
2	5/4	3	13.21	7.55	3.54	1.77	64	419	483	12.7	
3	5/7	3	15.98	8.27	3.32	1.66	50	368	418	9.9	
4	5/10	3	17.56	8.89	1.88	0.94	43	329	372	8.5	
5	5/13	3	19.88	10.60	2.72	1.36	38	173	211	7.5	
6	5/16	3	21.31	12.13	1.68	0.84	41	112	153	8.1	
7	5/19	3	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0	0	0	0.0	



Predicted % fruitset of the original measured fruitlets (blue bar).

Predicted number of fruit setting (blue bar).



Target number of fruit (green bar).

Predicting Fruitset 2013.xls SummarySheet Page 1 of 1

Table 5. Predicting Fruitset Model Directions.

Predicting Fruitset Model Directions	
Developed by Dr. Duane Greene, UMASS and this spreadsheet designed by Philip Schwallier, MSU.	
This model can be downloaded at:	
1	Apples.msu.edu
2	http://www.glexpo.com/summaries/2013summaries
3	http://extension.umass.edu/fruitadvisor/resources/clements-corner
	This model will help predict fruitset early before the thinning window closes allowing another chance to chemically thin.
	You must have you **Macros** turned on.
Select and Number Clusters and Fruitlets	
	Shortly after bloom (6 mm) select and mark at lease 40 (200 fruitlets) representative flower clusters in a block you want to predict fruitset.
	Number the fruits in each cluster with a number or dots (1 dot =1, 2 dots=2, etc.) with a sharpie marker.
	Start with the King fruitlet and number the fruit clockwise starting at the north fruitlet.
Setup Sheet (yellow areas)	
	Enter your farm name.
	Enter the block name.
	Enter the dates of your measurements in sample.
	Enter the number of clusters you are measuring.
	Enter what you determine to be the target number of fruit for the measured canopy area.
	All of these entries will be automatically copied to the other appropriate cells.
Input Sheet	
Enter Fruitlet Diameters	
	The Input Sheet will accept direct input of diameters or they can be pasted in from another spreadsheet.
	The Tree, Cluster and Fruitlet number is not important, but only as a reference # for your marking system.
	The Cluster and Fruitlet number is copied to the staging sheet and not used anywhere else.
Summary Sheet	
	Move to the summary sheet after entering your diameters.
	Click on the button: Calculate Fruitlet Set
	This will start the macros:
	1. The macro will copy the diameters from the staging sheet to the Diameter and Count sheets
	2. The macro will sort the diameters in descending order (Diameter Sheet).
	3. The macro will sort the diameter growth in descending order (Count Sheet).
	4. The macro will move back to the Summary Sheet.
Summary Sheet	
	You can print the Summary Sheet by clicking button: Print This Page.
Errors	
	The program will not run correctly if a " " (space) is entered into the input page.
Staging, Diameter, Count Sheet	
	These sheets are used by the program to copy, check, calculate and sort data, do not change these sheets.

Method 1. Determining the Target Number of Fruit/Tree by Tree TCSA.

This table is a guide to help set target fruit densities based on TCSA (trunk cross-sectional area). Use this table to determine the target cropload/tree. For example; a 1.5" diameter mature Gala tree should have about 91 to 114 apples/tree. Target about 91 apples/tree for trays and/or 114 for bags for Gala's.

Table 6. Trunk or Limb Diameter and Target Number of Fruit/CSA of limb or trunk.

Limb or Trunk Diameter		CSA (Cross-sectional Area)	Target fruit density/cross-sectional area (sq. cm)						
			4	5	6	8	10	12	15
mm	inches	sq. cm	Fruit/tree or Limb for above target density						
8	0.31	0.5	2	2	3	4	5	6	7
10	0.39	0.7	3	3	4	6	7	9	11
12	0.5	1.2	5	6	7	10	12	15	19
19	0.75	2.8	11	14	17	22	28	34	42
25	1	5	20	25	30	40	50	60	76
31	1.25	7	31	39	47	63	79	95	118
38	1.5	11	45	57	68	91	114	136	171
44	1.75	15	62	77	93	124	155	186	232
50	2	20	81	101	121	162	202	243	304
63	2.5	31	126	158	190	253	316	380	475
76	3	45	182	228	273	364	456	547	684
101	4	81	324	405	486	648	810	972	1216

Target Fruit Density Guideline	Mature Trees	Comment	Young trees
Honeycrisp	7 to 8	Biennial and large fruited.	5 to 6
Gala	8 to 10	Small fruited.	6 to 8
Jonagold	8 to 11	Biennial and large fruited.	6 to 7
Most Varieties	8 to 9	Standard varieties.	6 to 7

For large fruit size, target the lower of density range, i.e. for tray Gala's, target 8 fruit/CSA.
For bag fruit size, target the higher of density range, i.e. for bag Gala's, target 10 fruit/CSA.

Method 2. Estimating the Target Number of Fruit/Tree by Tree Planting System.

Dr. Terence Robinson of Cornell University provided the following steps listed at the top of Table 6. This table is an alternate method of calculating Target Fruit/Tree and Target % Fruitset for high-density apples (Tall Spindle and higher densities). The highlighted cells at the top of the table match directly with the same example information in the bottom tables. For example, a desired 1500 bu./acre yield of a 3x12 Tall Spindle = a calculated Target Fruit/Tree of 119 fruits. At 200 flower clusters/tree then target number of fruit = 119 fruits/tree or 11.9%. The Target % Fruitset of 11.9 is highlighted in Table 6 at the top and bottom.

Table 7. Calculated Target Fruit/Tree and Target Fruit % Set for 100 Count Galas.

#	Steps	Example (Gala)	
1	Determine Desired yield/acre	1500 bu.	
2	Desired fruit size (100 count)	100 count	
3	Target Fruits/acre	150,000	1500 x 100
4	Trees/acre (3 x 12)	1260	
5	Target Fruits/Tree	119	150,000 / 1260
6	Flower Clusters/Tree	200	
7	Potential Fruits/Tree (Clusters x 5)	1000	200 x 5
8	Target % Fruitset (Target / Potential)	11.9 %	1191000 / 119

Target Fruits/Tree (100 count)

	Tree Spacing	2.2 x 10	3 x 10	3 x 12	4 x 12
	Trees /Acre	2016	1512	1260	945
Desired Yield (bu/acre)	**Target Fruits /Acre**	**Fruits/Tree (100 count)**			
1600	160,000	79	105	126	169
1500	150,000	74	99	119	158
1400	140,000	69	92	111	148
1300	130,000	64	85	103	137
1200	120,000	59	79	95	126
1100	110,000	54	72	87	116
1000	100,000	49	66	79	105

Target % Fruitset at Various Flowers Clusters/Tree.

Flower Clusters/Tree	100	200	300	400	500
Potential Fruit/Tree	500	1000	1500	2000	2500
Target Fruit /Tree	Target % Fruitset				
126	25.2	12.6	8.4	6.3	5.0
119	23.8	11.9	7.9	6.0	4.8
111	22.2	11.1	7.4	5.6	4.4
103	20.6	10.3	6.9	5.2	4.1
95	19.0	9.5	6.3	4.8	3.8
87	17.4	8.7	5.8	4.4	3.5
79	15.8	7.9	5.3	4.0	3.2