Hazels – Emergence from Dormancy

John Kelsey - - - 2019 Apr 08

I'll spare you the sermon on the importance of pollination. We are true believers, and we have been collecting data from our European hazel flowering for several years. It has been a learning process and our observation skills and stage definitions have improved over time. We have a lot of complex and confusing data, but we are starting to see some cause-and-effect daylight between wild swings of winter weather patterns and wild swings of fall hazelnut harvest results.

We must be 300 miles from the nearest lake-effect. The jet stream wigwags aloft all winter and brings us alternating tropic and arctic temperatures. The wild temperature swings of winter and spring go un-moderated here. We have 30-some varieties of hazels, each with both sexes. That is 60 different dormancy alarm clocks that ring sometime during the first 3 months of the year. Here is a good explanation of the two-part emergence from dormancy.

from Franz Niederholzer, UC Farm Advisor, Sutter/Yuba Counties:

Deciduous fruit trees have a mechanism to avoid damage from cold or freezing weather. We generally refer to this as winter dormancy – the annual life stage of the tree between leaf drop and bud break. Winter dormancy has two stages that can't be visually separated in the field.

In the first part of winter dormancy, technically called endodormancy, tree growth is limited by some unknown factor inside the plant itself - actually in each plant bud. A certain amount of cool temperature is required to end this first stage of winter dormancy. This is referred to as the Chilling Requirement. Temperatures between roughly 30°F – 60°F contribute towards ending this first stage of winter dormancy, with temperatures between 35°F – 50°F contributing the most chilling.

In the second part of winter dormancy, technically called ecodormancy, growth is controlled by an external factor – temperature. Each species of deciduous plant requires a certain amount of heat to begin growing after the first stage of winter dormancy has been completed. So, deciduous fruit trees first need some cool weather and then some warm temperatures to start growing. Different tree species need different amounts of chilling and/or warm temps to begin bloom.

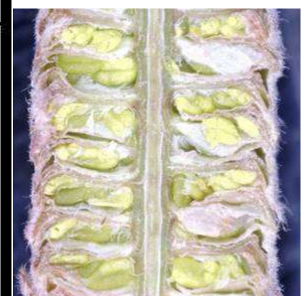
The same story applies tree nuts. It is not just species that have different requirements; this is also true for varieties within tree nut species. Furthermore, female and male requirements within a tree nut variety are independent and often quite different.

Dormant hazel flowers are protected from bitter cold and oblivious to unseasonal warm spells while asleep. They are vulnerable to freeze damage once sexual development begins, i.e. stigmas and anthers become exposed. The process is again safe from cold injury once pollen has been captured. Each type of flower has a period of injury exposure which lasts between two to several weeks. Our earlier articles on male and female flower damage are posted on the www.thescalepit.com website under the "hazels" tab.

Endodormancy - Accumulating Chill Requirement:

For fruit trees there are 3 well-known models that attempt to mimic the first (chill) part of dormancy. The simplest model is "Chill Hours". The "Utah Model" is a bit more complicated, and the "Dynamic Model" is mathematical magic. Since all three rank our hazel varieties in nearly the same order each year, we will report the 32-45 Chill Hours to avoid further complication of a complicated story.

We start our chill hour accumulation count when our hazel trees seem to go dormant. There is a late-fall day when hazel leaves turn from a photosynthetic bright green to a much darker green and you know that they are done producing plant energy for the year. For us, this change event has been surprisingly consistent, within a few days of November 8th each year.



Leaves Green

Leaves Turn

Leaves Drop

<---- Only Chill Advances Clock
Heat ignored

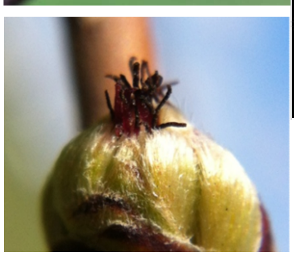
ENDODORMANCY

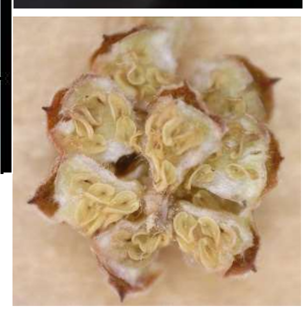
Stage 0

<---- Only Chill Advances Clock
Heat ignored

Chill Requirment met - Imaginary Alarm Clock Rings

Female (Stigma)		*Male (Catkin)*
Red Dot <---Heat induces Progress 1mm Bush	**ECODORMANCY** Stage 1	Expansion Begins <---Heat induces Progress
2 mm Bush or Red Spider Receptive to Pollen Capture Red	**SEXUAL ACTIVITY** Stage 2	10% of Anthers Open Shedding Pollen All Anthers Open
Maroon Black	Stage 3	Brown Brittle Drop





Hopefully the Wind is blowing right to left across the page.

We can't hear the dormancy alarm clocks ring at the end of the first part of dormancy. At the first signs of flowering, however we know that the chill requirement has clearly been met so that only more heat will be needed to further flowering progress. When the first sign of flowering is seen, the variety's chill requirement is something less than today's accumulated chill hours. The first sign for female flowers is the red dot stage. The first sign for male flowers is the beginning of catkin expansion.

The accuracy of this exercise is not the best, but for pollination studies the data can be a little sloppy and still be useful. Accuracy of the temperature data is good. Predicted start date is also good. The end date is something we cannot see. We survey once a week and chill hours go up about 80 hours per week. Red dots are easy to miss. To reduce some annual errors,we average all of our varieties and then report plus/minus difference from the average. We also average several years' data, which helps even out some embarrassing observations.

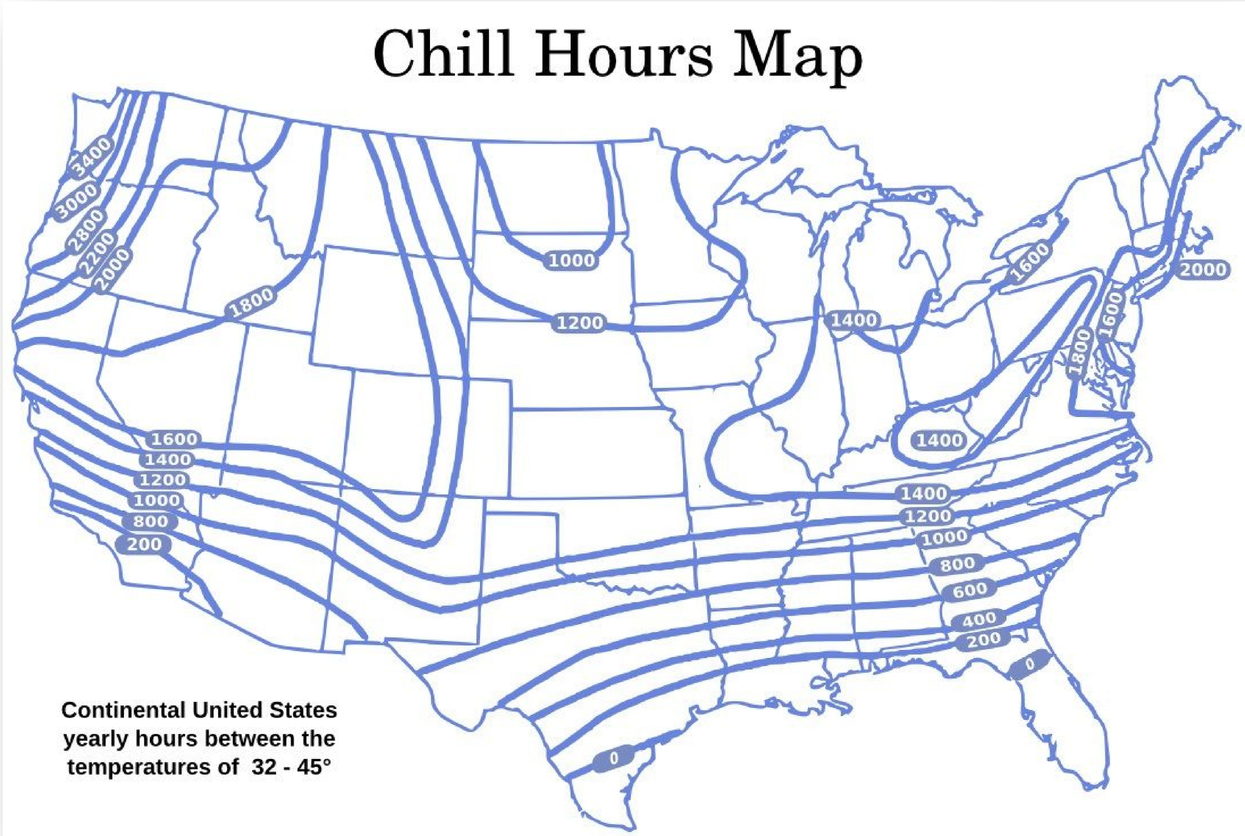
FEMALE	**Chill Hours 32 - 45**					**Chill Hours from avg**						
	2013	2014	2017	2018	2019	2013	2014	2017	2018	2019	Avg	sDev
Rutgers H3FR05P69					626					-448	-448	
Rutgers H3FR04P66					626					-448	-448	
Slate	670	871	600	646	701	-412	-125	-292	-235	-373	-287	114
Tonda di Giffoni	670	923	600	646	701	-412	-73	-292	-235	-373	-277	133
Sacajawea			792	646	626			-100	-235	-448	-261	175
Yamhill	719	923	659	936	871	-363	-73	-233	55	-203	-163	160
Hall's Giant		923	634	852	811		-73	-258	-29	-263	-156	122
Rutgers CRXR04P43			749	936	811			-143	55	-263	-117	160
Rutgers CRXR12P35			749	936	811			-143	55	-263	-117	160
Farris G17	719	968	1095	936	1114	-363	-28	203	55	40	-19	210
Royal	787	987	1095	936	1114	-295	-9	203	55	40	-1	182
Gem	859	987	974	936	1201	-223	-9	82	55	127	6	137
McDonald					1088					14	14	
Dorris			906	936	1114			14	55	40	36	21
Delta	1098	987	974	936	1114	16	-9	82	55	40	37	35
Grimo Marion				936	1114				55	40	48	10
York			974	936	1114			82	55	40	59	21
Wepster				970	1114				89	40	65	34
Rutgers CRXR11P07			1010	936	1114			118	55	40	71	41
Grimo 208P	1099	1074	1010	936	1201	17	78	118	55	127	79	45
Felix			1095	936	1114			203	55	40	99	90
Rutgers CRXR06P56			974	970	1201			82	89	127	99	25
Rutgers CRXR11P10			1095	936	1114			203	55	40	99	90
Rutgers H3FR04P42					1201					127	127	
Grimo 208D	1329	1139	1095	936	1114	247	143	203	55	40	138	90
Butler	1372	1139	1010	936	1312	290	143	118	55	238	169	95
Geneva	1372	1189	1095	970	1201	290	193	203	89	127	180	77
Jefferson	1461	1242	1095	970	1201	379	246	203	89	127	209	114
Eta	1372	1242	1095	970	1312	290	246	203	89	238	213	76
Grimo 186M	1616	1292	1095	970	1201	534	296	203	89	127	250	178
Contorta			1095	1043	1526			203	162	452	272	157
average	1082	1059	943	912	1048							
average both sexes	**1082**	**996**	**892**	**881**	**1074**							

MALE	Chill Hours 32 - 45				Chill Hours from avg					
	2014	2017	2018	2019	2014	2017	2018	2019	Avg	sDev
Farris G17	791	634	451	626	-205	-258	-430	-448	-335	122
Grimo 186M	791	634	528	701	-205	-258	-353	-373	-297	79
Tonda di Giffoni	791	634	528	811	-205	-258	-353	-263	-270	61
Royal	871	659	451	811	-125	-233	-430	-263	-263	126
Hall's Giant	791	634	528	871	-205	-258	-353	-203	-255	71
Butler	923	749	646		-73	-143	-235		-151	81
Dorris		749	773	1114		-143	-108	40	-70	98
Rutgers CRXR04P43		749	717	1201		-143	-164	127	-60	163
Yamhill	1011	749	773	1114	15	-143	-108	40	-49	90
Rutgers CRXR11P10		749	936			-143	55		-44	140
Slate	923	792	936	1114	-73	-100	55	40	-20	79
Sacajawea		792	936	1114		-100	55	40	-2	86
Grimo 208D	923	792	936	1201	-73	-100	55	127	2	107
Grimo 208P		792	936	1201		-100	55	127	27	116
Wepster				1114				40	40	
Rutgers CRXR12P35		792	936	1312		-100	55	238	64	170
Gem	1011	974	936	1201	15	82	55	127	70	47
Jefferson	1011	974	936	1201	15	82	55	127	70	47
Rutgers CRXR11P07		974	970			82	89		85	5
Geneva		974	936	1201		82	55	127	88	37
Grimo Marion			936	1201			55	127	91	51
Eta	1011	1095	936	1201	15	203	55	127	100	83
Delta	923	1095	970	1312	-73	203	89	238	114	140
McDonald			1143	1047			262	-27	118	204
York		974	936	1312		82	55	238	125	99
Felix		1095	936	1201		203	55	127	128	74
Contorta		1095	1379			203	498		350	209
average	905	840	847	1095						
average both sexes	**996**	**892**	**881**	**1074**						

Chill hours counting starts at leaf color change for everybody. Accumulated hour numbers shown above are captured at red dot time for females and at the onset of catkin expansion for males. It has been the usual practice to compare varieties to Barcelona as a standard. However, we don't have Barcelona, so we average everybody, males and females combined, as a standard.

We didn't collect male data in 2013. We have flowering observations for 2015 and 2016, but our temperature recorder broke down mid-winter – aargh!

I would like to take this opportunity to say a few nasty words about the U.S. Weather Service: There are two kinds of software related to data collection, "insies" and "outsies". If I can only have one, I want "outsides". Everybody writes "insies" programs first, and then good programmers move somewhere else and write more "insies". "Outsies" go begging. At the USWS, you have to write your own "outsies" - in FORTRAN! There, I feel better.



Comparing the Chill Hours Map with our chill hour data will show which varieties can accumulate enough chill to make it through endodormancy. If a variety doesn't make it through endodormancy, it will leaf out late and poorly and have a lousy crop year. To get a very rough idea of chill hours per week, divide your number on the map by the total weeks of your winter. For example, the map shows 1400 chill hours for West Virginia. Our winter lasts about 22 weeks, 1400 / 22 = 64 hours per week average. Actually we are getting about 1600 annual chill hour locally, and we average 80 chill hours per week.

<u>Ecodormancy – Heat Promoting Sexual Development:</u>

The second part of emergence from dormancy is independent of the first part. A certain flower may lie awake in bed for weeks after the alarm has sounded waiting for heat to begin. Again our accuracy is poor. The temperature data is good. Start time is the end of the chill requirement, an event we cannot see. End time of the heat requirement is the beginning of sexual activity, receptivity for females, and pollen shedding for males. Our definition for the beginning of female receptivity is the 2mm stigma bush stage. Our definition for the start of male pollen shedding is when about 10% of anthers have opened. For most of us a 10x magnifier is needed to see the anthers.

This is our poorest data (too shabby to show), but we are slowly getting better. This heating stage is highly variable, from year to year depending on weather. It is about the same for males and females – typically two weeks most years for us. One year there was plenty of chill, but little heat, so everyone came out of endodormancy and was waiting for heat. When the heat finally came, everybody opened together and everybody was happy, like Oregon. Such a consistent weather pattern is the advantage of a lake effect, or better yet, an ocean effect. We're lucky to have a creek effect in West Virginia.

FEMALE					Too Cold			Spring Peepers	First Robin			Crocus	Daffodils		Forsythia	Mow the Lawn	Chill Requirment
2019	12/22	12/29	1/5	1/12	1/19	1/26	2/2	2/9	2/16	2/23	3/1	3/8	3/15	3/22	3/29	4/5	hours
Rutgers H3FR04P66	1.0	1	1	1		1	1	1.6	1.9	2.2	2.5	2.5	2.8	2.8	4	4	626
Rutgers H3FR05P69	1	1	1	1.6		1.9	1.9	1.9	2.2	2.2	2.2	2.2	2.2	3.1	4	4	626
Sacajawea	1	1	1.18	2.08		1.6	1.6	1.78	2.02	2.2	3.4	3.4	4	4	4	4	626
Slate		1	1.18	1.96		1.9	1.3	2.2	2.08	2.5	3.4	2.68	4	4	4	4	701
Tonda di Giffoni		1.18	1.78	2.2		2.2	2.02	2.2	2.98	3.1	3.4	3.4	4	4	4	4	701
Hall's Giant			1.9	2.2		2.2	2.2	2.2	2.8	3.1	3.4	3.4	4	4	4	4	811
Rutgers CRXR04P43			1.18	1.6		1.6	1.78	1.9	1.9	2.2	1.6	2.2	4	3.7	4	4	811
Rutgers CRXR12P35			1	1.3			1.3	1.6	1.3	1.9	2.2	2.5	4	4	4	4	811
Yamhill				1.12		1.6	1.3	1.66	1.9	2.5	3.1	3.1	4	4	4	4	871
McDonald							1	1.6	1.6	2.2	2.2	2.5	2.2	2.2	4	4	1088
Delta								1	1.6	2.2	1.9	1.9	2.2	2.2	4	4	1114
Dorris								1.6	1.6	2.2	2.2	2.38	2.32	2.62	2.5	4	1114
Felix								1.3	1.3	1.9	1.6	2.2	2.2	2.2	2.32	4	1114
G17								1.6	2.2	2.2	2.8	2.8	3.4	3.4	4	4	1114
Grimo 208D								1	1	1.6	1.9	1.78	2.2	4	4	4	1114
Grimo Marion								1	1.9	2.2	2.2	2.2	2.2	2.8	4	4	1114
Royal								1.6	1.6	2.2	2.2	2.2	2.2	2.5	4	4	1114
Rutgers CRXR11P07								1.3	1.6	1.9	1.6	2.2	2.32	2.38	4	4	1114
Rutgers CRXR11P10								1.3	1.42	1.6	1.6	1.9	1.9	2.62	2.2	4	1114
Wepster								1.6	1.6	1.9	2.5	2.5	2.5	2.5	3.1	4	1114
York								1	1.3	1.6	1.6	3.4	4	3.4	4	4	1114
Gem									1.6	2.2	1.6	1.9	4	4	4	4	1201
Geneva									0.8	1.78	2.8	2.02	2.2	2.38	2.68	4	1201
Grimo 186M									1.6	1.6	1	1	1.66	2.2	4	4	1201
Grimo 208P									1.6	2.2	2.2	2.38	2.56	2.32	2.8	4	1201
Jefferson									1	1.78	2.02	2.14	2.26	2.68	2.68	4	1201
Rutgers CRXR06P56									1.3	1.6	1.6	2.2	2.8	2.8	4	4	1201
Rutgers H3FR04P42									2.2	2.2	2.2	2.2	2.5	4	4	4	1201
Butler										1	1	2.02	2.2	2.2	4	4	1312
Eta										1	1.9	2.2	2.32	2.2	2.2	4	1312
Rutgers H3FR03P33													1	2.2	4	4	1525
Contorta													1	1.6	2.2	2.2	1526

Maximum (degF)	51	60	60	64	47	61	51	66	59	55	66	57	81	64	81	75
Minimum (degF)	23	22	30	22	24	1	-8	17	18	26	21	10	25	21	23	21
Chill Hours (32-45)	626	701	811	871	1009	1047	1088	1114	1201	1312	1420	1482	1526	1611	1643	1695
Heat (deg day >50 / week)	0	3	5	8	0	1	0	23	5	2	5	1	35	5	40	35

Typical flowering stages are shown above. Black denotes partial or full injury. Green is bud break. The Rutgers H3FR05P69 females broke all records for receptivity, but they were inside tree tubes. The plus 1 degree minimum temperature during the week ending 1/26 demonstrates how exposed flowers are injured and dormant flowers are protected. TdG, Hall's, Slate, Sacajawea, Yamhill, and CRXR04P43 were all injured, but rebounded with black tipped stigmas. Notice that Rutgers H3FR05P69 (in tree tubes) survived two weeks of bitter cold unscathed.

The 23 degree-days of heating during week ending 2/9 brought out many varieties that were awake and waiting for heat. Another interesting point is ---- but that's another story.

Sexual Activity - Pollen Shed and Pollen Capture:

Both females (look closely) and males are fully active in this picture. The time-span of sexual activity varies greatly between varieties. The start times for sexual activity are the end times for ecodormancy described above. If we are trying to find well-matched pollinators, the end time of activity is equally important as the start time. A few varieties of female flowers extend part way and appear receptive most of the winter. I'm not sure of the sign that female receptivity has ended. I have assumed that the capture of some pollen ends receptivity, and the stigma's color changes from red to maroon to black. I have observed this within a few days after hand pollination. I also have observed early flowering stigmas staying red all winter inside a tree tube (where they most likely capture no pollen). Without pollen capture, I have no idea what ends the receptive period, but "no pollen" unfortunately is a common occurrence. Knowing nothing better, we call the onset of the maroon stage the end of female sexual activity.

The end of pollen shed is difficult (read impossible) to see. When catkins become brittle and central stem turns brown shedding is clearly over. In some varieties the catkin attachment becomes weak and catkins are easy to knock off. These signs assure that pollen shedding is finished, but it likely was finished sooner.

Pollination Parings:

All of the confusing data is combined in the confusing table below.

Pollination Timing (32-45 Chill Hours)		MALE	Farris G17	Grimo 186M	Tonda di Giffoni	Royal	Hall's Giant	Butler	Dorris	Rutgers CRXR04P43	Yamhill	Rutgers CRXR11P10	Slate	Sacajawea	Grimo 208D	Grimo 208P	Wepster	Rutgers CRXR12P35	Gem	Jefferson	Rutgers CRXR11P07	Geneva	Grimo Marion	Eta	Delta	McDonald	York	Felix
		avg	-334	-296	-268	-261	-253	-150	-68	-58	-48	-43	-18	0	4	29	44	66	71	71	86	90	93	101	116	119	127	130
		catkin production*	3.2	1.2	2.2	3.5	3.5	1.0	3.2		4.4		5.0	3.7	0.8	3.6			3.0	4.5		3.7		3.2	3.5		4.5	
		EFB resistance**	5.0	5.0	3.5		2.5	2.0	4.0	5.0	4.5	5.0	5.0	3.5	5.0	5.0	4.0	5.0		4.0	5.0	5.0	5.0	4.0	4.0	4.0	4.0	4.0
FEMALE	avg	s-allele			2	3	5,15	3	1,12	3	8		1,23	1			1		2,14	3		15,23		11,26	1,15	15	21	15,21
Rutgers H3FR05P69	-444	1,12	-110	-148	-176	-183	-191	-294	-375	-386	-396	-401	-426	-444	-448	-473	-488	-510	-515	-515	-530	-534	-537	-545	-560	-563	-571	-574
Rutgers H3FR04P66	-444		-110	-148	-176	-183	-191	-294	-375	-386	-396	-401	-426	-444	-448	-473	-488	-510	-515	-515	-530	-534	-537	-545	-560	-563	-571	-574
Slate	-286	1,23	48	10	-18	-25	-33	-136	-218	-228	-239	-243	-268	-286	-290	-315	-330	-352	-357	-357	-373	-376	-379	-388	-402	-405	-413	-416
Tonda di Giffoni	-276	2,23	58	20	-7	-14	-22	-126	-207	-218	-228	-233	-258	-276	-279	-305	-320	-342	-347	-347	-362	-366	-368	-377	-391	-395	-403	-406
Sacajawea	-259	1,22	75	37	9	2	-6	-109	-191	-201	-211	-216	-241	-259	-263	-288	-303	-325	-330	-330	-345	-349	-352	-360	-375	-378	-386	-389
Yamhill	-162	8,26	172	134	106	99	91	-12	-94	-104	-115	-119	-144	-162	-166	-191	-206	-228	-233	-233	-249	-252	-255	-264	-278	-281	-289	-292
Hall's Giant	-154	5,15	180	142	114	107	99	-5	-86	-96	-107	-111	-136	-155	-158	-184	-198	-221	-226	-226	-241	-244	-247	-256	-270	-274	-281	-285
Rutgers CRXR04P43	-115	3,10	219	181	153	146	138	35	-47	-57	-67	-72	-97	-115	-119	-144	-159	-181	-186	-186	-201	-205	-208	-216	-231	-234	-242	-245
Rutgers CRXR12P35	-115		219	181	153	146	138	35	-47	-57	-67	-72	-97	-115	-119	-144	-159	-181	-186	-186	-201	-205	-208	-216	-231	-234	-242	-245
Farris G17	-17		316	278	251	244	236	132	51	41	30	26	1	-18	-21	-47	-61	-84	-89	-89	-104	-107	-110	-119	-133	-137	-144	-148
Royal	0	1,3	334	296	268	261	253	150	68	58	48	43	18	0	-4	-29	-44	-66	-71	-71	-86	-90	-93	-101	-116	-119	-127	-130
Gem	8	2,14	341	303	276	269	261	157	76	66	55	51	26	7	4	-22	-36	-59	-64	-64	-79	-82	-85	-94	-108	-112	-119	-123
McDonald	18	2,15	352	314	286	279	271	168	87	76	66	61	36	18	14	-11	-26	-48	-53	-53	-68	-72	-75	-83	-98	-101	-109	-112
Delta	38	1,15	372	334	306	299	291	188	106	96	86	81	56	38	34	9	-6	-28	-33	-33	-48	-52	-55	-63	-78	-81	-89	-92
Dorris	38	1,12	372	334	307	300	292	188	107	96	86	81	56	38	35	9	-6	-28	-33	-33	-48	-52	-54	-63	-77	-81	-89	-92
Grimo Marion	49		383	345	318	311	303	199	118	107	97	92	67	49	46	20	5	-17	-22	-22	-37	-41	-44	-52	-66	-70	-78	-81
York	61	2,21	395	357	329	322	314	211	129	119	109	104	79	61	57	32	17	-5	-10	-10	-25	-29	-32	-40	-55	-58	-66	-69
Wepster	66	1,2	400	362	335	328	320	216	135	124	114	109	84	66	63	37	22	0	-5	-5	-20	-24	-27	-35	-49	-53	-61	-64
Rutgers CRXR11P07	73		407	369	341	334	326	223	141	131	121	116	91	73	69	44	29	7	2	2	-13	-17	-20	-28	-43	-46	-54	-57
Grimo 208P	80		414	376	349	342	334	230	149	138	128	123	98	80	77	51	36	14	9	9	-6	-10	-12	-21	-35	-39	-47	-50
Felix	101	15,21	435	397	370	363	355	251	170	159	149	144	119	101	98	72	57	35	30	30	15	11	9	0	-14	-18	-26	-29
Rutgers CRXR06P56	101		435	397	370	363	355	251	170	159	149	144	119	101	98	72	57	35	30	30	15	11	9	0	-14	-18	-26	-29
Rutgers CRXR11P10	101		435	397	370	363	355	251	170	159	149	144	119	101	98	72	57	35	30	30	15	11	9	0	-14	-18	-26	-29
Rutgers H3FR04P42	131	1,3	465	427	399	392	384	281	200	189	179	174	149	131	127	102	87	65	60	60	45	41	38	30	15	12	4	1
Grimo 208D	139		473	435	407	400	392	289	207	197	186	182	157	139	135	110	95	73	68	68	52	49	46	37	23	20	12	9
Butler	170	2,3	504	466	438	431	423	320	238	228	218	213	188	170	166	141	126	104	99	99	84	80	77	69	54	51	43	40
Geneva	182	15,23	515	477	450	443	435	331	250	240	229	225	200	181	178	152	138	115	110	110	95	92	89	80	66	62	55	51
Jefferson	210	1,3	544	506	478	471	463	360	278	268	258	253	228	210	206	181	166	144	139	139	124	120	117	109	94	91	83	80
Eta	214	11,26	548	510	483	476	468	364	283	272	262	258	232	214	211	185	170	148	143	143	128	124	122	113	99	95	87	84
Grimo 186M	251		585	547	519	512	504	401	319	309	299	294	269	251	247	222	207	185	180	180	165	161	158	150	135	132	124	121
Contorta	274	5,10	608	570	543	536	528	424	343	332	322	317	292	274	271	245	230	208	203	203	188	184	182	173	159	155	147	144

* 0 to 5 rating. Two year average data

** 0 to 5 rating. We have no EFB (yet). These ratings are third-hand hearsay

This table brings together a lot of information, and it needs some explanation. The red squares are self-pollination no-nos. All numbers in the grid are chill hours. Positive numbers mean pollen shed is early. We average about 80 chill hours per week here, so we could divide all of the numbers by 80 and change the matrix numbers to weeks. However, if we did that, it might not apply for other areas. In the lower left zone pollen is shed well before female emergence, so those combinations are shaded tan - useless. Likewise at the upper right, the pollen is too late. Green elements have onset of sexual activity timing within plus/minus 80 chill hours (one week for us).

The incompatibility gene s-alleles are a big story for another time. The short story is that s-alleles numbers cannot be a match (orange). The darker green combinations have both timing and known s-alleles right. There are surprisingly few. The last two years we have recorded and averaged catkin density. The EFB resistance numbers are my impressions, a mixture of science, hearsay, and advertizing hype. A commercial pollinator needs to (1) have the timing right, (2) produce plenty of catkins, (3) have high EFB resistance, and (4) avoid an s-allele collision. If the candidate pollinator fails any one of the four tests, it is commercially useless.

Choosing Pollination Parings:

From crop production results, let's say you decide to make a large planting of Yamhill. Looking across the Yamhill female row in the matrix, only Butler gets everything right, but Butler gets EFB and is a lousy catkin producer. Hall's is a week early, produces catkins, but gets some EFB. Dorris is -94 chill hours (about a week) late for Yamhill – good catkins - good EFB resistance – a winner! Yamhill females are receptive for several weeks so we might find a second pollinator to fill in a couple of weeks after Dorris. We should then be looking around -94 – 2 * 80 = -254. Marion has the timing we want, but unknown (to me) characteristics. Eta has the timing right, but has an s-allele 26 conflict. Both Geneva and Delta pass all four tests, with Geneva inching out Delta for catkin production and EFB resistance.

There are quite a few blanks in our potential pollinator properties. Some of the newer varieties are still in kindergarten here. It is okay for a hobbyist to try a combination with unknowns, but a commercial grower cannot be so cavalier. We have all of these pollinators, so there should be a pollen cloud here from G17 shed until Felix is spent. The latest female flowering producers here, Butler, Geneva, and Jefferson have no pollen for the later part of their receptive periods. "The game's afoot".

Choosing a good commercial pollinator is crucial and not simple. Our data is a little shaky but the overall method is a sound approach. Using numbers is the basis of science, better than "early", "mid", and "late". Way better than "buy two". People often ask me "What is a good pollinator for _______". They think I have memorized that matrix???