Horticulture Diagnostic Laboratory

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Using Growing Degree-Days for Insect Pest Management

When pest management is based on calendar timings, daily temperature is not taken into account. This can result in misleading information regarding current insect activity. Depending on weather conditions, insect development may vary from year to year by a few weeks, consequently predicting the proper time for control measures is difficult.

Insects, like plants and many other organisms, are dependent on temperature to develop. These organisms begin developing when the temperature exceeds the lower developmental threshold or base temperature. The rate of development increases as the temperature exceeds the base temperature and decreases as the temperature drops. Thus, insect development is accelerated during warm years and delayed during cooler years. Upper developmental thresholds, temperatures above which growth slows or ceases, are seldom used for insects since these thresholds are either not known, or they live in habitats where the upper threshold is seldom exceeded. Growing Degree-Days (GDD) takes into account the average daily temperature by calculating the number of heat units received. Thus, this system can be more accurate than the calendar method for estimating insect development and timing management strategies.

Several mathematical equations, can be used for calculating GDD based on minimum and maximum temperature. The easiest method is to average the daily maximum and minimum temperatures and subtract from-it the base temperature as follows:

$$\frac{\text{Max Temperature + Minimum Temperature}}{2} \quad \textbf{minus} \quad \textbf{Base Temperature} \quad = \quad \textbf{Daily GDD}$$

For each day that the average temperature is one degree above the base temperature, one degree-day accumulates. Depending on the species, the base temperature can vary. Cool weather organisms will have lower base temperatures while other types of organisms will have higher ones. For most situations though, a base temperature of 50^{o}F: is satisfactory. If a development prediction for a particular insect varies more than expected, using a lower base temperature could be necessary for that organism.

Biophenometers are instruments, which record the temperature every few minutes and accumulate the GDD as that portion of a 24-hour period. This is the most accurate way of calculating GDD but it does not retain minimum and maximum temperature data which would be important to calculate the most appropriate base temperature to use. When using GDD from other sources it is important to determine the method and 'base temperature used for calculations.

Ideally, taking temperature readings from the property or general area where the pest problem exists would be most accurate. When doing so several things should be considered. Minimum/maximum thermometers or any other devices used to detect temperature should be placed in a well ventilated, white weather shelter. The thermometer should not be exposed to direct sunlight. Shelters should be placed in the full sun, ideally in areas free from excessive radiant heat from driveways, sidewalks, buildings, etc. The accumulated GDD for various locations in Nassau and Suffolk Counties as well as New York City can be accessed from the Cornell Cooperative Extension – Suffolk County web site at the following web address http://ccesuffolk.org/growing-degree-days-gdd-/

Each day between March 1 and September 30 the daily GDD are calculated (using the above mentioned formula) and totaled to determine the accumulated GDD (**Table 1**). If the average temperature is below the base temperature, which would return a negative daily GDD number, just enter zero - 0 - for the day. For the system to work you must collect the maximum and minimum temperature every day. Early in the season the numbers will accumulate slowly but as the average daily temperature increases the GDD will accumulate faster.

Table 1. Example calculating growing degree-days (GDD) and accumulated growing degree-days (AGDD)

Date	Min	Max	Avg.	GDD	AGDD
March 1	30	40	35	0[1]	0
March 2	40	65	52.5	2.5	2.5
March 3	50	65	57.5	7.5	10

[1]Negative numbers are never added, enter zero.

The GDD for many insects are listed in (**Table 2**.) The time for pest control is expressed in a range of numbers beginning with first perceptible feeding injury and continuing until approximately the end of the insects' plant injury cycle. In other cases, ranges indicate optimum control periods. If more than one range of numbers appears, this is indicative of multiple generations and/or control- periods in an insect's life cycle. For example, Cooley spruce gall adelgid GDD (on spruce) are 22 - 81 and 1850 - 1950. This means the insect is active starting around 22 GDD and control measures can be implemented until approximately 81 GDD. Cooley spruce gall adelgid

also has another period during the growing season when controls may be effective and necessary. This period is between 1850 and 1950 GDD.

GDD should be used as a guide as to determine when pest control actions should be utilized. Monitoring should be employed at some point before the GDD number is reached to determine if a pest problem exists and if some type of control is warranted. Decisions as to whether or not to use control measures will be dependent upon such things as the level of damage or potential damage and the life stage of the insect. Treatment, if decided upon, would be timed to correspond with some point within the GDD range.

Table 2. A partial list of common insects found on woody trees and shrubs along with the stage of development and the coordinating growing degree-day (GDD) range of the particular insect pest. This information was provided by Dr. Warren T. Johnson, Department of Entomology, Cornell University and the *2006 PMG for Commercial Production and Maintenance of Trees and Shrubs*. Unless specified otherwise (i.e. Soil Treatment) the GDD ranges pertain to foliar applications.

Common Name	Scientific Name	Dormant[2]	Stage[3]	GDD Min[1]	GDD Max[1]
American plum borer	Euzophera semifuneralis		A	245	440
Aphids	Leaf and twig forms	*	E	7	120
			N,A	100	200
			N,A	100	250
			N,A	250	2800
Arborvitae leafminers	*Argyresthia spp.*		A	533	700
			L	150	260
			L	1800	2200
	Soil Treatment		L	1700	2100
Azalea leafminer	*Caloptilia azaleela*		L	450	800
			L	1260	1500
Azalea whitefly	*Pealius azaleae*		N,A	448	700
			N,A	1250	1500
			N,A	2032	2150
Bagworm	*Thyridopteryx ephemeraeformis*		L	600	900
Balsam gall midge	*Paradiplosis tumifex*		L	120	299
Balsam twig aphid	*Mindarus abietinus*		N	30	100
Birch leafminer	*Fenusa pusilla*		L	190	290
			L	530	700
Black Vine Weevil	*Otiorhynchus sulcatus*		A	148	400
Boxwood leafminer	*Monarthropalpus buxi*		A	350	600
			L	1200	2400
Boxwood mite	*Eurytetranychus buxi*		N,A	245	600
Boxwood psyllid	*Psylla buxi*		N	290	440
Bronze birch borer	*Agrilus anxius*		A	440	800
Cankerworms (inch worms)			L	148	290
Cooley spruce gall adelgid	*Adelges cooleyi* – on Douglas Fir		N,A	1500	1775
			N,A	120	190
Cooley spruce gall adelgid	*Adelges cooleyi* - on Spruce		N,A	1850	1950
			N,A	22	81
Cottony maple scale	*Pulvinaria innumerabilis*	*	C	802	1265
Cottony maple leaf scale	*Pulvinaria acericola*	*	C	802	1265
Cottony taxus scale	*Pulvinaria floccifera*		C	802	1388
		*	N	7	91
Dogwood borer	*Synanthedon scitula*		A	148	700
Eastern spruce gall adelgid	*Adelges abietis*		N	22	170
Eastern tent caterpillar	*Malacosma americanum*		L	90	190
Elongate hemlock scale	*Fiorinia externa*		C	360	700
		*	A	7	120
Euonymus scale	*Unaspis euonymi*		C	533	820
			C	1150	1388
		*	N	35	120
European fruit lecanium	*Parthenolecanium corni*		C	1266	1645
		*	N	35	145
European Pine Sawfly	*Neodiprion sertifer*		L	78	220
European pine shoot moth	*Rhyacionia buoliana*		L	34	121
			L	480	710

Common Name	Scientific Name	Dormant[2]	Stage[3]	Min[1]	Max[1]
European red mite	*Panonychus ulmi*		E,L,N	240	810
		*	E	7	58
Fall webworm	*Hyphantria cunea*		L	1266	1795
Fletcher scale	*Parthenolecanium fletcheri*		C	1029	1388
			C	2515	2800
			N	38	148
Fruitree leafroller	*Archips argyrospilus*		L	300	618
Gypsy moth	*Lymantria dispar*		L	90	448
Hemlock eriophyid (rust) mite	*Nalepella tsugifolia*	*	N,A	7	450
Hemlock scale	*Abgrallaspis ithacae*		C	1388	2154
		*	N	35	121
Hickory leaf stem gall phylloxera	*Phylloxera carvaecaulis*		N	91	246
Holly leafminer	*Phytomyza ilicis*		L,A	246	448
	Soil Treatment		L	192	290
Honeylocust spider mite	*Eotetranychus multidigituli*		E,L,N,A	912	1514
Honeylocust plant bug	*Diaphnocoris chlorionis*		N,A	58	246
Honeylocust pod gall midge	*Dasineura gleditschiae*		L	192	229
Honeylocust spider mite	*Platytetranychus multidigituli*		N,A	912	1514
Japanese beetle	*Popillia japonica*		A	1029	2154
Juniper scale	*Carulaspis juniperi*		C	707	1260
		*	N	22	148
Juniper webworm	*Dichomeris marginella*		L	1645	1917
Lace bugs	*Corythuca spp*		N,A	239	363
			N,A	1266	1544
	Stephanitis spp.		N,A	120+	
Leafhoppers	Several species		N,A	618	802
			N,A	1266	1514
			N,A	1917	2155
Lilac borer	*Podosesia syringae*		A	200	299
			A	400+	
Locust borer	*Magacyllene robiniae*		L,A	2271	2805
Magnolia scale	*Neolecanium cornuparvum*	*	N	7	35
Mountain ash sawfly	*Pristiphora geniculata*		L	448	707
Nantucket pine tip moth	*Rhyacionia frustrana*		L	121	448
			L	1514	1917
Native holly leafminer	*Phytomyza iliciola*		L	192	298
			L	1029	1266
Oak blotch leafminers	*Cameraria spp., Tischeria spp.*		L	533	912
Oak leaftier	*Croesia semipurpurana*		L	7	35
Oak skeletonizer	*Bucculatrix ainsliella*		L	448	707
			L	1798	2155
Oak spider mite	*Oligonychus bicolor*		L,N	802	1266
Oystershell scale	*Lepidosaphes ulmi*		C	363	707
		*	E	7	91
Peachtree borer	*Synanthedon exitiosa*		L	1500	1800
Pine bark adelgid	*Pineus strobi*		C	58	618
		*	C	22	58
Pine eriophyid mites	*Eriophyidae*		N,A	298	533
Pine needle miner	*Exoteleia pinifoliella*		L,A	448	802
Pine needle scale	*Chionaspis pinifoliae*		C	1290	1917
			C	298	448
		*	E	98	248
Pine sawflies	*Diprion spp., Neodiprion spp.*		L	246	1388
Pine spittlebugs	*Aphrophora cribrata*		N	148	298
	A. saratogensis		N	148	298
Pine webworm	*Tetralopha robustella*		L	802	2000
Pitch twig moth	*Petrova comstockiana*		L	298	707
Privet rust mite	*Aculus ligustri*		L,N,A	1266	1515
			L,N,A	298	802

Common Name	Scientific Name	Dormant[2]	Stage[3]	Min[1]	Max[1]
Privet thrips	*Dendrothrips ornatus*		L,A	192	618
			L,A	1029	1266
Rhododendron borer	*Synanthedon rhododendri*		A	533	707
			A	192	298
Rhododendron gall midge	*Clinodiplosis rhododendri*		L	192	363
Rhododendron stem borer	*Oberea myops*		A	298	802
Rose chafer	*Macrodactylus subspinosus*		A	448	802
Roundheaded apple tree borer	*Saperda candida*		A	802	1029
			A	1514	1798
Rust mites	*Eriophyidae*		L,N,A	1644	2033
			L,N,A	533	802
Southern red mite	*Oligonychus ilicis*		N,A	246	363
			N,A	618	802
			N,A	2500	2700
		*	E	7	91
Spruce needle miner	*Endothenia albolineane*		L	448	802
Spruce spider mite	*Oligonychus ununguis*	*	E	7	121
			N,A	192	363
			N,A	2375	2806
Taxus bud mite	*Cedidophyopsis psilaspis*		N,A	148	448
			N,A	707	912
Taxus mealybug	*Dysmicoccus wistariae*		N	246	618
		*	N	7	91
Tuliptree aphid	*Macrosiphum liriodendri*		N,A	1151	1514
			N,A	1917	2033
Tuliptree scale	*Toumeyella liriodendri*		C	2032	2629
		*	N	12	121
Tussock moth	*Orgyia leucostigma*		L	192	298
			L	2145	2516
Twobanded Japanese weevil	*Callirhopalus bifasciatus*		A	1644	2271
Twospotted spider mite	*Tetranychus urticae*		N,A	363	618
			A	1300	2000
White pine aphid	*Cinara strobi*		A	1917	2271
			N	121	246
		*	E	7	121
White pine weevil	*Pissodes strobi*		A	7	58
White prunicola scale	*Pseudaulacaspis prinicola*		C	707	1151
			E	35	145
Woolly beech aphids	*Grylloprociphilus imbricator*		N,A	363	707
	Phyllaphis fagi		N,A	363	707
Woolly elm aphid	*Erisoma americanum*		N	121	246
Zimmerman pine moth	*Dioryctria zimmermani*		L	121	246
			A	1917	2154

[1]If more than one range of numbers appears this is indicative of multiple generations and/or control periods in an insect's life cycle.

[2]If an asterisk (*) appears in this column, then a treatment with an appropriate insecticide may be warranted during the dormant season (before bud break) providing a pest problem is present. For specific guidelines homeowners may refer to the current version of *Part II Guide to Pest Management around the Home – Pesticide Guidelines*, Cornell Misc. Bulletin S74II and commercial pesticide applicators can refer to the current version of *Pest Management Guidelines for Commercial Production and Maintenance of Trees and Shrubs.*

[3]A = adult; C = crawler; E = egg; L = larvae; N = nymph.

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