Correlation of Growing Degree Days and the Timing of Cuttings©

H. William Barnes
Lorax Farms LLC, Warrington, Pennsylvania 18976 U.S.A.

INTRODUCTION

The proper timing for taking cuttings is essential for good propagation results. It is well known that some plants have very narrow time frames in which cuttings can be taken with any degree of success. Some obvious examples are *Euonymous alatus* and *Syringa vulgaris;* if the cutting wood is allowed to mature beyond a certain point, the percentage of rooted cuttings declines greatly. Alternatively, if cuttings of some plants are taken too early in the season, carbohydrates and essential cellular components are not in sufficient quantity to allow for good rooting. Therefore it is critical that the time frame for taking cuttings be watched closely. Violate the time frame, and deleterious results can be quickly found. For instance, *Scabiosa* and asters make two types of growth: one is strictly vegetative and the other gives rise to flowering. Cuttings taken of flowering shoots will often root, flower, and then die; they will not set the needed basal rosettes or buds that will bring the plant through as a perennial. One type of cutting essentially makes it an annual; the other type keeps the perennial characteristics intact.

This quest for the proper timing of cuttings for propagation depends heavily on a variety of tools for success. Calendars immediately come to mind but fall short of delivering consistent results. Weather conditions such as rain, drought, late frosts, early frosts, and a host of events that cannot be readily controlled have considerable influence. Calendars are useful as a starting place, but with many plants things have to be more quantitative. This technique has its drawbacks, though, in that plant development can vary from one year to the next as well as change based upon specific localities (Wunderground.com, 2005). Basing pesticide and chemical applications on a particular week of a calendar is not adequate. Orton and Green (1999) hit upon a good idea with their tome on correlating plant pests with the bloom time and other phenological expressions of plant growth. Their system worked by associating specific pests with specific activities of plants in a large area where it is known that a certain plant such as *Amelanchier canadensis* will bloom or leaf out at the same time period that a specific pest such as Gypsy moth begins to hatch. This technique goes back in time because A. *canadensis* is known as "shadbush" because it blooms at the same time that the shad (a fish) starts their annual migration up the rivers of the East Coast. Their technique has some application in plant propagation, but it is not precise and only gives a general approximation as to when to look for the proper cuttings.

Growing degree days (GDD) came along as a means of determining heat units during a given season. The heating and air conditioning industry has used it for years to determine energy requirements for any given time period. The agricultural industry tied onto the concept and applied it to agricultural crops such as corn and sugar beets for both the timing of crop harvest (Eckert, 2005; Holen and Dexter, 1996) and for insect and pest control measures (University of Massachusetts Extension, 2005; Wunderground.com, 2005). As a result of such work it did not take long for horticulturists to look at GDD for pest control measures and then at GDD as plant status indicators (Annenberg Media, 2001; Griffith and Nelson, 2000).

Specifically GDD is a means of establishing a cumulative measure of the heat units during a specific time period. Heat units are best and most simply determined by looking directly at temperature. Temperature (Holen and Dexter, 1996) is considered the main factor that influences the rates of plant growth, although others such as moisture levels, day length, and light qualities also have secondary affects. GDD is the simplest of a number of models predicting plant growth and development and GDD is versatile enough to be adapted to specific plants if the situation calls for it.

Growing degree days can be calculated by a variety of ways but 50/86 formula is the most common and easiest to implement (Pacific Northwest Co-Operative Agricultural Weather Network [Agrimet], 2005; University of Massachusetts Extension, 2005; Eckert, 2005) and is best illustrated by the formula: 50 "F is the base temperature, 86 "F is the upper limit.

Example 1. High temperature is 80 "F, low temperature is 60 "F, base temperature is selected to be 50 "F.

$$[(80 + 60)/2] - 50 = 5 \text{ GDD}$$

Adjustments are necessary when temperatures exceed 86 "F or fall below 50 "F. For instance, a high of 95 "F is converted to 86 "F because 86 °F is the upper limit. A low of 45 "F is used as 50 "F. If a negative number is encountered as a GDD it is regarded as 0 GDD (University of Massachusetts Extension, 2005).

Example 2. High temperature is 95 "F and the low is 75 "F, the GDD is calculated as

$$[(86 + 75)/2] - 50 = 30.5 \text{ rounded to nearest number of 31 GDD}$$

Once a given date is selected as the starting point, then each GDD is added to the previous day's total number so that by the fall of the year it is not unusual to see accumulated GDDs or AGDD as 3000 or above.

The base numbers 86 and 50 are derived from the expectation that most plants in the Northeastern U.S.A. begin growth at an average of 50 "F and will generally grow well until temperatures start to exceed 86 "F. It is thought that temperatures past 86 "F do little to add to the growth rate, and in some cases growth rates may stall at 90 "F or better (Pacific Northwest Co-Operative Agricultural Weather Network [Agrimet], 2005; University of Massachusetts Extension, 2005; Wunderground.com, 2005). The base lines can be tailored to meet specific plant requirements, for instance if someone is studying skunk cabbage *(Lysichiton americanus)* or tulips (Annenberg Media, 2001) then the lower base should be adjusted to 40°F and the upper limit should perhaps be changed as well to a lower temperature such as 70 "F to be more applicable to the given plant. Spring ephemerals need special consideration, and the base temperatures can be lowered to 34 "F to compensate for their unique growth patterns (Orton and Greene, 1999).

Growing degree days can also be expressed in Centigrade temperature scales with base lines being adjusted to meet the centigrade equivalent, i.e., 10 °C and 30 °C being close approximations of the 50/86 settings (Natural Resources Canada, 2005).

The concept of GDD has been further integrated into the horticultural world where GDD is used to note differences in cultivars (University of Massachusetts Extension, 2005) and their bloom times with plants as varied as corn (Eckert, 2005) sugar beets (Orton and Greene, 1999), and fescue grasses (Griffith and Nelson, 2000). If seed set, nitrogen metabolism, leaf stage development, flowering, and similar phenological traits can be followed by GDD, then it seems realistic to think that something such as the propensity for rooting in cuttings can be deduced as well.

This study was implemented to test this hypothesis and make conclusions based upon three different woody plant species with three different rooting thresholds.

METHODS

Three species of woody plants were selected to determine if GDD can be applied to the rooting of cuttings. Rooting proficiency ranged from easy to difficult, with *Hydrangea paniculata* 'Tardiva' being easiest, *Syringa josikaea* a moderate rooter, and *Magnolia* 'Betty' the most difficult. The experiment was started on 7 June and progressed to 19 July for the taking of cuttings and 20 Aug. for the evaluation of cuttings.

Cuttings were stuck under mist, 10 sec/10 min, in a greenhouse with supplemental bottom heat set at 70 "F. Cuttings were direct stuck in 2'/4-inch pots with a substrate of 1 Metromix 510: 1 perlite (v/v). Hormone applications were consistent throughout the trial with Dip *'N* Grow at 1:15 dilution rate (600ppm IBA/300 ppm NAA) for *H. paniculata* `Tardiva', 1:10 dilution rate (1000 ppm IBA/500 ppm NAA) for *S. josikaea,* and 0.8% IBA powder for M. 'Betty'. All cuttings except for *H. paniculata* 'Tardiva' were wounded.

Cutting rooting status was determined by pull and tug with visual inspection for root emersion from the bottom of the pot as a definitive marker.

Growing degree data was obtained via the Internet by a subscription service through Penn State Extension Service. Specific data was available from 10 to 12 sites depending upon those reporting for a given week. To concentrate the data, four sites were selected for a physical proximity to the test site. Those that were outside of a 12-air-mile radius were eliminated. The GDD was tabulated by taking an average of the four sites. Figures were included for base temperatures of 50, 47, 43, and 40 °F and a soil base temperature of 32 °F, listed respectively as B50, B47, B43, B40, and soil B32.

RESULTS AND DISCUSSION

Table 1 shows data concerning cutting days to rooting, actual number rooted, and rooting percentages for all three species and collection and evaluation dates. Table

Table 1. Growing degree data for specific dates.

	Base temperature*				
Date	B50	B47	B43	B40	B32
6/07/05	757	935	1205	1435	2135
6/22/05	1062	1292	1626	1925	2739
6/24/05	1110	1340	1674	1973	2789
6/26/05	1152	1386	1728	2031	2861
7/13/05	1413	1698	2112	2448	3432
7/18/05	1553	1838	2252	2588	3572
7/19/05	1582	1867	2281	2617	3601
8/01105	2168	2506	2990	3380	4501.
8/20/05	2528	2954	3524	3977	5250

* Base temperatures of 50, 47, 43, and 40 °F and a soil base temperature of 32 °F, listed respectively as B50, B47, B43, B40, and soil B32.

Table 2. Rooting of three taxa.

	Timing and removal data					
Species	Date stuck	Date removed	Total stuck	Days to rooting	Rooted (no.)	Rooted (%)
*Hydrangea paniculata T*ardiva'	06/07	06/22	32	15	30	94
	06/24	07/13	32	20	32	100
	07/19	08/01	32	14	32	100
Syringa josikaea	06/07	06/26	32	19	30	94
	06/24	07/18	32	25	28	88
	07/19	08/20	32	33	32	100
Magnolia 'Betty'	06/07	07/18	32	42	28	88
	06/24	08/01	32	39	15	47
	07/19	08/20	32	33*	1	3

*Cuttings pulled due to leaf drop and overall death or rotting.

2 shows the rooting data for individual species responses with respect to the AGDD at the time of sticking. Table 3 shows a comparison of growing degree days (GDD), days to root, and rooting percentage. There were no significant differences in rooting percentages for either *H. paniculata* 'Tardiva' and *S. josikaea* with respect to an increasing AGDD. However, with the case of *S. josikaea*, there was a noticeable difference with respect to the total number of days it took the cuttings to root. With AGDD of 757, rooting time for *S. josiakea* was 19 days, which then increased to 25 days at 1110 AGDD and climbed again to 33 days for AGDD of 1582. This is sig-

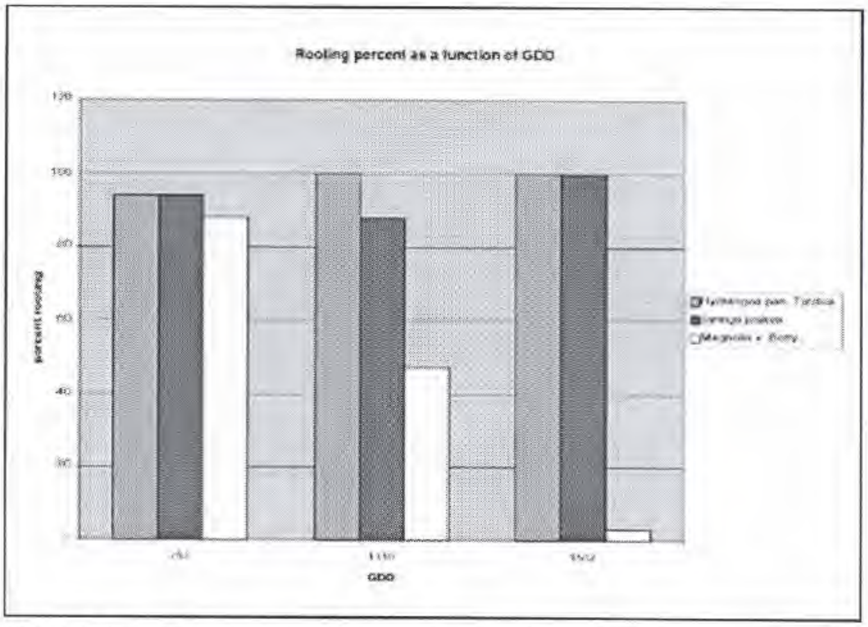

Figure 1. Rooting percentage as a function of growing degree-days.

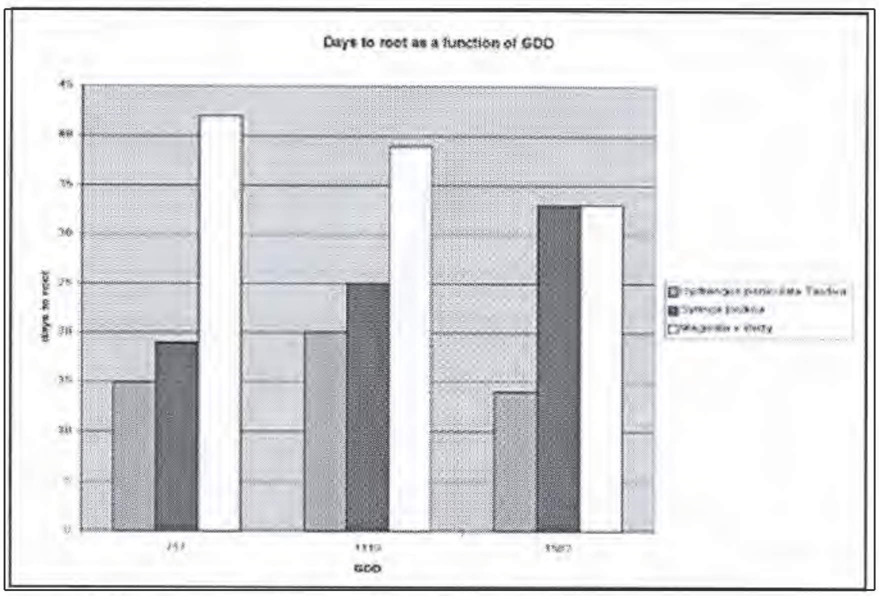

Figure 2. Days to root as a function of growing degree-days.

Table 3. Comparison of growing degree days (ODD), days to root, and rooting percentage.

06/07/05	GDD B50 (757)	Days to root	Rooting (%)
	Hydrangea paniculata. `Tardiva'	15	94
	Syringa josikaea	19	94
	Magnolia 'Betty'	42	88
06/24/05	GDD B50 (1110)		
	Hydrangea paniculata `Tardiva'	20	100
	Syringa josikaea	25	88
	Magnolia 'Betty'	39	47
07/19/05	GDD B50 (1582)		
	Hydrangea paniculata `Tardiva'	14	100
	Syringa josikaea	33	100
	Magnolia 'Betty'	33*	3

* Leaf drop rendered cuttings inviable.

nificant because cuttings taken early on an AGDD of 757 rooted well and quickly, which is valuable because it increases the production potential over the course of time; i.e., the quicker cuttings root, the faster valuable greenhouse space becomes available again.

When *M.* 'Betty' is considered, number of days to root does not seem to be a factor; however, rooting percentages did change by decreasing with an increase in AGDD going from a high of 88% at AGDD of 757 and declinin g to 3% when taken with AGDD of 1582. The graphic representations of the decline in percentages as a function of AGDD can be readily seen in Fig. 1 and the change in rooting time can be seen in Fig. 2.

Some general conclusions can be drawn from this data. Number one is that using AGDD as a tool to determine rooting potential has merits, but it is not always needed and, with easy-to-root plants such as *H. paniculata* `Tardiva', the time for data gathering and processing has little value unless extended far into the fall of the year to determine exactly when cuttings can no longer be taken with any degree of success. With respect to plants that root well it is surprising to see that an AGDD can detect changes in rooting responses based upon the number of days it takes to achieve a satisfactorily rooted cutting. In these cases an AGDD might be warranted to establish a protocol for future reference that could be used for scheduling particular plants so that those that have been shown to root slowly with advancing AGDD can be stuck earlier and those that show no response can be stuck later in the summer season. For instance, for a limited propagation space it would be better to stick the *S. josikaea* first, obtain a good crop, and then stick the *H. paniculata* `Tardiva', thereby maximizing potential rooting space. AGDD can be used to detect declines in rooting response in more difficult to root. plants, such as was found in *M.* 'Betty'. It is clear that cuttings of that plant taken at an AGDD of 757 performed well, while those taken at an AGDD of 1582 were woefully inadequate.

A practical suggestion would be to examine particular cutting profiles and isolate those plants that normally root poorly or slowly. Looking at them specifically with a critical study such as AGDD can establish a base line of when to take these cuttings for maximum results. Ideally an AGDD study should be carried out for 2 or 3 years to compensate for the vicissitudes of climate variation. But, once a thorough history has been compiled for a particular difficult-to-root plant the resultant data can serve as a readily available reference. Knowing that a plant like M. 'Betty' roots best around when the AGDD is 757 could prove to be invaluable for the production of that plant on a profitable basis. Many plants have very short time frames for successful cutting propagation, and a program based upon an AGDD study with very narrow variations of AGDD such as 10% might prove to be useful for clearly identifying a start and stop time.

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