## Crop Scheduling with Computers

Detailed crop planning is one of the basic tools of a successful nursery manager. Growing schedules provide a good way to record the various steps in crop production and how they relate in time. They also serve as visual time charts of the type of propagation environment that must be maintained, the various cultural operations that must be done, and the amount of labor that will be needed from seed preparation to seedling shipment.

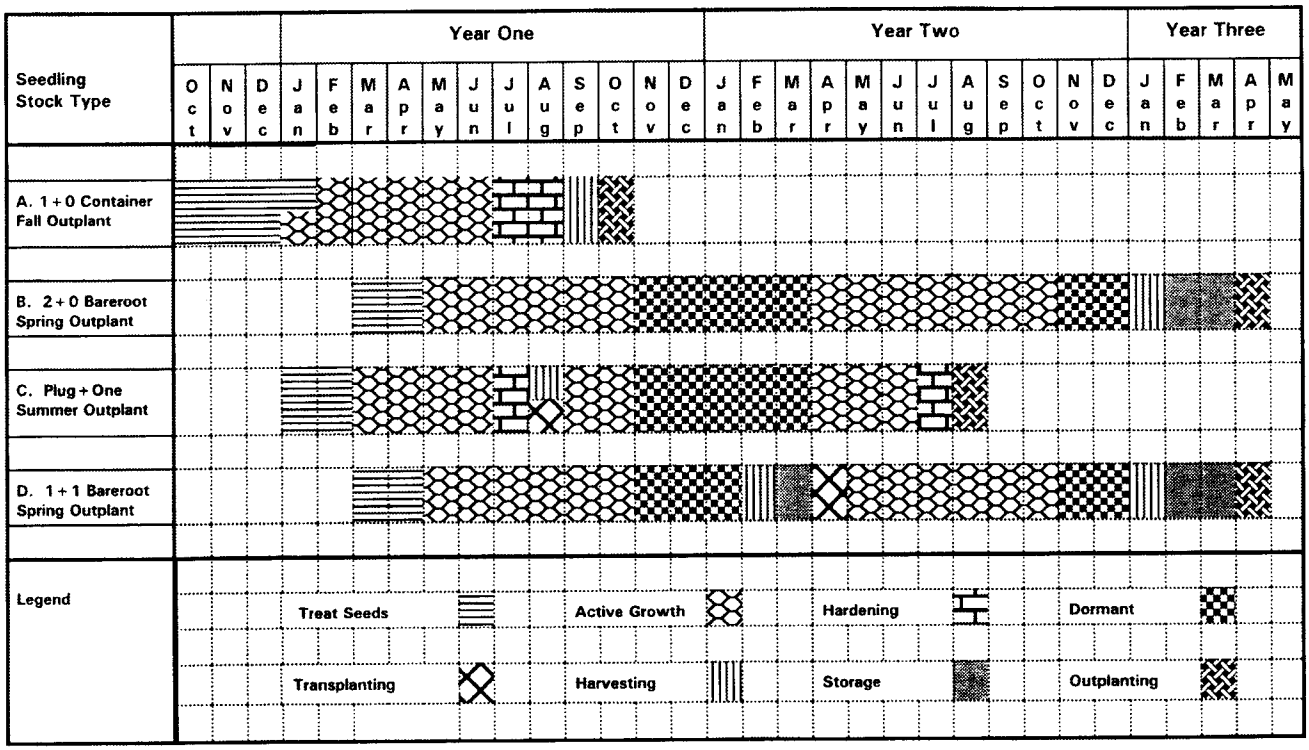
The format for a growing schedule can be as simple as a handmade chart on graph paper or as detailed as a commercial scheduling calendar. If you haven't already found out, growing schedules are easy to construct with modern word processing or spreadsheet computer software programs. The sample schedules in this article were developed in Corel WordPerfect 8.0® in a couple of hours using the "Table QuickCreate" feature. Microsoft Word' and other programs have similar capabilities. Not only are computer growing schedules easy to design, but multiple hard copies can be printed and given to workers or posted around the nursery. In addition, computer files are easy to store to make permanent records.

There are many different types of growing schedules but I have come up with three: **Crop Production schedules, Space and Facilities schedules,** and **Cultural schedules.** For each, the format is basically the same—time is plotted in columns along the top of the chart with cultural factors in rows along the left side. Time intervals in the columns will vary from weeks, to months, to years depending on which factors you are tracking and the amount of detail that you want. All growing schedules are filled-out in the same way-backwards. Start with the date that the crop must be shipped and work backwards, blocking out sections of time for the various operations until you reach the date at which the crop must be started. Once the overall time frame of the growing schedule is complete, then information can be easily typed into the cells. Visual enhancements like background shading and special fill designs make the information even easier to illustrate and understand.

**Crop Production schedules.** These long-term growing schedules help visualize the "big picture". Crop production schedules typically are designed on a month-to-month time scale, and include all phases of nursery production from presowing seed treatments to outplanting (Table 1). Thus, crop production schedules often cover more than one year.

Because many nursery customers fail to appreciate how long it really takes to grow forest and conservation species, crop production schedules are particularly useful for explaining all the various steps in the nursery process

**Table 1. Crop production schedules for four typical stock types with different outplanting seasons**



and the amount of time involved in each. For example, a crop production schedule will illustrate that it is necessary to ship seeds to the nursery several months prior to sowing, especially if germination tests and presowing seed treatments are necessary. These growing schedules are also useful in illustrating how different seedling stock types are produced, the time required to grow them, and when each would be available for outplanting (Table 1).

## Space and Facilities schedules.

This second type of growing schedule is organized by months and goes for the entire crop cycle. Space and facilities schedules are particularly useful in container nurseries that produce multiple crops per year or move crops between various growing facilities. However, they can also be used for bareroot crops to show the sequence of the various cultural practices through the growing season. Combined with site maps, space and facilities schedules give a comprehensive picture of how much area each crop will require in the greenhouse or seedbed. In addition, they help schedule time and allocate space in processing and storage facilities as well as the required labor, equipment, and supplies.

For example, consider a space and facilities schedule for a crop of western white pine which will be grown in a greenhouse for fall outplanting (Table 2). Note that seeds must be received at the nursery by September of the year prior to sowing because this species requires an unusually long 90 to 120-day cold, moist stratification treatment. Because it is a one-year crop, the seeds must be sown in mid-January to allow enough time for seedlings to meet target specifications by the shipping date. This sowing is significantly earlier than normal and the space and facilities schedule helps illustrate this requirement. These schedules also show that workers will be needed during late fall to clean used containers in the headhouse and to sterilize the greenhouse before sowing. A sowing line must be assembled during early January and then crews will be needed again in late February for thinning. A small crew will be needed in July to move the seedlings from the greenhouse to the shadehouse. The final labor requirement will be in September when the packing line needs to be assembled so that seedlings can be graded, packed, and shipped during the fall outplanting window

**Table 2. Space and facilities schedules show location, labor, equipment and supplies for a specific crop; in this case, a 1+0 container crop for fall outplanting (See #A in Table 1)**

| YEAR ONE | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
| Seedling Growth Stage | | | | | | | | | | Seed Stratification | | |
| Facility Space | | | | | | | | | | Refrigerator and Headhouse | | |
| Labor Needs | | | | | | | | | | Clean Containers and Greenhouse | | |
| Equipment and Supplies | | | | | | | | | Seed | | Growing Media and Fertilizer | |

| YEAR TWO | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
| Seedling Growth Stage | Establishment Phase | | Rapid Growth Phase | | | | Hardening Phase | | Harvest | Outplant | | |
| Facility Space Requirements | Greenhouse | | | | | | | Shadehouse | | | | |
| Labor Needs | Sowing | | Thinning | | | | Moving | | Packing | Loading | | |
| Equipment and Supplies Required | Sowing Line | | | | | | Conveyor | | Packing Line | Conveyor | | |

(Table 2). This visual scheduling of equipment and labor needs can help anticipate and solve problems before they occur. Space and facilities schedules also make scheduling multiple greenhouse crops much simpler.

**Cultural schedules.** With weeks as the basic unit of time, cultural schedules are the most detailed of the growing schedules. Even though cultural schedules may differ slightly in format, there are several common factors that should be included: the month and week, the number of weeks from sowing, the propagation environment, target seedling specifications, and the growth stage at that particular time in the crop cycle (Tables 3A and 3B). Following this general information, the schedules can list specific cultural processes and operations, such as thinning or seedling inventory, as well as the number of workers that will be needed. Finally, each of the potentially growth-limiting environmental factors should be listed along with any pertinent information about how they will be controlled and monitored.

Cultural schedules will be much simpler for bareroot nurseries because growers have control over fewer factors. As an example, let's look at a four-week segment of a cultural schedule for a 1+1 transplant crop. (Note that this Cultural Schedule can be linked to the Crop Production Schedule-see #D in (Table I ). Besides the general descriptive information, irrigation and fertilization are the principal limiting factors that can be controlled in a bareroot facility (Table 3A). In this example, the cultural schedule can be used to document the amount and type of fertilizer to be incorporated into the soil before the seedlings are transplanted and how much water to supply through irrigation. In addition, the schedule can highlight potential disease problems and the timing and application rate for pesticides.

A cultural schedule will typically be more detailed for a container nursery. Let's look at a four-week schedule for a crop of white spruce grown in a shelterhouse at the change between the

**Table 3a. Four-week segment of a cultural schedule for a 1+1 bareroot nursery crop illustrating the time of transplanting (See #D in Table 1)**

Customer: T. Planter  Species: Douglas-Fir  Seed Source: Zone 072 - 1000f1

Target Specifications:  Height: 18 in. (14 to 22)  Stem Diameter: 7.0mm (>6.0)

| Month and Week | 4/26-5/2 | 5/3-5/9 | | 5/10-5/16 | 5/17-5/23 |
|---|---|---|---|---|---|
| Weeks from Sowing | 54 | 55 | | 56 | 57 |
| Propagation Environment | Refrigerated Storage | | | Transplant Bed | |
| Seedling Growth Stage | Dormant | | | Active Growth | |
| Cultural Activities | Form Transplant Bed | | Transplanting | | |
| Irrigation: Amount & Frequency | | | | Irrigate as Needed to maintain Field Capacity | |
| Fertilization: N Rate & Frequency | Incorporate 18-46-0 at 100lbs/ac into transplant bed | | | | |
| Pest Management: Monitoring Pesticide and Rate | Check for Botrytis storage mold | | | Apply Pre-emergence Herbicide | |

**Table 3B. Four-week segment of a cultural schedule for a container nursery crop illustrating the change from the Rapid Growth Phase to the Hardening Phase**

Customer: T. Planter  Species: White Spruce  Seed Source: Zone 864-300m.

Target Specifications:  Height: 17cm (12 to 25)  Stem Diameter: 3.0mm (>2.4)

| Month and Week | 6/27-7/3 | 7/4-7/10 | | 7/11-7/17 | 7/18-7/24 |
|---|---|---|---|---|---|
| Weeks from Sowing | 19 | 20 | | 21 | 22 |
| Propagation Environment | Shelterhouse | | | | |
| Seedling Growth Stage | Rapid Growth Phase | | | Hardening Phase-Dormancy Induction | |
| Cultural Processes and Operations | Raise sides in good weather | | | Raise sides Permanently | |
| Labor: Crew Size (People Hours) | | | | | |
| Temperature: Day Setpoint(Range) | 22°C (20 to 24 °C) | | | Ambient | |
| Temperature: Night Setpoint (Range) | 18°C (16 to 20°C) | | | Ambient | |
| Relative Humidity: Setpoint (Range) | 50 to 80% | | | Ambient | |
| Light: Ambient | Full Sunlight | | Change Environment | Full Sunlight | |
| Light: Photoperiod Intensity & Duration | 20 hour Photoperiod HPS@250 to 400 lux | | | None-Shut off Lights | |
| Carbon Dioxide: Rate & Timing | Yes-800 to 1000 ppm when sides are down | | | None-Shut off Lights | |
| Irrigation: Amount & Frequency | Wet-Dry Cycle Irrigate at 80% wet block weight | | | Mild Water Stress-Irrigate at 75% wet block weight | |
| Fertilization: N Rate & Frequency | Fertigation at 150 ppm N with each irrigation | | | Fertigation at 50 ppm N with each irrigation | |
| Pest Management: Monitoring Pesticide and Rate | Walk through every week | | | Walk through twice each week-Be alert for Botrytis | |

Rapid Growth Phase and the Hardening Phase (Table 3B). Note that some environmental factors will be listed as discrete numbers whereas others should be listed as ranges. While the sides of the shelterhouse are down, temperatures are specified as discrete temperature **"set points"** which correspond to the setting on the thermostat or environmental control computer. Because it is more difficult to control precisely and is not as critical to seedling growth, relative humidity is listed only as an **"allowable range".** Note that both temperature and relative humidity are not controlled **("ambient")** after the Hardening Phase is initiated and the sides of the shelterhouse are raised permanently. Other cultural information is recorded according to the nature of the environmental factor and the ability to control it. For example, the carbon dioxide generators are operated only when the sides of the structure are down (Table 3B). As you can see from this example, cultural schedules for container nurseries can be as detailed as you want to make them.

Cultural schedules are valuable not only for planning and reference while the crop is growing, but also can be used to document the actual time and environmental conditions that were used to produce the crop. These "planned" and "actual" records can then be consulted and modified for subsequent crops and, because they are computer-generated, are much easier to store and retrieve than traditional planning calendars.

**Summary and Recommendations.** Standard word processing or spreadsheet software can be used to construct growing schedules that make it easy to plan nursery crops. Different formats can be designed to fit time frames from weeks to years depending on the objectives. Because they are based around the limiting factors concept, growing schedules can be customized to serve the needs of both bareroot and container nurseries. Although they will vary from nursery to nursery, the important point is not the growing schedule format itself but rather the fact that nursery managers have a detailed plan of action before starting the crop.

In addition, their utility extends beyond the current crop as actual conditions can be recorded along side planned conditions and this information used to fine-tune schedules for future crops. These accumulated cultural records can provide a wealth of information for years to come.

**Source:**

Landis, T.D.; Tinus, R.W.; Barnett, J.P. 1998. Seedling Propagation Vol. 6. The Container Tree Nursery Manual. Agric. Handbk. 674. Washington, DC: U.S. Department of Agriculture, Forest Service. In Press.