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CONTAINER (PLUG) STOCK HANDLING

Introduction

This paper will review current container seedling handling practices and the physiological principles behind the recommended guidelines. As nursery growers, we have all invested a lot of time and effort in ensuring that quality seedlings leave our nurseries in optimum condition. Our job is not done once the seedlings leave the nursery gate. All stages of the reforestation process are important, as poor stock handling practices once the seedlings leave the nursery can destroy all of our previous efforts. It is to our benefit to ensure that planted seedlings establish quickly and become free growing plantations as soon as possible. Nowadays, everyone involved in the reforestation process is under increasing pressure to be cost efficient. One way that we can ensure that the seedlings' needs are met is by working with the planting contractors, so that we both understand each others' concerns. Stock handling guidelines have been developed by taking into account the biological needs of the seedlings, along with consideration of various logistic and economic constraints. However, guidelines should not be inflexible, but need to be reviewed for each particular situation. As well, they should be periodically evaluated as various stages of the system change and/or new knowledge becomes available.

If we are to continually improve reforestation success, careful record keeping is important, so that the causes of poor or mediocre plantation establishment can be identified. Although the cause of poor seedling performance may be traced back to a single, easily identifiable event; poor performance due to small, repeated stresses over time is difficult to detect. Seedling stress is generally thought of as being cumulative, such that once weakened, a seedling's resistance to further stress and its ability to recover is compromised. However, not all stresses accumulate in the same way. Whereas damage from desiccation and moderate temperatures seem to accumulate, damage due to rough handling and very high or very low temperatures occurs rapidly once a critical threshold is reached[7]. Once stressed or damaged, the seedling triggers a survival response, shifting its resources from growth to repair and adjustment. The amount of stress required to cause a detectable reduction in growth is related to the site and weather conditions the seedling experiences after planting. While a certain stress may be too subtle to effect growth on a rich site, the same level of stress may reduce growth and even survival on a harsh site. Seedling stock type and physiological condition at time of planting will also have an influence, as large seedlings with greater reserves and more woody tissue may have more resistance to certain stresses.

Packaging

Proper stock handling begins in the nursery, with the transport of the seedlings from the growing to the lifting area. During lifting, seedling bundles should be formed and aligned neatly so that there are no stray seedlings sticking out the top or bottom of the bundle, which may dry out and/or be crushed during storage. From an economic point of view, the aim is to maximize the number of trees per box, so that less space is required for storage and shipping. To minimize handling once

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in the field, hot lift stock should be packaged upright whenever possible. If hot lift stock has to be laid down, only the amount of seedlings that can easily be stood up should be packed in the box. Heavier boxes also increase the likelihood of rough handling. Box strength is also very important, as it is very likely that a particular box of seedlings will be handled many times in its journey from nursery to planting site.

Transportation

Previous research on bareroot seedlings has shown that dropping boxes of seedlings from various heights resulted in growth reductions after planting. It has since been suggested that many small shocks are not as damaging as a few large ones, and that the maximum force experienced by the plant is more important. Current stock handling guidelines dictate that seedlings be handled with care at all times. Cartons are not to be thrown or dropped, nor laid on their side, which may cause bundles to fall out and sit on top of the other seedlings. Cartons should also be staged down at the rear if the trailer is not full. In general, ensuring cartons are well secured during shipping reduces the potential for seedling stress. Recent studies in which container seedlings just thawed from frozen storage were dropped repeatedly, reported no reduction in their subsequent field performance. However, dropping hot lift seedlings reduced their growth once planted. One reason for the discrepancy between the various studies is the comparison of bareroot to container seedlings. Container seedlings have more protection against various stresses because of the buffering capacity of the growing medium in the seedling plug. An in-depth study examining current operational stock handling and transportation procedures used in B.C. and Alberta reported that mechanical shocks resulting from our current practices are not normally sufficient to reduce seedling survival or growth. This should not be interpreted as a call to relax our guidelines, but as evidence that our current stock handling guidelines are effective.

Depending on trailer capacity and box size, seedling boxes are typically stacked seven boxes across, five high (hot lift stock is not usually stacked as high). Some sort of dunnage such as plywood is commonly used between the layers of boxes to stabilize the load and avoid boxes from being crushed, especially on off-highway trips. Seedling boxes should be stacked in the reefer in such a way that space is left between some of the boxes and the bulkhead at the front of the reefer for proper air circulation. Without proper air circulation, there can be large differences in box temperatures throughout the reefer. This is especially important for hot lift stock, which is actively respiring and creating its own heat, thus must be cooled or internal box temperatures will rise quickly.

It is generally accepted that plants subject to warm temperatures increase their respiration rates, resulting in a cycle of increased heat production followed by further increases in respiration. In a closed seedling box, this results in a depletion of seedling carbohydrates which are not able to be replenished via photosynthesis. The appropriate shipping temperature varies somewhat depending on the type of stock being shipped (i.e. spring plant vs. summer plant), although the general recommendations are to keep them cool. Again, the length of time that seedlings must be exposed to warm temperatures to cause a noticeable reduction in field performance will depend on many factors. For example, box temperatures of up to 20ºC for up to four days after thawing were found to have no measurable effect on the survival, growth, or ability of the buds to flush in interior spruce seedlings planted into a hand weeded, farm-field site.

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A successful hot lift planting program requires good communication between the forester, nursery, planting contractor, and trucking company. As shipping hot lift stock involves dealing with actively respiring tissue, the potential for overheating is much greater than when shipping spring plant stock. All hot lifted seedlings should be irrigated thoroughly prior to lifting and packaging, thus a minimum half day is required to allow the excess moisture to drain from the plug prior to lifting. Refrigerated vans should be used, with the reefer temperatures set to maintain internal box temperatures of approximately 10ºC. To avoid overheating, freshly lifted stock can be precooled by placing seedling boxes in a cooler set at 4ºC for 4-6 hours prior to shipping. As maintaining proper temperature is critical for shipping hot lift stock, some form of temperature monitoring and record keeping is a good idea. Along with manually checking internal box temperatures at scheduled intervals with a dial thermometer, reusable temperature data loggers can be placed inside seedling boxes. Frost buildup on the refrigeration coils reduces cooling efficiency, thus the cooling unit should be checked regularly and manually defrosted if necessary, even on automatic units.

Seedlings that have been freezer stored may be shipped in either frozen or thawed condition. The mass of a trailer load of seedlings has a large effect on the reefer temperature, thus if initial temperatures are low, it will take quite a while to heat up, especially in an insulated reefer. Refrigerated vans are recommended, but are not mandatory at certain times. Although considered essential for long hauls, the use of refrigerated vans on short hauls provides extra insurance against the possibility of breakdowns and delays. Reefer temperatures are commonly set at –2ºC when transporting frozen stock, and 2-4ºC for thawed stock. As seedling roots can be damaged by temperatures of only -10ºC, it is important to ensure that seedling roots are not allowed to reach harmful cold temperatures if shipping during periods of extremely cold winter weather. In most cases, this would only be an issue if a load of seedlings were left outside for an extended period of time during a cold spell.

Seedlings transported via pick-up trucks are commonly covered with reflective tarps, keeping the white side up. It has been found that the effectiveness of reflective tarps deteriorates significantly with age. As well, not all reflective tarps are created equal, as it has also been reported that with one type of reflective tarp, seedling box temperatures were not significantly different from leaving the boxes unprotected. An alternative to using reflective tarps is the use of insulated canopies in the back of pick-up trucks. During transport, vehicle speed and road conditions have been shown to influence the number of mechanical shocks seedlings are exposed to (e.g. travel on gravel roads resulted in more mechanical shocks). As would be expected, seedling transport with all terrain vehicles can cause a high number of mechanical shocks.

On-Site Storage

Hot Lift Seedlings

Although the top growth is partially dormant, hot lift seedlings are still physiologically active, thus the essence of “hot-planting” is speed. After lifting in the nursery, seedlings should be shipped to the field immediately and planted as soon as possible. Rather than stacking boxes at the field cache, they should be opened to prevent heat buildup, facilitate watering, and allow light to reach the seedlings. Along with allowing photosynthesis, exposing the seedlings to light prevents the seedlings from receiving unintentional blackout, which may reduce subsequent diameter and root

growth after planting. If packaged horizontally seedlings must be placed upright. Seedlings should be kept out of direct sunlight, but allowed indirect light (i.e. dappled light through the forest canopy, or suspend a tarp over the boxes). Most seedling boxes are white to reflect radiation from the sun, although most box interiors are dark coloured and when opened exposed areas will absorb radiation.

Seedlings from Frozen Storage

Refrigerated trailers set at 2-4ºC provide ideal conditions for storage of thawed spring plant seedlings. If setting up a field cache, a location in the shade (e.g. timber, North Slope, near streams, patches of snow) where there is good air circulation is preferred. To avoid crushing, don't stack boxes too high. If sufficient shade is not available, shelter can be provided by stringing a tarp above the cache. It is important to be careful how you provide shade, or you can do more harm than good. When stringing a tarp above seedling boxes to provide shade, enough space (e.g. 60 –100 cm) should be left between the tarp and boxes to allow for air circulation. It is also recommended that canvas tarps not be used as they are very effective at trapping heat.

While internal box temperatures are low, seedling boxes can be covered with a silver-white reflective tarp, keeping the white side up, to maintain low temperatures. The overall aim is for the seedling to initiate root growth before bud burst, so that the seedling can better deal with the high moisture demands of the new flush. How soon the seedling flushes after planting is related to the temperatures it receives after thawing; seedlings exposed to lengthy warm temperatures will break bud sooner. Warm temperatures may also result in root elongation while still in the seedling box. Root elongation prior to planting spring stock is generally not desired due to the sensitivity of the new root tips to breakage and desiccation during handling and planting. In some instances field practitioners have purposely warmed up spring plant stock prior to planting. In this case the goal is to hasten bud burst of late spring plant stock, so that it will not be so out of sync with the natural environment. There has also been concern that taking thawed seedlings from a cool, dark seedling box and planting into a bright, warm clear-cut, is unnecessarily stressful. It has been reported that recovery of water potential after thawing only takes a matter of hours, and recovery of the photosynthetic process takes approximately five days after planting. However, it is not known whether a brief conditioning period consisting of opening the boxes and exposing to ambient conditions prior to planting would be beneficial for spring plant stock.

Seedlings are usually checked daily to monitor internal box temperature, moisture content, root and shoot activity, and for the presence of disease. If spring plant seedlings are stored for any length of time and internal box temperatures start to rise, the reflective tarp can be removed and the seedlings treated more like hot-lift stock by spacing to allow for adequate air circulation. If seedlings are still partly frozen, the bundles can be sorted and finished thawing in the shade, never in the direct sun or near a heat source. Seedlings with frozen plugs could theoretically be planted, but under our current packaging regimes, frozen seedling plugs can not be separated without damaging the roots.

Cooling units on reefers storing spring plant seedlings in the field have been known to malfunction in various ways, due to both mechanical and human error. The potential for seedling damage depends on the maximum or minimum temperature obtained, how long it lasted, and the seedling condition at the time of the incident. If allowed to overheat, seedling boxes should be removed from the reefer, then spaced and opened, as due to the continued respiration of the seedlings,

internal box temperatures would otherwise cool slowly. Severely damaged tissue will show symptoms soon after the damaging event; however less severe, but still deleterious damage will not be visible to the naked eye. Stock can be evaluated at the nursery via a potting test, but results take approximately a week. Results can be obtained sooner via a portable chlorophyll fluorescence meter.

Although most cooling systems can dehydrate seedlings, maintaining adequate seedling moisture is usually not a problem in spring plant seedlings if their bags are properly sealed. Repairing or replacing punctured boxes will aid in preventing moisture loss. Stress due to desiccation is accumulative, continuing as the seedling dries out[7]. As well, desiccation has been commonly reported to interact with other stresses, resulting in damage greater than that caused by the combined sum of the two individual stresses[7]. With hot lift stock, seedling moisture status should be closely monitored as it may dry out prior to planting, depending on the weather, storage conditions, and length of time before planting. Seedling moisture status may be monitored by feeling the seedling plug (i.e. the “squeeze test”), or through the use of box weights. While the visual or squeeze test is variable and subjective, the use of seedling box weights provides a more quantifiable method. The average weight of a seedling box for a particular stock type can be determined and used to estimate seedling moisture status on summer plant stock the same way block weights are used in the nursery. Although seedling block weights in the nursery can drop a substantial amount before the seedlings are at risk, it is well recognized that you would not want to plant a seedling with a dry plug, so it is better to keep them topped up. At the other extreme, over watering is a concern due to the possibility of seedlings left in standing water. Any surplus water left in the boxes after watering should be drained.

Care of Seedlings during Planting

Seedling care during planting should be guided by the general principles outlined for transportation and on-site storage. That is, it is desirable that seedlings be kept cool, in the shade, with good ventilation. Boxes of spring plant stock should be kept shut to retain moisture. Seedling boxes can be stored under a reflective tarp in the shade, under logs or brush, but never out in the open without protection. As well, the amount of seedlings stored outside of the field cache should be limited to no more than half-a-day’s supply of seedlings. During breaks, planting bags ought to be placed in the shade. Reflective inserts are commonly used in planting bags to aid in keeping seedlings cool. With the exception of the feeder bag, they must be kept closed at the top when full of trees. Planting bags should be kept in good condition, as holes and tears will allow drying of the seedling roots. A moist layer of peat moss or a sponge in the bottom of the planting bag will aid in preventing drying of the seedling roots. It goes without saying that seedling bundles should be handled and unwrapped carefully, not wrenched apart. As well, planters should only work with one tree at a time. Lastly, proper stock handling should go hand in hand with optimum planting spot selection. Once planted, there are many factors out of our control which may hinder plantation performance, but we can at least feel good knowing that we have done what we can to ensure prompt seedling establishment for future plantations.

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