The Importance of Good Seed

Robert P. Karrfalt

Robert P. Karrfalt is Director, National Seed Laboratory, USDA Forest Service, Dry Branch, GA 31020; email: rkarrfalt@fs.fed.us

Karrfalt RP. 2013. The importance of good seed. In: Haase DL, Pinto JR, Wilkinson KM, technical coordinators. National Proceedings: Forest and Conservation Nursery Associations—2012. Fort Collins (CO): USDA Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-69. 49-52. Available at: http://www.fs.fed.us/rm/pubs/rmrs_p069.html

Abstract: The importance of seed to human culture and conservation of the natural world is briefly discussed. The effect of seed on seedling quality and cost is described through several examples and illustrations.

Keywords: seed germination, seed vigor, seedling cost

Introduction

What is a seed? Biologically, it is an embryo that is often accompanied by some nutritive tissue for the embryo (endosperm or gametophyte) and enclosed in a seed coat. In most cases, seeds are the source of plants for regenerating native plant communities. From a philosophical and spiritual point of view, seeds are our past, present, and future. They provide cultural connections to past generations of people through foods and other plant materials. Natural selection worked in plant populations over the centuries to produce well adapted plants, and this adaptation is delivered to us in the seeds of today. Therefore, seeds sustain us in our present. Climates are changing. The strongest and most basic response to mitigating the risks of climate change is to preserve a maximum of genetic diversity among and within species of plants. Therefore, our plants determine what we can become in the future. The quality and abundance of our plants depends on high quality seeds.

Good Seed Defined

Good seed will have high germination, high vigor, and produce genetically adapted plants.

Germination, expressed as a percentage, is the ratio of the number of seeds that produce a normal seedling to the number of seeds that were sown. What is considered high germination will be relative to species, year, and nursery protocols. Pine and spruce will generally have higher germination than will true firs. In a bareroot nursery, germination as low as 90% might be considered high, but in a container nursery, germination below 90% begins to significantly affect cost of seedlings.

A *high vigor* seed is one that will germinate rapidly and perform better under suboptimal conditions. A second definition for high vigor seed is that it will maintain high germination over many years in storage.

The final characteristic of good seed is being *genetically adapted*. This is important because regardless of germination or seed vigor, if the plants are not adapted well to the growing conditions, they (and the new plant community they form) will fail to thrive. Only well-adapted plants or plants with the capacity (i.e. high genetic variability) to adapt to new conditions will survive.

Table 1. The consequences of decreasing seed germination in a container seedling nursery.

Germination %	Seeds/cell	% Filled cells	% double seedlings	Some Consequences
100	1	100	0	Life is good
98	1	98	0	Life is still pretty good
95	1	95	0	5% space lost/cost per seedling up
90	1	90	0	10% space lost/cost per seedling up
90 + Thinning	2	99	81	Thinning required, higher seed costs
85	1	85	0	15 % space lost/cost per seedling up
85 + Thinning	2	98	72	Thinning required, higher seed costs

The Economic Case for High Quality Seeds

Table 1 gives an overview of the effect of changing seed quality on container seedling production. As the table shows, 100% germination is ideal as all the cells are filled and no expense is incurred that does not return a seedling. As germination drops, even to 90%, significant losses begin to occur. While 90% might seem high, the cost to maintain the 10% of the cells that are empty has to be added to the cost of seedlings, and our production is decreased by 10%. One solution is to put two seeds in each cell. In this case the number of empty cells drops to 1%.

The number of filled cells is computed in this manner: at 90% germination, the probability of a seed not germinating is 10% (100 – 90). So the chance that the two seeds in any one cell both fail to germinate is 0.10 x 0.10 or 0.01. 100 cells – 1 cell that is empty makes for 99 full cells. However, seed costs had to be doubled because we used twice as many seeds. In addition, 81 cells have two seedlings and one seedling must be thinned out, which increases labor costs. There are 81 cells with two seedlings because the probability or chance that both seeds in a cell germinate is the product of the likelihood that each one geminates which is 0.90 x 0.90 or .81 (81% or 81 cells in 100 cells have two seedlings).

Table 2 illustrates more specifically how seed quality affects seedling costs. On the first line in this table 100% seed germination and a cost of $200 per thousand is taken as the baseline for all other comparisons. With 100% germination then a seedling would cost $0.20. The second line of Table 2 shows that if germination is 98%, and one seed is sown per container cell, then 980 seedlings are produced. This is 20 seedlings less per 1000 seeds sown than if germination was 100%. Costs of production remain the same so now the $200 per 1000 seedlings has to be spread over 980 seedlings. $200/980 seedlings gives a cost of $0.204 per plant, an increase of $0.004 per plant ($0.204 - $0.200). This amounts to a 2% increase cost per plant ($0.004/$0.20 = .02). In line 3 of Table 2, germination is further reduced to 95% while still sowing just one seed per cell. Repeating the calculations used in line 2 with this 95% germination shows that cost have increased 5.5%. Dropping germination to 90% with single seed sowing raises costs up 11%. An additional drop in germination to 85% raises seedling costs 17.5%. Cost increases are almost directly proportional to drops in germination.

Sowing two or more seeds per cell is one strategy to compensate for lower seed germination. In our example, double sowing reduces cost increases by half (line 6 of Table 2). However, to achieve this we had to waste 720 seeds for every 980 plants produced. That is 73% increase in the amount of seeds required. This strategy requires an abundant supply of seeds, and could lead to seed shortage if certain sources are harder to acquire. The thinning to remove the double seedlings also requires good timing to avoid major disturbance of the seedling that is kept.

Transplanting the thinned seedlings can recover some of the seed loss. In our example, line 7 of Table 2, seedling production costs are comparable to costs from double sowing and throwing away the extra seedlings. This operation is very time sensitive as germinates have a narrow window during which they can be transplanted without stunting or death occurring. This is not a very common practice because it is difficult to do successfully.

Detailed calculations for Table 2 are presented at the end of this paper. These calculations are only for illustrating general trends

Table 2. The cost of seedlings increases in a container nursery with decreasing seed germination.

Germination %	Seeds/cell	% Filled cells	% double seedlings	Cost per 1000 plants/ cost per plant	% Cost increase over 100% germination
100	1	100	0	$200/$0.20	0
98	1	98	0	$200/$0.204	2
95	1	95	0	$200/$0.211	5.5
90	1	90	0	$200/$0.222	11
85	1	85	0	$235/$0.235	17.5
85 + Thinning	2	98	72	$213.50/$0.214	8.75
Transplanted Seedlings	-	100	0	$214/$0.214	7

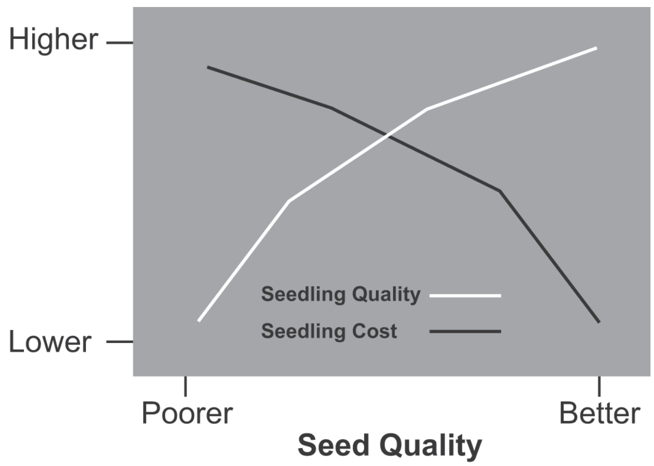

Figure 1. Relative seedling costs and quality vs. seed quality.

and each nursery would need to make these calculations in accordance with the local conditions and financial constraints.

Figure 1 graphically illustrates the general relationship between seed quality and the cost and quality of seedlings. Better quality seed results in lower seedling costs and higher seedling quality.

The Role of Seed Vigor

Vigor is the ability of a seed to germinate under adverse conditions and/or produce vigorous seedlings. High vigor seeds also will store better than lower vigor seeds. Therefore, high vigor seeds are needed for routine seed banking and especially for genetic conservation through long term seed storage. High viability usually means high vigor, but not always. This can be illustrated as in Figure 2.

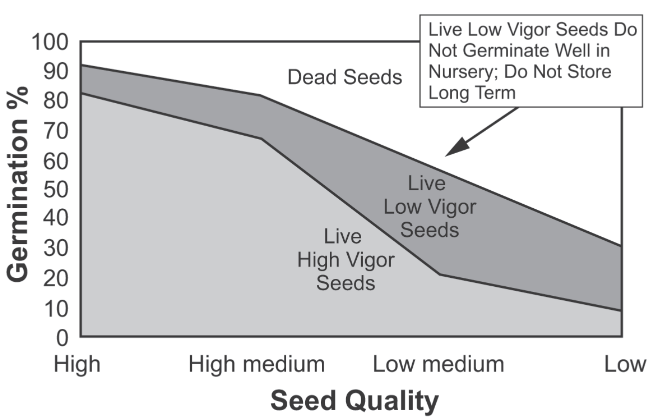

Figure 2. Fractions of viability and vigor of a seed lot.

All seed lots are made up of three portions: live high vigor seeds, live low vigor seeds, and dead seeds. Vigor tends to decline faster than germination. Therefore, germination in the nursery can take a sudden drop. This can be predicted with a current germination test. A significant drop in germination, usually more than 5%, would indicate vigor has probably changed to a greater degree. Although in tree seeds there is not an official test for vigor, paired tests have often been useful in detecting seed lots of low or declining vigor. A paired test, sometimes called a double test, is where an unstratified and stratified test are both conducted on the same sample submitted for testing. Alternatively, two stratified tests can be conducted but of different stratification lengths (e.g. one test with 30 days stratification and one with 45 days stratification.) If both tests are equal in viability or the one with longer stratification is higher, the seed lot is of good vigor. If the test with longer stratification is inferior, then the seed lot is likely to be declining in vigor. It should either be used as soon as possible or not at all. Which alternative to choose will depend on the circumstances.

Summary

Good seeds are the foundation of native plant work. Good seeds enable significant benefits in cost control and higher quality plants. Even in a noncommercial environment, poor seeds will consume more resources than good seeds, resources that could and likely should go to furthering the main objectives. Good seeds ensure that plant production targets are met and that restoration projects will be completed and successful. For orthodox seeds, good seeds cost less to store and store for longer periods of time than poorer quality seeds. This better storability is very important for routine seed banking and especially important for long term seed storage for genetic conservation. Good seeds ensure our future survival and prosperity, and that of generations of people yet unborn.

Detailed Calculations for Table 2

Germination = 95%, 1 seed sown per cell, production costs of $200 per 1000 cells.

Price: 950 plants produced, $200/950 = $0.211/plant
Price increase: $0.211 - $0.200 = $0.011 per plant, $0.011/$0.20 = 5.5%

Germination = 90%, 1 seed sown per cell, production costs of $200 per 1000 cells.

Price: 900 plants produced, $200/900 = $0.222/plant
Price increase: $0.222 - $0.200 = $0.022 per plant, $0.022/$0.20 = 11%

Germination = 85%, 1 seed sown per cell, production costs of $200 per 1000 cells.

Price: 850 plants produced, $200/850 = $0.235/plant
Price increase: $0.235 - $0.200 = $0.035 per plant, $0.035/$0.20 = 17.5%

Germination = 85%, 2 seed sown per cell, production costs of $213.50 per 1000 cells.

Price: 980 plants produced per 1000 cells sown, $200/980 = $0.204/plant

Seed costs double: 2000 seeds are needed. At $300/pound and 50,000 seeds per pound one seed costs $0.006/seed, or 1000 additional seeds x $0.006 = $6.00. This $6.00 of additional seed produces 980 plants. Therefore, per seedling cost of additional seed is $6.00/980 seedlings = $0.0061/seedling. (100 – (.15 x .15) = 100 - .02 = .98 chance of filled cell. 1000 cells x .98 = 980 seedlings.)

Thinning costs: Minimum wage of $7.25 per hour/3600 seconds in an hour = $0.002/sec. Thinning rate of 5 seconds per cell, 720 cells to thin = 5 x 720 = 3600 seconds, 3600 seconds x $0.002/sec = $7.25. 720 cells to thin is the number of double seedlings which from Figure 1 is 0.85 x 0.85 = .72 or 72%. The chance that one seed germinates is .85 and the chance the second seed in the double sow germinates is .85. Chance that both germinate is the product. These thinning costs are shared over the 980 seedlings produced. Cost per seedling for thinning is $7.25/980 = $0.0074 price increase per seedling.

Total cost increase for extra seeds and thinning is: $.0061 + $0.0074 = $0.0135 per seedling or $13.50 per thousand seedlings. From above, the base cost of 980 seedlings was $0.204 per seedling or an increase of $0.004 per seedling in base cost from what they were if germination was 100%. Total cost increase from all sources is, therefore, $0.0175.

Price increase: $0.2175 - $0.200 = $0.0175 per plant, $0.0175/$0.20 = 8.75%

Germination = 85%, transplant the extra seedlings.

Here, there is the attempt to save the thinned seedlings and recoup the extra seed cost. If it takes 10 seconds to transplant a seedling and labor is the minimum of $7.25 per hour or $0.002per second ($7.25/hour divided by 3600 seconds/hour), then transplanting 1000 seedlings would cost $20. Add this to the base cost of $200 per thousand to produce seedlings and subtract the $6.00 in seed cost which was part of the last example and we arrive at $214 per thousand transplanted seedlings. These seedling are 7% more expensive than seedlings had it been possible to have 100% germination and produce seedlings for $200 per thousand (14/200 = .07). Timing the transplanting of seedlings is very critical and would require an adequate labor supply to get the job done quickly. These costs do not also take into account the number of seedlings that might become stunted or die because of transplanting.