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USES OF SEED QUALITY ENHANCEMENT

Steven W. Cull[1]

I was asked to talk about enhanced seeds, or as a grower in New Jersey referred to it, enchanted seeds. I think I like that name better, however, I'm here to, "take a little of the magic out."

Although I suppose there are several definitions floating around; when I say "enhanced," I am referring to characteristics involving germination behavior. These characteristics include one or more of the following:

- Higher % germination
- More rapid germination
- Better germination under adverse conditions (temperature, light, moisture stress)
- More uniform germination
- More vigorous seedlings
- High % normal plants

Notice that five of the six characteristics refer to aspects of vigor rather than germination per se.

As I am sure most of you are aware, vigor is related to, but distinct from, germination. In storage, vigor declines more rapidly than germination percentage.

Also, we often notice, that when two lots of similar germination are placed under some stress -- in this case low soil temperatures -- they respond very differently.

Thus, we like to think of germination percent as only one important factor, which interacts with percent emergence and seedling uniformity to produce the final result -- a usable or normal plant. This is the only thing a grower is interested in: 1 seed -> 1 plant.

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Now, how do we perform this magic? There are three general methods used to enhance seeds. First are the simple physical separations. Separations based upon size, weight, density, or surface texture can affect many of the characteristics relating to germination and seedling vigor. The second general method is application of growth regulators. It is well known that growth regulators at various concentrations and various combinations can have significant effects on germination behavior. The third method involves controlling the uptake of water by the seeds.

When seeds are exposed to water, they imbibe initially at a very rapid rate (Figure 1). After this phase, the imbibition rate slows for a period, then increases rapidly. It is at this point that the radicles emerge. In this process, called priming or osmo-conditioning, we control the rate at which water is taken up in this phase and stop the process before this point by drying the seeds. This is the point of no return. Once the radicles emerge, the seeds cannot be dried without suffering a reduction in germination.

This procedure allows us to accomplish several things. First, the dried seeds, once planted, germinates more rapidly because they do not have to repeat many of these germination processes. Second, because we control the rate of water uptake, we can allow the slow germinating seeds to catch up to the fast seeds. Thus, when they are planted, all seeds are starting from the same point, resulting in more uniform seedlings. Third, by controlling conditions that the seeds are exposed to during this phase, we can "fool" the seeds regarding actual conditions at planting. For example, many lettuce varieties have light requirement for germination. By providing light during this period, we can satisfy the light requirement, allowing the seeds to germinate as well in the dark as in the light.

While improvement in seed performance can be observed using only physical separations, much more dramatic improvements are possible using these other methods. For PetoPlus, our trade name for enhanced seeds, we use some or all of these methods depending on the species or lots.

Enhancement processes involve a certain amount of stress on the seeds. For this reason, enhancement yields the best results when performed on vigorous, high germinating lots. Much of our efforts to produce enhanced seeds involve lot selection. As we find that standard laboratory germination tests often fail to distinguish between vigorous and weaker lots, we perform soil and thermogradient tests in addition to the standard laboratory test to identify promising lots.

Thermogradient tests are conducted on an aluminum table which has cold water circulating on one end and hot water on the other.

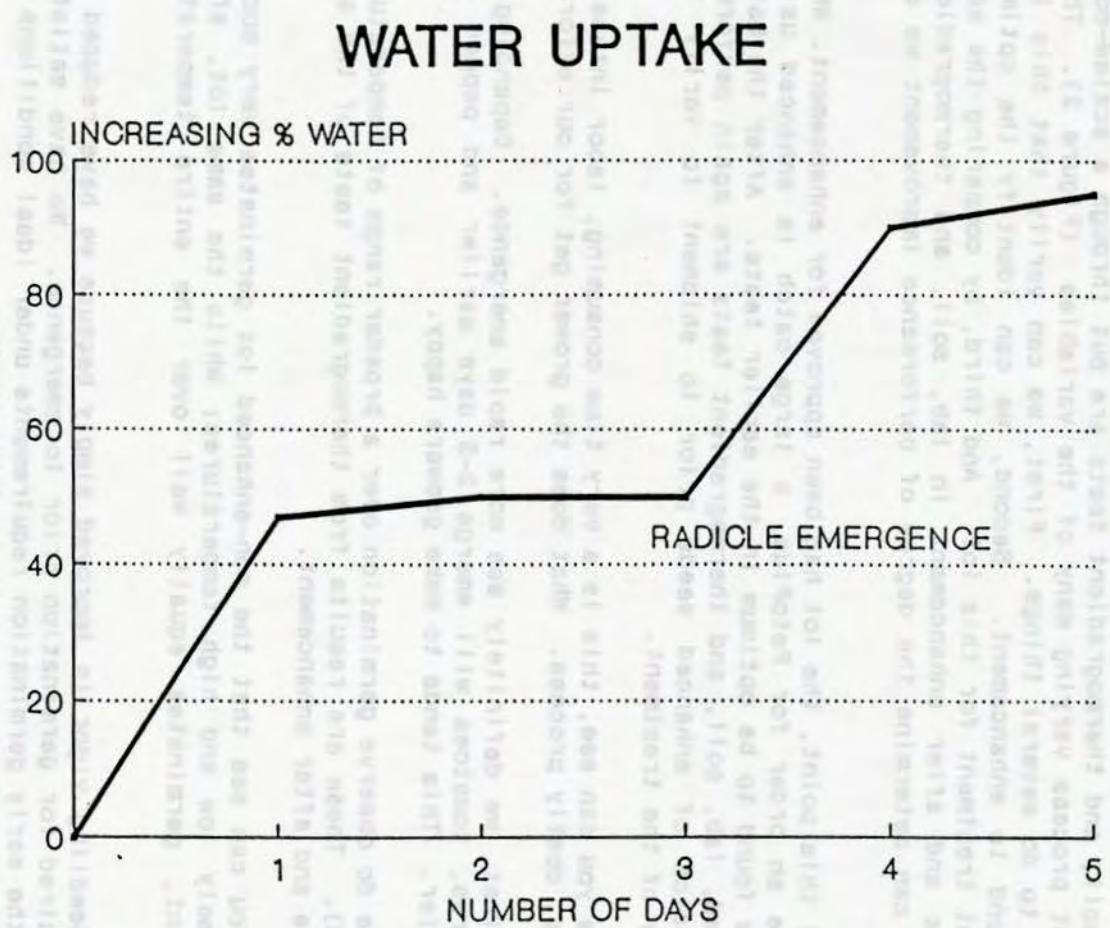

Figure 1. Generalized imbibition curve.

Thus, germination tests are conducted over a wide range of temperatures.

Running lots side-by-side allows us to identify lots which are capable of germination over a wide range of temperatures and are, thus, more likely to withstand the stress of the enhancement process.

Not all lots respond to the enhancement process in the same manner. For this reason, samples of the candidate lots identified by the lab, soil, and thermogradient tests are put through a scaled-down enhancement process varying many of the variables (Figure 2). This allows us to do several things. First, we can verify that this lot will respond to enhancement. Second, we can identify the optimum enhancement treatment for this lot. And third, by comparing the same lot before and after enhancement in lab, soil, and thermogradient tests, we can determine the degree of performance improvement we can expect.

At this point, the lot has been approved for enhancement. When we receive an order for PetoPlus, a large batch is enhanced using conditions found to be optimum in the earlier tests. After the batch is enhanced, lab, soil, and thermogradient tests are again performed on the batch of enhanced seeds prior to shipment to verify the efficiency of the treatment.

As you can see, this is a very time consuming, labor intensive and, hence, costly process. What does the grower get for our efforts?

First, we definitely see more rapid emergence. Depending on temperatures, tomatoes will emerge 2-3 days earlier and pepper 4-7 days earlier. This tends to make growers happy.

We do observe germination over a broader range of temperatures (Figure 3). These are results from thermogradient tests of the same lot before and after enhancement.

You can see that the non-enhanced lot germinates very poorly at extremely low and high temperatures; while the same lot, after enhancement, germinates equally well over the entire temperature range.

Seedling vigor is improved simply because we have reduced the time required for germination prior to emergence. We have satisfied many of the early germination requirements under ideal conditions and this shows up as an increase in seedling vigor.

While PetoSeed is actively researching the use of enhanced seeds in field plantings, at this time the market most appreciative of extremely high quality seeds is the vegetable transplant producer. In this situation, both time and space are money. It costs a transplant

PETO PLUS PROCESS

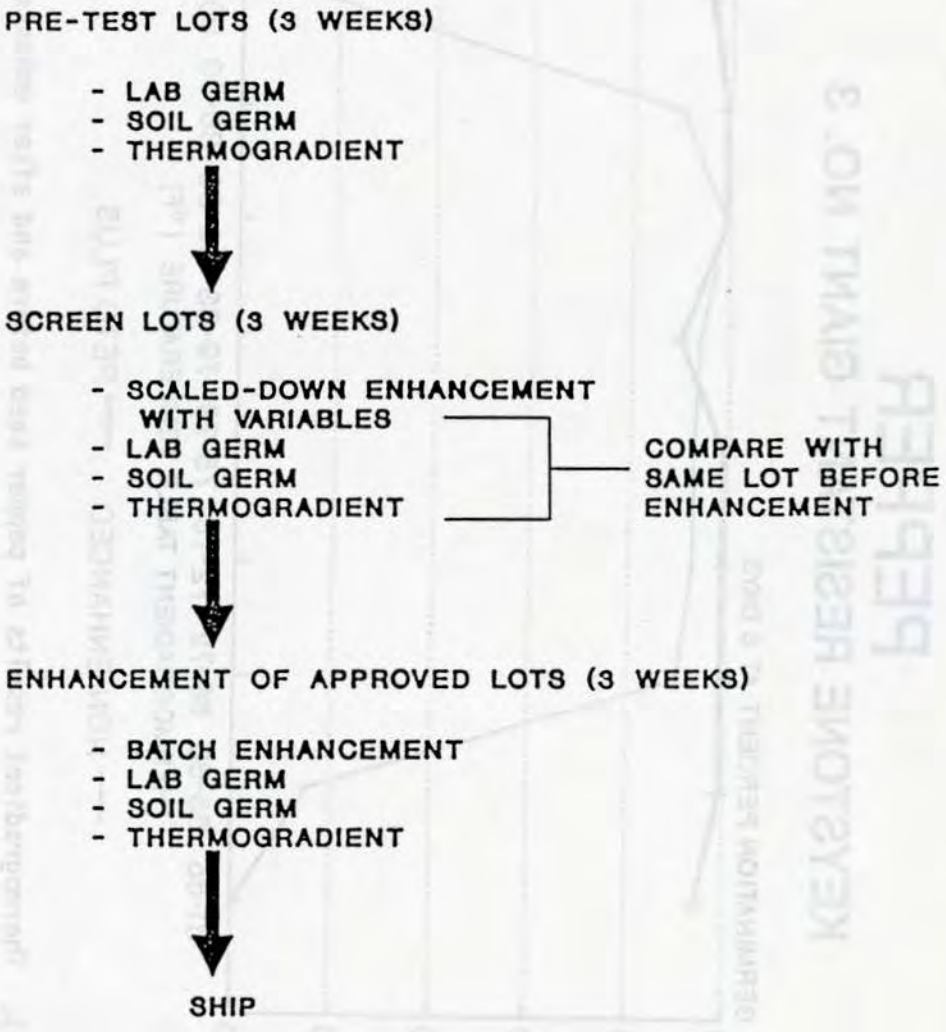

Figure 2. Flow chart of enhancement process.

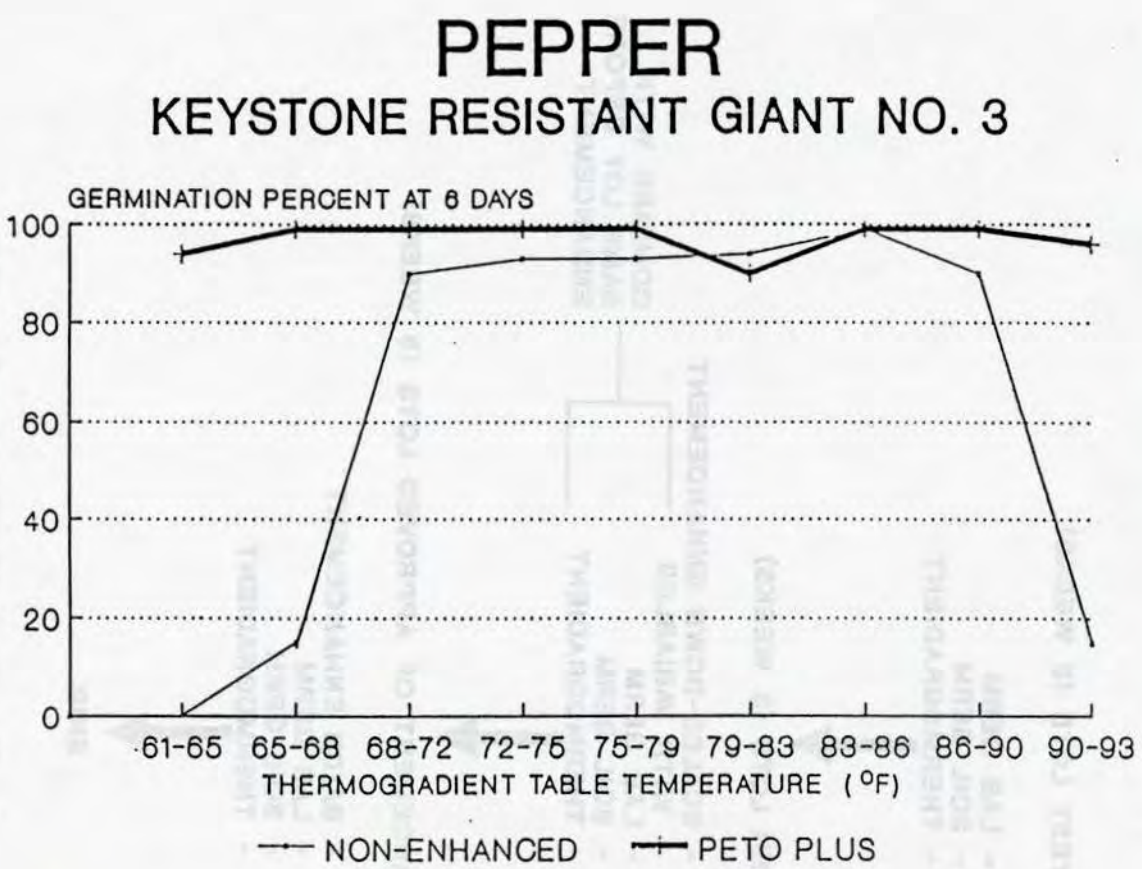

Figure 3. Thermogradient results of pepper seed before and after enhancement.

grower as much to grow a blank cell as it does to grow a plant. Thus, high germinating seeds are very cost effective. Also, the faster he can produce the plants and ship them to the field, the lower his cost.

Because of rapid germination and greater seedling vigor, plants from enhanced seeds are often ready to ship to the field many days ahead of plants from non-enhanced seeds. The plants from seeds that were not enhanced require another 10 days in the greenhouse while the plants from enhanced seeds are ready to ship. Even tests like these are difficult to interpret. The grower said if he had a whole house of enhanced seeds, he could have grown them differently and sent them out even earlier.

We observe a higher percentage of uniform seedlings. This is a result of allowing slow germinating seeds to catch up to the faster seeds, as I mentioned earlier.

Now, all of this is admittedly very impressive. But I am a firm believer that a new technology must pencil out, that is, the user must be able to derive an economic benefit by using this product. (Figure 4) illustrates the advantages of enhanced seeds.

Whenever I discuss a new product or technology, obviously a lot of time is spent telling all the things it can do. I also make it a point to tell people what it can't do (Figure 5).

We are continuing our research efforts to increase the number of species we can offer as enhanced. At this time, we are on the market with tomato, pepper, and eggplant. We have experimental treatments on lettuce which look very promising and are able to overcome both light requirements for some varieties and extend the temperature at which lettuce becomes thermo-dormant. Carrot also looks promising, allowing faster emergence before soil crusting becomes a problem.

Lastly, we are closing in on that illusive goal of 100% stands without resorting to very labor intensive methods such as pre-germination and hand planting.

We've come a long way in this technology and are learning about seed physiology in general. We find that we need to make improvements and to back up the system. This should include harvesting, production and handling of the seeds and working with breeders to develop lines with inherently high seed quality.

Figure 4. Advantages of Peto Plus in greenhouse plantings.

1. **More rapid emergence** -- less time in the most critical stage of development.

2. Germination under a broader **range of temperatures** -- does not require as critical attention to greenhouse temperatures.

3. Greater **seedling vigor** -- requires less time at high temperatures required for germination, and/or less time before sending to the field.

4. Better stands of more **uniform seedlings** -- reduced thinning/filling costs.

5. Higher **percentage** of normal (saleable) plants -- greater sales from the same greenhouse space.

The following example, using realistic figures, illustrates this last point.

	TOMATO	PEPPER
Sales price ($/1000 plants)	30.00	34.00
Additional sales ($/1000 seeds)		
5% more plants	1.50	1.70
10% more plants	3.00	3.40
Cost of Peto Plus ($/1000 seeds)	.91	1.04
Net gain ($/1000 seeds)		
5% more plants	.59	.66
10% more plants	2.09	2.36

It can be seen from this example that an increase in saleable plants by **3% will cover the cost** of Peto Plus -- anything over that is virtually all profit to the grower. Our tests with Peto Plus indicate increases in saleable plants by **5-10%** when compared to the same lot before enhancement. However, it should be remembered that these lots are of the highest quality available. Comparisons with typical lots over a period of time may well reveal that Peto Plus yields an average of 10-15% more salable plants.

Figure 5. Limitations of Peto Plus in greenhouse plantings.

1. **Peto Plus** should be considered as only **one important aspect** of successful transplant production. Using Peto Plus will compliment a good cultural system, but will not compensate for sloppy practices. Just as the most advanced growers have realized the potential of hybrids while others have not, the best greenhouse growers will be the first to realize the benefits of enhanced seed.

2. **Water management** is more critical with enhanced seed. Enhanced seed has already completed initial germination processes, thus demands an uninterrupted supply of adequate moisture. Also, **oxygen** requirements of germinating enhanced seed may be higher than non-enhanced, thus enhanced seed may be more susceptible to poor germination due to excess water.

3. **Stacking flats** in a germination room is being investigated as it relates to the performance of enhanced. It is possible that the supply of **oxygen is insufficient** under these conditions to meet the high demand of enhanced seed. As we are confident of the performance of enhanced seed when the flats are placed directly on the bench, we recommend this practice for now.

4. At this time, we are recommending that Peto Plus be planted within 6 months of enhancement, and that it be **store** under as **favorable conditions** as possible (Less than 20C with low humidity). Research is continuing to more thoroughly explore the relationship between shelf life and storage conditions.

5. As mentioned above, the **enhancement process** and testing takes **60 days.** While we are investigating ways to shorten this time period, in the meantime, it is important that we know what varieties and volumes may be sold as Peto Plus so that we can test lots to determine suitability for enhancement. Once lots are approved, we can enhance and ship in 3 weeks.