The Effect Of Waves In Soil On Seed Germination And Plant Growth

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ABSTRACT

A preliminary test was conducted to study the effects of vibratory waves on seed germination. It was observed that in some cases, when the wave length was the same as the seed mean dimension, the seeds sprouted sooner than a similar control group of seeds under identical environmental conditions. The heights of the plants when sprouted showed a measurable increase for the test seeds (with vibration waves) as compared with control seeds (no vibration).

SOMMAIRE

Un test préliminaire a été mené afin d'étudier l'effet des ondes vibratoires sur la germination des graines. Il fut observé dans quelques cas que lorsque la longueur d'onde est égale à la dimension moyenne des graines, celles-ci poussent plus tôt que les graines d'un groupe témoin sous des conditions environnementales identiques. Un accroissement mesurable de la hauteur des plantes provenant des graines soumises aux ondes vibratoires a été observé par rapport aux graines du groupe témoin non soumises aux ondes vibratoires.

1. INTRODUCTION

Several years ago, one of my students (the late Margaret E. Collins) and I worked with the Department of Plant Services of the University on the effect of sinusoidal sound waves on the growth of leafy plants. Ms. Collins is now deceased, but her work was of such significance that I had written a paper based on this work to her memory. It was published in the Journal of the Canadian Acoustical Association in June, 2001.

This previous work stimulated further interest in wave effects and a preliminary test was arranged, by propagating a vibration wave over seeds planted in soil (Figure 1). It was observed that in some cases, when the wave length was the same as the seed mean dimension, the seeds sprouted sooner than a similar control group of seeds under identical environmental conditions. The heights of the plants when sprouted showed a measurable increase for the test seeds (with vibration waves) as compared with control seeds (no vibration).

2. PROCEDURE AND APPARATUS

The details of the tests are schematically shown in Figure 1. The basic instrumentation consisted of a Bruel & Kjaer electro-dynamic vibration shaker. The sinusoidal signal generator (20 Hz to 20 KHz range) and the amplifier were built by the electronics shop of the University. The planting beds were simple plant window boxes, measuring 3ft. x 8in. x 8in. (See Figure 1 and Photo 1), mounted on a table on a back deck. A hole was drilled in the end of the test box, and the head of the shaker was inserted in the hole, flush with the soil in the box. Separate tests were carried out on different kinds of seeds. The details of the tests are presented below.

2.1 Test 1

Commercial Soya Beans, obtained from the Great Canadian Bean Co. of Ailsa Craig, Ontario, were used. The bean seeds were planted in soil (President's Choice Black Earth, provided by Sun Fresh Ltd. of Toronto Canada), and were approximately ½" deep and 3" apart. The excitation frequency for the bean seeds was determined as follows. The seed diameter was approximately 0.25", the wave propagation in moist soil was 75 m/sec (or 240.6 ft/sec), as obtained from the Geotechnical Research Centre at UWO. The frequency needed for the size of seed is $f = c/\lambda$, where c is the wave velocity, and λ is the wave length equal to the 0.25" diameter of seed (Reference 6).

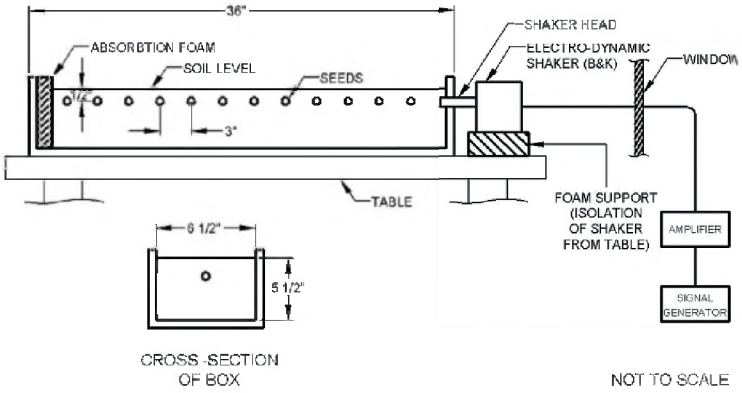

Figure 1. Schematic of Test Box with Shaker.

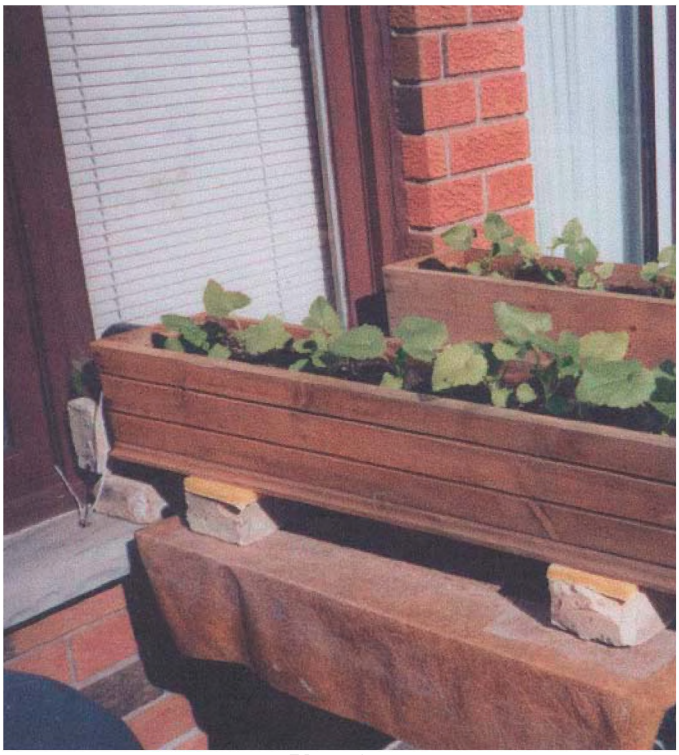

Photo 1

After 15 days, the bean seeds germinated and sprouted. The seeds in both the test box and the control box had sprouted at the same time. The heights of the sprouts are given in Table 1.

Table 1. Heights of Bean Sprouts, in.

Test Box	Control Box
5	3
4.5	5
4	4.75
4.5	4.25
5	4.5
4	4
5	4.75
4.5	5.25
Average: 4.56 in.	**Average: 4.40 in.**

As can be seen in Table 1, there was marginal difference in the average heights of the bean plants when exposed to vibration and with no vibration. An explanation as to why there was little difference, it was thought that the energy in the wave in the test box was insufficient to cause sufficient agitation of the large bean seeds, and consequent jacket splitting. Hence, a different seed was tested and is described below.

2.2 Test 2

Impatiens seeds were planted in the soil in the boxes, again approximately 3" apart with a light soil covering of 0.25" to 0.5". The signal generator was set at 15 KHz according to the previous calculations for the bead seeds. There was rain overnight at this time. The time-table for watering, temperature, etc. was identical to that carried out in Test 1.

After 16 days of observing the two plant boxes, it was noted that no sprouts had occurred in either the test or control boxes. This was two days after sprouts had occurred in the previously mentioned test with soybeans. After searching the literature (References 3, 4, 5), and talking with some experts (botanists in the Plant Sciences Department, and growers of flowers in greenhouses), it was noted that Impatiens plants are very hard to grow from seeds. It would appear that they require pre-planting procedures such as chilling the seeds, scarification or rubbing the seeds to loosen their jackets (Reference 1). To date, none of these pre-planting procedures were applied during the current investigation. The test was repeated using Nasturtium seeds in the boxes, as noted next.

2.3 Test 3

The Nasturtium seeds were planted with a light soil covering 0.25" and 3" apart. The excitation frequency for the shaker was determined for these seeds, as per the previous methods at 11, 550 Hz. In this test, in addition to moistening the soil before planting, two applications of Miracle Grow nutrient, one at the beginning and one approximately midway through the test, were given. These seeds were watered daily. After 10 days, it was observed that the test box had sprouted 5 healthy sprouts averaging 2.5" high, and the control box had only 1 sprout 1.25" high. However, this increase in the number of sprouts and in the average heights cannot be accepted as de rigueur. There are too many other factors which have affected the results, not much of which is the uncertainty associated with the germination of "store bought" seeds.

Lyn MacIntosh of Sandhill Nurseries, near Hunstville Ontario in the Muskoka district, confirmed that certain seeds need pre-treatment before planting, and some seeds will not germinate at all. In order to ensure that the test used good seeds, Ms. MacIntosh suggested that pre-treated seeds from Stokes Seeds in St. Catherines, Ontario be used in future tests. Further, she suggested that sweet pea seeds be used for the tests.

2.4 Test 4

Pre-treated sweet pea seeds from Stokes Seeds were planted after soaking for four hours. The nutrient used was Miracle Grow 15-30-15. The shaker was set for a sinusoidal frequency of 13000 Hz, determined as before for the bean seeds, and nutrient was mixed with water during watering. There was no visible showing of sprouts after five days, and hence the boxes were covered as testing was discontinued.

2.5 Test 5

Sweet Pea seeds were used (again, obtained from Stokes Seeds in St. Catherines, Ontario), and were soaked

overnight for at least 8 hours. Their average diameter was 0.256". Again, as before, the preferred frequency was determined as 11278Hz. The seeds were planted in the test box and the control box (10 seeds to each box) at an average depth of 0.5", approximately 3" apart in-line with the shaker head. The seeds were watered, and nutrient was added (nutrient was Miracle Grow 15-30-15).

The seeds in both boxes were watered from May 5 to May 9. The seeds were not watered on May 10 to May 12, as there was heavy rain during this period. Up until May 24, watering and nutrient continued. When only 6 sprouts and 5 sprouts were observed in test and control boxes, and because of small showing of sprouts, the testing on this set of seeds was discontinued.

2.6 Test 6

Finally, it was decided to use commercial wheat field crop seeds with watering and nutrition. Planting started in early August, (with nutrient at the start and mid-point of test period) for 17 days. The results are recorded in Table 2.

Table 2. Heights of Wheat Crops, mm.

Seed Number	Test Box	Control Box
1	25.0	25.5
2	24.5	18.6
3	23.0	19.0
4	26.5	21.5
5	25.5	
6	22.0	23.0
7	29.0	27.0
8	27.0	11.0
9	28.0	26.0
10	19.7	21.0
11	28.3	25.5
Average	25.3	21.6
Percentage Increase = 14.9%		

3. CONCLUSION

From these tests, it can be seen that in most cases, the test box produced more and higher plant shoots (with the exception of impatiens seeds, which as noted before, were an exceptionally different seed to grow from the seed itself. Most of these plants are grown from cuttings from mature plants (Reference 7).

The testing was changed to a wheat field crop, where the seeds were obtained from a local farmer who had grown these in his field. These seeds are relatively easy to grow from scratch. When the test-seeds were subjected to a pressure wave in the soil with a wavelength comparable to the seed diameter, the test seed produced a marked increase in the sprouts and height of the plants when compared with the control seeds under the same conditions as the test seeds with no vibrating pressure wave in the soil (Table 2 and Photo II).

Although there are many factors which affect germination of seeds, such as the variation of store-bought seeds, light, wind, temperature, nutrients in the soil, moisture and exposure to the sun, it would appear from the foregoing tests, that sinusoidal pressure wave of sufficient amplitude passing over the seeds in a soil test bed with a wave length comparable to the wheat seed diameter, all other influencing factors being the same for the both test beds, results in the an earlier germination of the seeds and greater plant growth. (See Photo II)

Photo 2

As far as further study is concerned, the tests above should be replicated. It would be also advantageous to test other seeds that are recommended by growers. Further it would be useful to ascertain the shape of the wave form in the soil from the face of the sine-wave generator to the last seed planted. This could be done by placing (or lightly hanging) an accelerometer attached to a charge amplifier and oscilloscope. Any changes in the wave-form profile and strength of wave-front could be recorded.

4. REFERENCES

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