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KUMANAB, CHANDA F. APRIL 2006. Effect of Duration of Sea Water Presowing Seed Treatment on the Germination and Seedling Emergence Behavior of Parsley. Benguet State University, La Trinidad, Benguet.

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ABSTRACT

The presowing seed treatment and germination test portions of the study was conducted at the Seed Laboratory of the Horticulture Research and Training Institute (HORTI), while the seedling emergence test was done at the Greenhouse of the Seed Technology Section, Vegetable Crops Division, Department of Horticulture, College of Agriculture, Benguet State University, La Trinidad, Benguet from December 2005 to February 2006 to evaluate the effect of various durations of sea water pre-sowing seed treatments on the germination and emergence; and establish the best duration of sea water pre-sowing seed treatment on the germination and seedling emergence of parsley.

Pretreating the seeds in sea water for 2 and 10 days considerably increased germination percentage but 10 days treatment duration was more effective in enhancing germination rate (G_{50}) and in improving uniformity of germination (G_{90}-G_{10}).

Likewise, priming the seeds for 2 to 10 days significantly increased emergence percentage, significantly hastened emergence rate (E_{50}) and uniformity of emergence (E_{90}-E_{10}) but10 days pretreatment was more effective in enhancing emergence rate and in improving uniformity of seedling emergence. All the seeds primed for 2 to 10 days had increased shoot and root lengths and seedling dry weight. However, 10 days pretreatment with sea water was more effective in promoting seedling growth.

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INTRODUCTION

Parsley (*Petroselium crispum* L.) was cultivated as early as the 3rd century BC. The Romans used parsley as a garnish and flavoring. They put it on their tables and around their necks in the belief that the leaves would absorb fumes. Medieval European believed that one could kill an enemy by plucking a sprig while speaking the person's name. It spread to the America in the 17th century, where it now grows abundantly (Simon, *et al*., 1984).

Parsley is one of the best known and most widely used as culinary herb in the United States. However, parsley is difficult to process because it takes twelve pounds of fresh parsley to make one pound of dried materials. More people still use the fresh leaves as garnish in soups, salads, meats, vegetables, and sauces (Hamden, 1984).

Seed priming is a technique to promote early germinative metabolic processes that result in a rapid and uniform emergence of crops in the field which plays on important role in the production of various species of vegetable crops (Heydecker and Coolbear, 1977; Haigh *et al*., 1986; O'Sullivan and Bouw, 1984; Brock LeHurst and Dearman, 1983a; 1983b). Adopting this technique in parsley species may lessen the burden of the farmers in the field operation.

The presowing seed treatment and germination test portions of the study was conducted at the Seed Laboratory of the Horticulture Research and Training Institute (HORTI), while the seedling emergence test was done at the Greenhouse of the Seed Technology Section, Vegetable Crops Division, Department of Horticulture, College of Agriculture, Benguet State University, La Trinidad, Benguet from December 2005 to

February 2006 to evaluate the effect of various durations of sea water pre-sowing seed treatments on the germination and emergence; and establish the best duration of sea water pre-sowing seed treatment on the germination and seedling emergence of parsley.

REVIEW OF LITERATURE

.Description of the Crop

Parsley is a biennial herb native to Europe and Western Asia (Simon, *et al*., 1984). The erect-growing parsley reaches a height of 0.3 to 0.7 m and had green leaves and greenish-yellow flowers in compound umbels with seeds that are smooth, ribbed, and ovate.

The reported life zone for parsley is 5^0 to 25^0C with an unusual precipitation of 0.3 to 4.6 mm and a soil pH of 4.9 to 8.3. The plant prefers a rich moist soil with good drainage. Seeds germinate very slowly, and therefore a pretreatment soaking is usually employed to hasten germination. The plant can either be seeded directly or transplanted. Only a rosette stem growth is produced in the first year with a flowering stem appearing early in the second year. Several harvests per year are feasible. Commercially produced parsley seeds are actually mericarps (Hamden, 1984).

Parsley is a rich source of vitamin C and yields a fixed oil, an essential oil, and tannins. The seeds contain both a fixed and volatile oil, the latter composed of apiol, mysiticin, tetramethoxybenzene, pinene, and other compounds. The leaf or herb oil is considered superior to seed oil, as the volatile characteristics are more similar to parsley leaves. The fixed oil of parsley contains petroseline, plus oleic, linoleic, palmitic, and other fatty acids (Hamden, 1984).

Importance/Uses of Parsley

The seeds, leaves, and essential oils of parsley are utilized as condiments or seasoning. Fresh leaves are used for garnishing such food dishes as meat, fish, and

vegetable. Fresh, dried, and dehydrated leaves flavor a wide array of food products, including salads, sauces, soups, stews, eggs and processed foods. Parsley seed oil is used as a fragrance in perfumes, soaps, and creams. The plant is sometimes grown as an ornamental plants for landscaping.

As a medicinal plant, parsley has traditionally been used as an antispasmodic, carminative, diuretic, emmenagogue, and stomachic. The plant has also been used as a remedy for asthma, conjunctivitis, dropsy, fever, and jaundice. The essential oil of parsley seed has been reported to stimulate hepatic regeneration.

Presowing Seed Treatments

First, presowing treatments of seeds can be done to improve germinability and/or emergence performance not only under favorable but also stressful conditions. Such treatments involved controlled water hydration of the seed in either pure distilled water, osmotica (polyethylene glycol, or inorganic salts) and low temperature. The seeds are allowed to imbibe water in a solution of reduced osmotic potentials so that some initial steps in the germination process will proceed by radicle emergence or after surface drying.

Sea Water-Based Treatments

In chive seeds, Dela Cruz (2005) found that sea water as a priming agent significantly increased germination capacity compared to the dry control seeds. Priming the seeds at concentration of 60-80% considerably hastened germination (G_{50}). The uniformity of germination (G_{90}-G_{10}) was markedly improved by 60 to 70% sea water treatment.

Toledo (1997) found that sea water as a presowing treatment to aged asparagus seeds impressively increased final seed germination and seedling emergence percentages, increased germination/emergence rates and uniformity against the dry untreated control seeds.

Baucas (1998) found that 10% sea water was effective in reducing median germination times. Likewise, 10-20% sea water treatment significantly reduced median emergence times and at only 10% solution effectively reduced median spread of emergence times. Longer seedling shoots and roots were noted at 10 to 40% sea water treatments.

Polyethylene Glycol-Based Priming Agent

Akers *et. al.* (1987) showed that parsley seeds leached for three days in aerated water at 25^0C and then primed in aerated PEG '8000' solution for 45 days at 25^0C improved earliness of germination at temperatures of 5, 15, 20 and 25^0C, with the largest improvement at the lowest temperature. Primed seeds germinated significantly faster than unprimed ones when PEG solutions of -0.25, -0.5 or -0.75 MPa were used as the germination media instead of distilled water. The latter results supports the hypothesis that priming induces the development of low cellular osmotic potentials. The priming effect was not lost during eight months of storage, suggesting a good treatment longevity.

Inorganic Salt-Based Priming Agent

A study conducted at BSU by Valdez (1989) showed that germinating eggplant seeds at various concentration of KNO_3+ KH_2PO_4 significantly reduced percentage and

spread of germination times. Similarly, germinating the seeds at the effect of reduced mean and spread of germination times when the seeds were germinated at high osmotic potential (distilled water). Surface drying after priming at 1.5 and 2.0% also tends to be more effective in improving germination percentage.

A study conducted by Amcay (2005) discovered that priming the seeds with KNO_3 + K_3HPO_4 significantly increased the percentage of germination. Seed primed at 30% + 30% concentration markedly enhanced germination rates (G_{50}). The different concentrations considerably improved uniformity of seed germination (G_{90}-G_{10}).

MATERIALS AND METHODS

Materials

The materials used in this study were commercial seeds of parsley (*Petroselinum crispum* L.), sea water (30 ml), filter paper, Erlenmeyer flask, graduated cylinder, distilled and tap water (170 ml), and modified germination boxes.

Methods

Experimental design and treatments. The experiment was laid out in a randomized complete block design (RCBD) with four replications. The treatments was as follows:

Code	Duration (days)
D_1	2
D_2	4
D_3	6
D_4	8
D_5	10
D_6	Dry seed

Sterilization. The seeds were sterilized by soaking in 1.0% NaOCl (chlorox) solution for 10 minutes. The seeds were then washed in distilled water. Surface drying was done between blotting papers until the seeds flowed freely on the surface of the paper.

Priming. The seeds were sown on-top of moistened filter paper and allowed to imbibe in the dark at room temperature in accordance to the treatments following the

method of Toledo and Coolbear (1988). The treatment were carried out in modified enclosed germination boxes. The filter paper was supported by glass platform and was continuously moistened by wicks from a reservoir of 15% sea water solution below. The boxes were set-up and pre-equilibrated at room temperature overnight after which the seeds were sown. After pretreatment, the seeds were rinsed in running tap water followed by final rinsing in distilled water. After washing, the seeds were surface-dried between blotting papers at room temperature until the seeds will flow freely on the surface of the paper.

Laboratory germination test. One hundred pre-treated seeds each of four replications together with the control dry seeds were sown. The same procedure as in the priming treatment were followed except that pure distilled water was used. The seeds were allowed to germinate at room temperature. Germinated seeds were counted and discarded at 24-h intervals until no more seeds germinated. Considered germinants and counted were seeds that had visible radicles protruding from the seed coat.

Greenhouse seedling emergence test. The same number of seeds and replicates as in the laboratory germination test together with the control dry seeds were tested under greenhouse condition. The seeds were sown in a sandy loam soil half-filled seedling plugs and covered with 1.0 cm of the same soil material. The newly sown seeds were immediately provided with water. Emergents at hypocotyl protrusion were tag at 24-h intervals and allowed to develop for 40 days then 12 randomly selected sample plants were harvested.

The seedlings were watered/irrigated every other day with tap water. After 2 weeks from sowing in the seedling plugs, fertilizer application was done using Peters

Professional (20-20-20) at the rate of 2.5 g/2.0 li of water. Application of fungicide (KOCIDE 101) was done after 3 weeks from sowing at the rate of 2.5 g/2.0 li of water.

Data gathering. The data gathered were subjected to variance analysis and mean separation tests were determined using the Duncan's multiple range test (DMRT) were the following:

1. Laboratory germination test. The following were taken using the method of Toledo and Coolbear (1988). Considered germinants and counted were seeds with visible radicle protruding from the seed coat at 24-h intervals. From this the following were calculated:

a. Germination percentage. The percentage germination was computed using the formula:

$$\text{Germination (\%)} = \frac{\text{Number of germinants}}{\text{Number of seeds sown}} \times 100$$

b. Median germination times (G_{50}, h). The number of seeds germinated were recorded at 24-h intervals and G_{50} were computed using the formula:

$$G_{50} = t_i + \frac{[(N + 1)/2 - n_i]}{n_j - n_i} \times (t_j - t_i)$$

c. Median spread of germination times ($G_{90} - G_{10}$, h). The number of seeds germinated were recorded at 24-h intervals.

$$G_{10} = t_i + \frac{[(N + 1)/10 - n_i]}{n_j - n_i} \times (t_j - t_i)$$

$$+ \frac{[9(N+1)/10 - n_i]}{(n_j - n_i)} \times (t_j - t_i)$$

where: $n_i < (N+1)/10 < n_j$

$$G_{90} = t_i + \frac{[9(N+1)/10 - n_i]}{(n_j - n_i)} \times (t_j - t_i)$$

where: $n_i < [9(N+1)]/10 < n_j$

2. Greenhouse emergence test. Similar procedures of computations as in the laboratory germination test were used. Considered emergents and counted were seedlings with visible hypocotyl protruding from the soil surface at 24-h intervals. From this, the following were calculated aside from the added data gathered:

a. Emergence percentage.

b. Median emergence times (E_{50}, h).

c. Median spread of emergence times ($E_{90} - E_{10}$, h).

d. Shoot length (cm). This was measured from the shoot node to the tip of the longest shoot of 12 randomly selected sample seedlings.

e. Root length (cm). This was measured from the root node to the tip of the longest root of the same randomly selected sample seedlings in (d.).

f. Dry weight (g). This was taken from the same randomly selected seedlings in (d) and (e) 40 days after sowing and oven dried at 65^0C for two days.

3. Documentation of the study in pictures.

RESULTS AND DISCUSSION

Laboratory Seed Germination Tests

Percentage germination. Table 1 shows that pretreating the seeds for 2 and 10 days considerably increased germination percentage against the other treatments except 8 days although comparable with each other.

Median germination times. On one hand, 10 days pretreatment markedly enhanced germination (G_{50}) against the other pretreatment durations. This was followed by 8, 6, 4 and 2 days which also showed significant enhancement on the germination rates *vis-a-vis* the control dry seeds (Table 1).

Spread of germination times. Concerning uniformity of germination, 8 and 10 days pretreatment with sea water promoted similar but significantly uniform (G_{90}-G_{10}) germination

Table 1. Laboratory germination tests

TREATMENT	GERMINATION (%)	G_{50} (h)	G_{90}-G_{10} (h)
2 days	95.0a	138.28b	103.70b
4 days	90.0b	106.25c	57.68c
6 days	91.0b	71.79d	27.43d
8 days	93.0ab	39.34e	7.41e
10 days	95.0a	26.50f	5.28e
Dry seeds	91.0b	208.63a	150.71a

In a column, means with a common letter are not significantly different at 5% level by DMRT

than the other treatments. In addition, pre-treatment at 2, 4 and 6 days also showed promoted considerable uniformity in parsley seeds compared to the control dry seeds, but the three treatments were not comparable as shown in Table 1.

Seedling Emergence Tests

Percentage emergence. Table 2 shows that priming the seeds for 2 to 10 days significantly increased emergence percentage against the dry seeds. However, all treated seeds had comparable percentage of seedling emergence which ranged from 92.00 to 97.00%, compared to only 79.00% in the dry seeds.

Median emergence times. The median seedling emergence times (E_{50}) as affected by durations of sea water presowing seed treatment is shown in Table 2. All the pretreated seeds significantly hastened emergence compared to the control dry seeds. However, 10 days pretreatment was significantly more effective pre-treatment duration than the other duration treatments.

Median spread of emergence times. Significant differences were likewise observed on the median spread of emergence times (E_{90}-E_{10}) as affected by sea water pretreatment durations (Table 2). Pretreating the seeds for 10 days was significantly more effective in improving uniformity of emergence compared to the other durations and the control dry seeds. Nevertheless, the other pretreatment durations markedly improved emergence uniformity against the control dry seeds but were statistically different with each other. Results further show that as the pre-sowing treatment with sea

water duration was increased, there was a corresponding increase in the uniformity of seedling emergence from 160.72 to 63.66 which means that longer duration of treatment had removed or reduced the inhitors with in the seed that affects the germination rate in seeds.

Table 2. Seedling emergence tests

EMERGENCE (%)	E_{50} (h)	E_{90}-E_{10} (h)
97.0a	186.07b	160.72b
97.0a	160.97c	128.98c
92.0a	133.53d	102.32d
97.0a	110.33e	79.88e
94.0a	84.03f	63.66f
79.0b	266.97a	229.02a

In a column, means with a common letter are not significantly different at 5% level by DMRT

Shoot length. Table 3 shows that priming the seeds in sea water for 2 to 10 days increased shoot lengths compared to the control dry seeds. However, 10 days pretreatment was markedly more effective in increasing vegetative growth producing the longest shoots among the seeds with better the other pretreatment durations. Nevertheless, the other priming durations also promoted seedling growth against the control dry seeds.

Root length. Among the durations of sea water evaluated as a priming agent, only 10 days duration markedly increased seedling root length compared with the other sea water durations and the control dry seeds (Table 3). Similarly, 8 days duration

significantly increased root length over other durations and the control dry seeds. Likewise, the other pretreatment durations markedly promoted the production of longer roots compared to the control dry seeds.

Seedling dry weight. Table 3 shows that all the pretreated seeds at different durations with sea water as a pre-sowing seed treatment had remarkably higher seedling dry weights

Table 3. Shoot length, root length and dry weight

SHOOT LENGTH (cm)	ROOT LENGTH (cm)	DRY WEIGHT (g)
9.42c	2.81d	0.32d
9.84c	3.26c	0.34cd
11.37b	3.60bc	0.35c
12.02b	3.87b	0.38b
13.43a	4.63a	0.42a
8.12d	1.82e	0.13e

In a column, means with a common letter are not significantly different at 5% level by DMRT

compared to the dry control seeds. However, 10 days pretreatment duration was markedly more effective in improving seedling growth over the other durations.

The increased germination percentage (Table 1) of parsley seeds primed with the different durations of sea water corroborated with the earlier findings on pre-treated asparagus seeds (Legueb, 1998), celery seeds (Aniwasal, 2000), parsley seeds (Amcay, 2005), rosemary seeds (Pablo, 2004) and celery seeds (Mangapan, 2003) but contradicted with the results obtained by Baucas (1998) on parsley pre-treated seeds. Likewise, the

improved germination rate (Table 1) was in complete agreement with the results obtained in pre-treated asparagus seeds (Legueb, 1998), parsley seeds (Baucas, 1998) and rosemary seeds (Pablo, 2004) however, refuted the finding of Aniwasal (2000) on celery seeds. On the other hand, the improved uniformity of germination (Table 1) was also in complete agreement with the findings observed in asparagus seeds (Baucas, 1998), rosemary seeds (Pablo, 2004) and celery seeds (Aniwasal, 2000).

The increased seedling emergence percentage, rate and uniformity of seedling emergence (Table 2) obtained in this study complemented previous findings in asparagus seeds (Legueb, 1998), parsley seeds (Baucas, 1998) but not on the rate of emergence of rosemary seedlings (Pablo, 2004). The markedly increase in seedling dry weight of the seedlings from pre-treated seeds for 10 days was attributed to earlier seedling emergence.

Documentation

Plate 1 shows the seedling harvested from the sea water pretreated seeds.

SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

The presowing seed treatment and germination test portions of the study were conducted at the Seed Laboratory of the Horticulture Research and Training Institute (HORTI), while the seedling emergence test was done at the Greenhouse of the Seed Technology Section, Vegetable Crops Division, Department of Horticulture, College of Agriculture, Benguet State University, La Trinidad, Benguet from December 2005 to February 2006 to evaluate the effect of various durations of sea water pre-sowing seed treatments on the germination and emergence; and establish the best duration of sea water pre-sowing seed treatment on the germination and seedling emergence of parsley.

Laboratory germination tests. Pretreating the seeds for 2 and 10 days considerably increased germination percentage against the other treatments except for 8 days duration although were comparable with each other. On one hand, 10 days pretreatment markedly enhanced germination (G_{50}) compared to the other pretreatment durations. This was followed by pre-treatment for 8, 6, 4 and 2 days which also showed significant enhancement on the germination rates *vis-a-vis* the control dry seeds. With regards uniformity of seed germination, 8 and 10 days pretreatment durations were statistically similar but were significantly more uniform (G_{90}-G_{10}) than the other treatment durations. In addition, seedlings which had 2, 4 and 6 days pre-treatment durations also showed considerable germination uniformity compared to the control dry seeds.

Seedling emergence tests. Priming the seeds for 2 to 10 days significantly

increased emergence percentage against the dry seeds but were comparable with the each other. All the pretreated seeds significantly hastened emergence (E_{50}) compared to the control dry seeds. However, 10 days pre-treatment duration was more effective than the other pre-sowing durations. Pretreating the seeds for 10 days was significantly more effective in improving uniformity of emergence (E_{90}-E_{10}) compared to the other durations and the control dry seeds. Nevertheless, the other pretreatment durations markedly improved emergence uniformity against the control dry seeds.

Priming the seeds in sea water for 2 to 10 days increased shoot lengths compared to the control dry seeds. However, 10 days pretreatment was markedly more effective in increasing vegetative growth producing the longer shoots than the other pretreatment durations. Nevertheless, the other priming durations also promoted seedling growth against the control dry seeds. Among the durations of sea water evaluated as a priming agent, only 10 days duration markedly increased seedling root length compared with the other sea water durations and the control dry seeds. Similarly, 8 days duration significantly increased root length over the other durations and the control dry seeds except for 6 days duration. Likewise, the other pretreatment durations markedly promoted root lengths compared to the control dry seeds. All the pretreatment durations of sea water as a pre-sowing seed treatment remarkably increased the seedling dry weight compared to the dry control seeds. However, 10 days pretreatment duration is markedly more effective in improving seedling growth over the other pre-treatment durations.

Conclusion

Pretreating the seeds in sea water for 2 and 10 days considerably increased

germination percentage but 10 days duration was more effective in enhancing germination rate and in improving uniformity of germination.

Priming the seeds for 2 to 10 days significantly increased emergence percentage, significantly hastened emergence rate but10 days pretreatment was more effective in enhancing emergence rate and in improving uniformity of emergence. All the seeds primed for 2 to 10 days increased shoot and root lengths and seedling dry weight, however 10 days pretreatment was markedly more effective in promoting seedling growth.

Recommendation

From the preceeding results and discussion, the use of sea water as a priming agent for parsley is highly recommended for it significantly improved germination and emergence percentages and increased shoot and root lengths and dry weight. Priming the seeds in sea water for 10 days is recommended for parley production.

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APPENDICES

Appendix Table 1. Seed germination (%)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
D_1	96.0	95.0	95.0	95.0	381.0	95.0
D_2	92.0	89.0	90.0	87.0	358.0	90.0
D_3	95.0	86.0	91.0	92.0	364.0	91.0
D_4	95.0	95.0	90.0	92.0	372.0	93.0
D_5	94.0	95.0	94.0	95.0	378.0	95.0
D_6	91.0	88.0	90.0	94.0	363.0	91.0

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Replication	3	22.333	7.444			
Factor A	5	103.833		20.767		
				4.38*	2.90	4.56
Error	15	71.167	4.744			
Total	23	197.333				

* = Significant

Coefficient of variation = 2.36%

Appendix Table 2. Median germination times (h)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
D_1						
					134.00	
					141.00	
					140.13	
					138.00	
					553.13	
						138.28
D_2						
					108.33	
					98.82	
					105.86	
					112.00	
					425.01	
						106.25
D_3						
					76.80	
					65.49	
					58.46	
					86.40	
					287.15	
						71.79
D_4						
					36.00	
					36.00	
					39.00	
					46.36	
					157.36	

39.34

D_5

26.15
25.12
28.00
26.73
106.00
26.50

D_6

211.76
202.20
205.41
215.14
834.51

208.63

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Replication	3	305.886	101.962			
Factor A	5	92673.082	18534.616	615.17**	2.90	4.56
Error	15	451.936	30.129			
Total	23	93430.904				

** = Highly significant

Coefficient of variation = 5.57%

Appendix Table 3. Median spread of germination times (h)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
D_1						
					106.20	
					102.24	
					103.47	
					102.90	
					414.81	
						103.70
D_2						69.90
				53.54		50.40
				56.86	230.70	
				57.68		
D_3						26.74
				25.68		26.40
				30.90	109.72	
				27.43		
D_4						7.43
				6.58		7.05
				8.58	29.64	
				7.41		
D_5						5.18
				5.01		5.56
				5.36	21.11	
				5.28		
D_6						
					155.52	
					141.36	
					154.46	
					151.50	
					602.84	
						150.71

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Replication	3	117.938	39.313			
Factor A	5	67818.227	13563.645	796.23**	2.90	4.56
Error	15	255.517	17.034			
Total	23	68191.681				

** = Highly significant

Coefficient of variation = 7.03%

Appendix Table 4. Seedling emergence (%)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
D_1	100.0	100.0	88.0	97.0	388.0	100.0
D_2	100.0	100.0	92.0	97.0	388.0	96.0
D_3	92.0	92.0	92.0	92.0	368.0	92.0
D_4	100.0	100.0	88.0	97.0	388.0	100.0
D_5	100.0	96.0	80.0	94.0	376.0	94.0
D_6	80.0	80.0	72.0	79.0	316.0	84.0

Analysis of Variance

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Replication	3	432.000	144.000			
Factor A	5	981.333	196.267	16.73**	2.90	4.56
Error	15	176.000	11.733			
Total	23	1589.333				

** = Highly significant

Coefficient of variation = 3.70%

Appendix Table 5. Median emergence times (h)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
D_1						
	201.60					
	200.00					
	186.67					
	156.00					
					744.27	
						186.07
D_2						
	176.40					
	165.33					
	144.80					
	157.33					
					643.86	
						160.97
D_3						
	136.00					
	136.80					
	128.00					
	133.33					
					534.13	
						133.53
D_4						
	120.63					
	112.00					
	102.86					
	105.82					

441.31

110.33

D_5 84.00

86.67 81.43
84.00 336.10
84.03

D_6

272.00
276.00
258.86
261.00

1067.86

266.97

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Analysis of Variance

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Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Replication	3	1184.780	394.927			
Factor A	5	84029.342	16805.868	220.89**	2.90	4.56
Error	15	1141.245	76.083			
Total	23	86355.366				

** = Highly significant

Coefficient of variation = 5.56%

Appendix Table 6. Median spread of emergence times (h)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
D_1						
						156.48
						169.60
						154.40
						162.40
						642.88
						160.72
D_2						
						130.00
						132.48
						125.20
						128.23
						515.91
						128.98
D_3						
						100.80
						107.52
						99.36
						101.60
						409.28
						102.32
D_4						79.80
					80.91	78.93
					79.89 319.53	79.88

D_5			60.48
	72.80		56.57
	64.80	254.65	63.66
D_6			
			233.60
			232.80
			226.08
			223.60
			916.08
			229.02

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Replication	3	266.707	88.902			
Factor A	5	73554.873	14710.975	1377.98**	2.90	4.56
Error	15	160.136	10.676			
Total	23	73981.716				

** = Highly significant

Coefficient of variation = 2.56%

Appendix Table 7. Seedling shoot length (cm)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
D_1	9.06	9.57	9.60	9.43	37.66	9.42
D_2	9.67	9.50	10.57	9.60	39.34	9.84
D_3	11.40	11.07	11.67	11.33	45.47	11.37
D_4	13.10	11.17	11.57	12.23	48.07	12.02

D_5

12.73
13.07
14.20
13.73
53.73
13.43

D_6

8.03
8.13
7.60
8.70
32.46
8.12

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Replication	3	0.765	0.255			
Factor A	5	74.918	14.984	51.20**	2.90	4.56
Error	15	4.389	0.293			
Total	23	80.073				

** = Highly significant

Coefficient of variation = 5.06%

Appendix Table 8. Seedling root length (cm)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
D_1						
	2.76					
	2.97					
	2.83					
	2.67					
					11.23	
						2.81
D_2						
	3.47					
	3.23					
	3.10					
	3.23					
					13.03	
						3.26
D_3						
	3.13					
	3.90					
	3.67					
	3.70					
					14.40	
						3.60
D_4						
	3.77					
	4.07					
	3.87					

3.76
15.47
3.87

D_5

5.00
4.93

4.37
4.23
18.53
4.63

D_6

1.60
1.90

1.90
1.87
7.27
1.82

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Replication	3	0.238	0.079			
Factor A	5	18.497	3.699	70.50**	2.90	4.56
Error	15	0.787	0.052			
Total	23	19.522				

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** = Highly significant

Coefficient of variation = 6.88%

Appendix Table 9. Seedling dry weight (g)

TREATMENT	REPLICATION I	II	III	IV	TOTAL	MEAN
D_1						0.32
					0.33	
					0.33	
					0.31	1.29
						0.32
D_2						0.34
					0.32	
					0.36	
					0.32	1.34
						0.34
D_3						0.34
					0.37	
					0.33	
					0.36	1.40
						0.35
D_4						0.38
					0.37	
					0.37	
					0.38	1.50
						0.38
D_5						0.41
					0.43	
					0.42	
					0.43	1.69
						0.42
D_6						

0.11
0.13
0.12
0.14 0.50
0.13

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Replication	3	0.000	0.000			
Factor A	5	0.211	0.042	209.52**	2.90	4.56
Error	15	0.003	0.000			
Total	23	0.214				

** = Highly significant

Coefficient of variation = 4.41%