Pepper (*Capsicum annuum*) Seed Germination and Vigor Following Nanochitin, Chitosan or Hydropriming Treatments

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Introduction

- Pepper is a warm-season crop that germinates slowly in cool soils, increasing the susceptibility of seeds and young seedlings to disease.
- Seed treatments with natural materials such as chitin and chitosan, increases natural plant disease resistance, improving seed germination and seedling growth of many crop species.
- Acetic acid has also antifungal effects as a seed treatment.
- Hydropriming (hydrating seeds in water followed by redrying) is another popular commercial seed treatment that makes pepper seeds germinate faster.
- There is a growing interest in application of nanoparticles in agriculture to improve seed germination, plant growth and development.
- One hypothesis is that nanochitin would be more permeable resulting in greater uptake into the embryo compared with larger chitosan molecules.

Objectives

- The objective of this study was to compare natural compounds that could be used as seed treatments to increase the speed of bell pepper seed germination, improve diseasse resistance, and improve cold tolerance.

Materials and Methods

- Bell pepper seeds were treated by hydration for 24 hours in aqueous nanochitin suspensions or chitosan solutions (0.001, 0.01 and 0.05% w/v), 1% acetic acid, hydroprimed in distilled water, or treated with 1% Captan (N-trichloromethylthio-4-cyclohexene-1,2-dicarboximide, 50% wettable-powder) fungicide.
- All seeds were dried back to their original moisture content before testing for:
  - Warm standard germination test at 25°C on blotter paper.
  - To calculate mean time to germination (MTG): Radicle protrusion was counted as seed germination 4, 5, 6, 7, 9 and 11 days after sowing to calculate:

$$MTG = \sum (n_i \times t_i) / \sum n_i$$

Where n_i is number of newly germinated seeds at time t_i.

  - Seedling emergence and seedling shoot length in a modified AOSA cold test (at 10°C for seven days before transfer to 25°C for 14 days).
- Based on the results of warm and cold germination tests, seeds treated with 0.05% nanochitin (rod shape) suspension, hydroprimed in distilled water, or 1% Captan as described above were compared with untreated control seeds at 19, 22, 26 and 30°C in growing media on a gusseted thermogradient table.
- The number of emerging seedlings and shoot length were measured at the end of the thermogradient experiment.

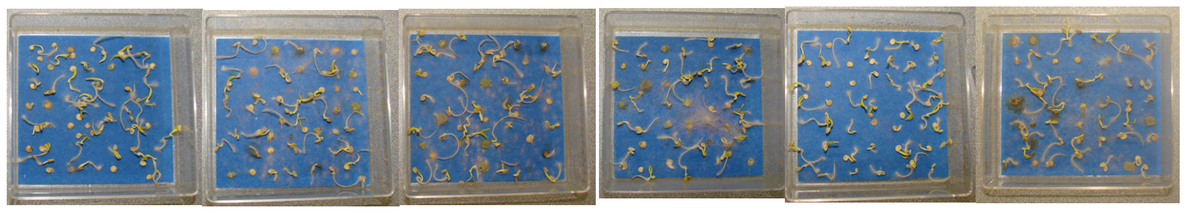
Results

- Treatments with nanochitin or hydropriming reduced MTG to 4.9 days compared with 5.4-6 days for other treatments or untreated seeds at 25°C on blotter paper (Table 1).
- Nanochitin, chitosan, acetic acid or hydropriming treatments enhanced low temperature emergence (cold test) compared with Captan treated or untreated seeds (Table 1).
- Hydroprimed seeds germinated faster with improved emergence similar to nanochitin, but nanochitin also visibly reduced mold and fungal growth on blotter paper (Figure 1).
- Treatments with 0.05% nanochitin or hydropriming improved seedling emergence over a range of temperature from 19 to 30°C (Table 3).

Table 1. Germination percentage, mean time to germination (MTG) from an AOSA germination test at 25°C compared with emergence percentage and seedling shoot length from a cold test of pepper seeds following ten seed treatments.

Seed treatments	Warm standard germination		Cold test	
	Germination (%)	MTG (days)	Emergence (%)	Seedling shoot length (mm)
Nanochitin (rod shape)				
0.001%	82 ns	4.9 d	53 a	48.4 ab
0.01%	88	4.9 d	55 a	45.6 bc
0.05%	85	4.9 d	52 ab	50.7 ab
Chitosan				
0.001%	76	5.5 bc	50 ab	50.0 ab
0.01%	81	5.4 c	54 a	53.0 a
0.05%	83	5.7 ab	49 ab	51.7 ab
Hydroprimed	84	4.9 d	57 a	49.2 ab
1% acetic acid	83	5.7 abc	57 a	41.9 cd
1% Captan	87	5.8 a	38 bc	41.1 cd
Untreated	78	6.0 a	32 c	39.0 d

Means followed by same letters are not significantly (ns) different ($P \leq 0.05$) by LSD.



Nanochitin | Chitosan | Acetic acid | Hydroprimed | Captan | Untreated

Figure 1. Mold growth on day-11 in a standard germination test at 25°C of pepper seeds. Nanochitin treated seeds had less disease similar to Captan fungicide treatment.

Table 2. Seedling emergence and root and shoot lengths for pepper seeds treated with nanochitin, Captan or hydroprimed. Seeds were germinated at 19, 22, 26 and 30°C in soil on a gusseted thermogradient table.

Treatment †	Emergence (%)				Mean	Shoot length (mm)				Mean
	19	22	26	30		19	22	26	30	
Nanochitin (W) 0.05%	32	85	90	87	**74 a ǂ**	11	37	45	48	**35 a**
Hydroprimed	32	93	90	83	**75 a**	13	38	45	46	**35 a**
1% Captan	10	79	81	80	**63 b**	13	33	45	47	**35 a**
Untreated	6	71	85	81	**61 b**	11	35	45	48	**35 a**
Mean	**20 b**	**82 a**	**87 a**	**83 a**		**12 b**	**36 a**	**45 a**	**47 a**	

Means followed by same letters are not significantly (ns) different ($P \leq 0.05$) by LSD.

Conclusions

- Nnanochitin and hydropriming were the most effective treatments to reduce mean time to germination and improve seedling emergence and growth of bell pepper seeds, particularly at low temperatures where pepper germination is typically poor.
- Nanochitin treatment improved germination but was delivered by hydropriming making it difficult to separate the effects.
- Nanochitin treatment produced fewer diseased seeds and seedlings at warm temperatures, similar to fungicide treatments.