GERMINATION AND EMERGENCE OF FRESH AND AGED SWEET PEPPER (*Capsicum anuum* L.) SEEDS AS INFLUENCED BY OSMOCONDITIONING TREATMENTS

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ABSTRACT

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Osmoconditioning using polyethylene glycol (PEG) '6000' solution restored the germination capacity of sweet pepper seeds subjected to accelerated ageing treatment to the level of the germination capacity of fresh seeds. It also enhanced uniformity of germination time and speed of germination and seedling emergence of the aged seeds. In fresh seeds, osmoconditioning did not further improve germination percentage but enhanced uniformity and rate of seed germination and seedling emergence. It caused development of taller, more vigorous and heavier seedling in both fresh and aged seeds.

The optimum osmotic potential of the PEG solution was -4 bars. Pretreatment duration of 8 days proved to be more effective than just 4 days.

KEY WORDS: Accelerated ageing. Osmoconditioning. Osmotic potential. Polyethylene glycol (PEG). Sweet pepper.

INTRODUCTION

The growth, development and final yield of vegetable crops are determined to a large extent by the rate and uniformity of seedling emergence and their subsequent vigor and establishment in the field. Ideal environmental condition is seldom met in the nursery where seedlings are raised, or in the field where some crops are directly seeded. The lag period from sowing to emergence predisposes the seeds to environmental stresses like extreme temperatures, water or oxygen deficit, soil crusting and pathogens (Cavallero et al., 1994). Consequently, the seedlings that develop are weak and their production potential is reduced.

One way of solving the problem is to accelerate seed germination and seedling emergence so that environmental stresses can be avoided. This can be done by subjecting seeds to certain pretreatments. One of the seed pretreatment method is osmoconditioning which involves hydrating the seeds in an osmotic solution created by an osmoticum. As a result, the water content within the seeds increases and permits pregerminative processes to occur but prevents cell division and radicle emergence (Karssen and Wages, 1987). Polyethylene glycol (PEG), an inert, non-toxic, high molecular weight compound is considered a good osmoticum because it allows hydration without penetrating into the seed (Michel and Kaufman, 1973).

Osmoconditioning has been found to enhance the rate and synchrony of seed germination and seedling emergence of a number of crops including carrots (Yanmaz, 1994), celery (Singh et al., 1985) and tomato (Saxena and Singh, 1987). The enhancement of germination and emergence leads to better plant growth, development and improved yields (Muhyaddin and Wiebe, 1987). Moreover, osmoconditioning has been reported to be particularly effective in restoring the germination potential of seeds which have undergone partial deterioration (Fu, 1988; Saxena and Singh, 1987).

This study aimed to determine the optimum PEG concentration and pretreatment duration in enhancing the germinability, emergence and subsequent seedling vigor of sweet pepper and compare the response of fresh and aged seeds to osmoconditioning treatments.

MATERIALS AND METHODS

Seeds of sweet pepper (*Capsicum anuum*), cultivar "California Wonder" were used in this study.

A two-factor factorial experiment was laid out in Completely Randomized Design with 3 replications. The first factor was state ofthe seed which consisted of fresh seeds and seeds subjected to accelerated ageing. The second factor was osmotic potential and pretreatment duration which consisted of control (w/o pretreatment), -4 bars for 4 days, -6 bars for 4 days, -8 bars for 4 days, -4 bars for 8 days, -6 bars for 8 days and -8 bars for 8 days.

For the accelerated ageing method, seeds were placed inside paper packets sealed at one end. The packets were then placed inside a bottle jar half-filled with water and fitted snugly with perforated cardboard as rack. The jar was sealed with four layers of paper to create high relative humidity condition inside the jar. The set-up was stored inside an oven at 45°C. The duration of ageing which caused at least 10% reduction in germination was considered. This proved to be 4 days.

For seed pretreatment, 100 mL PEG solutions with osmotic potentials of -4, -6 and -8 bars were prepared according to the formula given by Michel and Kaufman (1973). In a petri dish lined with filter paper, the osmotic solution was added to saturate the filter paper. The petri dish was placed in a germinator maintained at 25°C for a period of 4 or 8 days depending upon the treatment. Seeds that germinated during the pretreatment process were discarded. After the pretreatment, ungerminated seeds were washed thoroughly to remove the osmoticum, and dried in a blotter paper.

A hundred pretreated seeds were sown in petri dishes lined with filter paper saturated with 10 mL of distilled water. The dishes were covered and incubated at 25°C inside a germination chamber. Germination was monitored over a 14-day period. Seeds showing signs of radicle protrusion were counted as germinated.

Ten plastic cells (3 cm x 5 cm) filled with hot water-sterilized germination medium (1:1:1 sand, garden soil, compost) were prepared per treatment. Two seeds were sown in each cell. Later, only one seedling was allowed to grow per cell. Watering was done when necessary.

Data on percent germination (PG), coefficient of rate time (CRG) and standard deviation of germination time (SDG) were gathered after the germination test using the following formula:

PG = n/N

CRG = $n/[s_1(1) + s_2(2) + ... + s_x(x)]$

SDG = $[\{D^2 - (D)^2/n\}/(n-1)]^{1/2}$

where:

n = total number of seeds germinated

N = total number of seeds sown

s_1 = number of seeds germinated on day, D

x = last day of germination

D = number of days from sowing to germination

After the seed germination test, the percent seedling emergence (PSE), average number of days to emergence (AND), number of leaves, seedling height and seedling vigor were taken. PSE and AND were computed based on the following formula:

PSE = n/N

AND = $[s_1(1) + s_2 + ... + s_x(x)]/n$

where:

n = total number of seedlings emerged

N = total number of seeds sown

s_1 = number of seedlings emerged on the day, D

x = last day of germination

D = number of days from sowing to emergence

Seedling vigor was rated based on the following scale:

1 - very vigorous
2 - vigorous
3 - moderately vigorous
4 - weak
5 - very weak

The last three parameters were gathered 2 wks from seedling emergence based on average number of days to emergence.

RESULTS AND DISCUSSION

Germination percentage

The percentage germination of fresh sweet pepper seeds and those exposed to accelerated ageing, as influenced by osmoconditioning is presented in Table 1. On fresh seeds, osmotic pretreatment did not cause any significant increase in percent germination. However, in aged seeds pretreatment of -4 to -8 bars for 8 days caused significant increase in percent germination by as much as 8-10%. Pretreatment duration of 4 days was effective only when the osmotic concentration was -8 bars. Percentage germination of aged seeds became comparable with that of fresh seeds when subjected to osmoconditioning.

The increase in percent germination of aged seeds due to pretreatment may be attributed to the activation of biosynthetic mechanism causing 'repair' of the damaged portion of the seeds, particularly the membranes, during osmoconditioning (Fu, 1988; Saxena and Singh, 1987). Such biosynthetic repair mechanism includes increased synthesis in DNA and RNA as well as enhanced activity of many key enzymes such as isocitrate lyase for lipid metabolism and ATPase and phosphatase for mobilization of food reserves and production of ATP molecules, among others.

Table 1. Percent germination of fresh and artificially aged sweet pepper seeds as influenced by pretreatment using PEG solution at different osmotic potentials and pretreatment duration.[1]

Pretreatment	State of Seeds		Pretreatment Mean
	Fresh Seeds	Aged Seeds	
Control	92.67 abc	85.66 d	89.16 a
-4 bars; 4 days	96.00 ab	80.00 e	88.00 d
-6 bars; 4 days	94.33 abc	89.66 cd	92.00 bc
-8 bars; 4 days	95.33 ab	92.00 bc	93.66 ab
-4 bars; 8 days	93.33 abc	94.66 ab	94.00 a
-6 bars; 8 days	97.33 a	93.33 abc	95.33 a
-8 bars; 8 days	96.66 ab	95.33 ab	96.00 a
State of seed means	95.14 a	90.04 b	

[1] CV (%) = 2.68;State of seed interaction meansand state of seed means followed by a common letter are not significantly different at 5% level according to Duncan's Multiple Range Test (DMRT).

Rate of germination and seedling emergence

Accelerated ageing was also found to decrease the rate or speed of germination measured in terms of CRG (Table 2). The higher the CRG value, the faster is the speed of germination. In both fresh and aged seeds, osmoconditioning caused significant increase in CRG with maximum promotion at osmotic potential of -4 bars at 8 days time.

In terms of rate of seedling emergence from the soil, osmoconditioning also showed similar promotive effect on both fresh and aged seeds (Table 3). The best pretreatment was also found to be -4 bars at 8 days pretreatment duration which significantly shortened the average number of days to seedling emergence by as much as 50 and 40% relative to the control fresh and aged seeds, respectively.

The advanced seed germination and seedling emergence of sweet pepper brought about by the pretreatment could be attributed to hydration of seeds that permitted pregerminative processes but not cell division and

Table 2. Coefficient of rate of germination of fresh and artificially aged sweet pepper seeds as influenced by pretreatment using PEG solution at different osmotic potentials and pretreatment duration.[1]

Pretreatment	State of Seeds		Pretreatment
	Fresh Seeds	Aged Seeds	Mean
Control	16.6 f	12.5 g	14.5 ed
-4 bars; 4 days	33.5 d	20.8 ef	27.1 cd
-6 bars; 4 days	34.5 d	22.8 e	28.7 c
-8 bars; 4 days	24.8 e	21.3 ef	23.0 d
-4 bars; 8 days	74.0 ab	55.5 c	64.7 a
-6 bars; 8 days	78.6 a	38.6 d	58.6 b
-8 bars; 8 days	69.0 b	51.7 c	60.4 ab
State of seed means	47.3 a	31.9 b	

[1] CV (%) = 11.82; State of seed interaction means and state of seed means followed by a common letter are not significantly different at 5% level according to DMRT.

Table 3. Average number of days to seedling emergence of fresh and artificially aged sweet pepper seeds as influenced by pretreatment using PEG solution at different osmotic potentials and pretreatment duration.[1]

Pretreatment	State of Seeds		Pretreatment
	Fresh Seeds	Aged Seeds	Mean
Control	8.82 b	10.48 a	9.65 a
-4 bars; 4 days	6.93 de	8.46 b	7.69 bc
-6 bars; 4 days	7.45 cd	8.61 b	8.03 b
-8 bars; 4 days	7.08 de	7.82 c	7.44 c
-4 bars; 8 days	5.13 g	5.82 f	5.47 e
-6 bars; 8 days	4.80 g	5.95 f	5.37 e
-8 bars; 8 days	6.47 e	5.81 f	6.28 d
State of seed means	6.69 a	7.56 b	

[1] CV (%) = 4.64; State of seed interaction means and state of seed means followed by a common letter are not significantly different at 5% level according to DMRT.

subsequent radicle emergence due to the steep water potential created by the osmoticum. The same findings were reported by Karssen and Wages (1987).

Uniformity of seed germination

Another important germination parameter is the uniformity of germination. This is measured in this study as standard deviation of germination time (SGD); the lower the value, the more uniform is germination time. Only the main factor effect between the two factorswas found to be insignificant (Table 4). The aged seeds were found to have higher SDG value than the fresh seeds. Regardless of the state of seed, osmoconditioning appeared to improve uniformity of germination although

Table 4. Standard deviation of germination time (SDG), percentage seedling emergence (PE) and the number of leaves (NL) per seedling developed from fresh and artificially aged sweet pepper seeds as influenced by pretreatment using PEG solution at different osmotic potentials and pretreatment duration.[1]

Pretreatment	SDG (day)	PE (%)	NL
State of Seed			
Fresh	1.47	90.95 a	4.21 a
Aged	1.80	87.14 b	3.69 b
Pretreatment			
Control	2.41 a	77.22 c	2.16 c
-4 bars; 4 days	1.97 ab	87.27 b	4.11 ab
-6 bars; 4 days	1.58 ab	89.44 b	4.16 ab
-8 bars; 4 days	1.68 ab	92.23 ab	3.94 b
-4 bars; 4 days	1.26 b	90.57 b	4.38 a
-6 bars; 4 days	1.41 ab	90.55 b	4.33 ab
-8 bars; 4 days	1.15 b	95.56 a	4.11 ab
CV (%)	39.18	4.21	3.78

[1]Means in a column followed by a common letter are not significantly different at 5% level according to DMRT.

only pretreatments -4 and -8 bars for 8 days significantly reduced SDG relative to the control. It is possible that during pretreatment, when uptake of water is controlled by high osmotic potential, the "slower" seeds were able to catch up with the "faster" ones so that subsequent germination was much more uniform than that of untreated seeds.

Height, vigor and dry weight of seedlings

The height and vigor of seedlings taken 2 wks after their emergence from the soil were significantly affected by the state of seed and pretreatment (Table 5). Seedlings developed from fresh seeds were taller and more vigorous but had comparable dry weight with those that developed from aged seeds. The pretreatments caused production of taller, more vigorous and heavier seedlings. All the pretreatments caused more or less similar

Table 5. Seedling height (SH), seedling vigor (SV) and seedling dry weight (SDW) of 2-wk old seedlings developed from fresh and artificially aged sweet pepper seeds as influenced by pretreatment using PEG solution at different osmotic potentials and pretreatment duration.[1]

Pretreatment	SH (cm)	SV	SDW(g)
State of Seed			
Fresh	12.19 a	1.24 a	0.58
Aged	11.49 b	1.52 b	0.57
Pretreatment			
Control	9.78 c	2.44 a	0.31 d
-4 bars; 4 days	11.49 b	1.28 b	0.55 c
-6 bars; 4 days	11.95 b	1.33 b	0.59 b
-8 bars; 4 days	12.22 ab	1.17 b	0.60 b
-4 bars; 4 days	12.68 a	1.11 b	0.65 a
-6 bars; 4 days	12.64 a	1.16 b	0.65 a
-8 bars; 4 days	12.14 ab	1.16 b	0.66 a
CV (%)	5.88	22.71	5.69

[1] Means in a column followed by a common letter are not significantly different at 5% level according to DMRT.

enhancing effect in terms of height and vigor of the seedlings. With regard to increasing seedling dry weight, pretreatment duration of 8 days appeared to be more effective regardless of osmotic potential of the medium.

Results of this study suggest that osmoconditioning of sweet pepper seeds using PEG solution has the potential of restoring the germination potential of partially deteriorated seeds, enhancing uniformity and speeding up seed germination and seedling emergence of both fresh and aged seeds, and producing better quality seedlings.

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