

STORAGE TECHNIQUES FOR EXTENDING THE VIABILITY OF PRE-GERMINATED CUCUMBER SEED¹

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ABSTRACT

Germinated cucumber seeds were placed in two different packaging materials, suspended in three different media and stored at two temperature levels. Performances of the stored seeds were evaluated in a greenhouse under different storage periods. Viability of pre-germinated cucumber seeds was excellent up to 10 days in all environments. If pre-germinated seeds were stored longer, the reduction of seedling emergence ranged from 10% to 70% and tended to produce longer radicles. Longer radicles were difficult to handle and emerged slightly earlier than shorter ones, but enhanced the production of abnormal seedlings. Radicle elongation was linearly related to storage duration. Rapid radicle elongation occurred in cold air medium, while elongation was minimal in corn starch medium. However, corn starch medium seemed more unfavourable to maintain post storage viability and vigour. No single factor was favourable to extend the storage life of pre-germinated cucumber seeds, but both storage media and temperature seemed to be critical factors. Plant dry weight had strong correlation with storage duration for all storage period tested. Post-storage viability and vigour decreased when the storage duration was longer. Degradation of functional structures, increase of fatty acid content and enzymic degradation were suggested as reasons for loss of vigour.

KEY WORDS: Cucumber, Pre-germinated seeds, Radicle length, Seed storage, Seed vigour, Viability

INTRODUCTION

Fluid drilling is a planting technique, which leads to early establishment, uniform seedling stand and a better yield in most crops. In this technique pre-germinated seeds are sown with a carrier fluid

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soon after they develop 1—2 mm long radicles. However, germinated seeds are delicate, susceptible to mechanical damages and perishable like fruits and vegetables. Hence these seeds should be sown soon after they develop radicles.

Due to reasons such as inclement weather and equipment or labour failure in planting, the germinated seeds are not used immediately. If not properly stored, these seeds could either rot or develop long radicle and then gradually lose their viability. It is therefore necessary to develop methods for increasing the storability of germinated seeds and to make fluid drilling a more practical method of sowing.

Ability to store pre-germinated seeds for several weeks would also enhance the germinated seed marketing industry. In this connection, pre-germinated seed could be commercially produced, stored and then marketed to the farmers when needed. This would reduce loss of seed in germination, minimise farmers' complaints and eliminate risk if the sowing is delayed.

Many researchers have attempted to increase the storability of pre-germinated seeds (Brocklehurst *et al.*, 1980; Finchsavage, 1981; Frazier *et al.*, 1982; Ghatte *et al.*, 1986; Pill and Fieldhouse, 1982). However, the results varied greatly with the crop species, storage temperature and storage media. Hence, development of a suitable technique for extending storage life of pre-germinated vegetable seeds would be beneficial for small scale vegetable farmers.

This paper reports a procedure for storing pre-germinated cucumber seeds using locally available materials and its effect on the external features after storage period of up to 20 days and the seedling performance up to 9 days after planting.

MATERIALS AND METHODS

Experimental procedure

Germinated seeds of cucumber (*Cucumis sativus* L. cv. Pilmaria) were packed in two different packaging materials, suspended in three different media and stored under two different temperatures up to 20 days. Performance of the stored seeds was evaluated in the laboratory

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and greenhouse after four different storage periods (5, 10, 15 and 20 days). The experiment was laid out in a $2 \times 3 \times 2 \times 4$ factorial complete randomized design with 3 replications. There were 100 seeds in each experiment unit.

Seed germination technique and packaging materials

Seeds were germinated by immersing in deionized water at 25°C for 24 to 48 hours and aerated with a stream of humidified air bubbles which caused a constant circulation of the seed with water. This technique maintained the germinating seeds in suspension and the length of radicle between 1—3 mm long.

Two packaging materials, glass bottles (P_1) with 100 ml capacity (size M-730) and 100 micron thick aluminium laminated polyethylene bags (P_2), were used.

Preparation of the media and incorporation of germinated seeds with the medium

Native gelatin or "gulaman gel" (M_1) (21.9 g/l), pure corn starch (M_2) (37.5 g/l) and cold air (M_3) were used to prepare the media. The correct viscosity standard was determined by placing a pre-germinated seed on the surface of the medium and then shaking it smoothly in order to suspend the seed without totally drowning it in the medium.

A systemic fungicide (benlate) at a concentration of 0.3 g/l was added to the medium to avoid microbial contamination. The containers were filled with the medium and sterilized in an autoclave at 15 psi and 105°C for 30 minutes.

Two temperature levels, 5°C (T_1) and 10°C (T_2) were tested. A refrigerator was used to maintain 10°C while a cold room was used to obtain 5°C. All the stored seeds were sown on the same day with three other freshly germinated controls (unstored, 0 day), so that all emerging seeds were exposed to the same environmental conditions. These procedures were repeated at five-day intervals to provide 5 (S_1), 10 (S_2), 15 (S_3) and 20 (S_4) day-storage periods.

Prior to sowing, randomly selected seeds were analyzed for radicle length, colour changes and moisture, and compared with freshly germinated unstored seeds. The necrotic damages due to treatments were observed under the microscope. Other visual signs of stored seeds such as wetness, mold development etc. were also examined both visually and under the microscope.

Planting techniques

Stored seeds were sown in seed boxes containing 1:1:1 fine sand, coir dust and soil mixture, under greenhouse condition. Seeds were planted in rows (150 cm long), using a hand made plastic funnel-like structure. The medium acted as a carrier for the seeds and minimized mechanical damage during the planting process. Pure water was used as the carrier medium when planting the seeds stored in cold air. The first irrigation was applied just after sowing to wash off the excess medium on the soil. These seed boxes were arranged randomly inside the greenhouse.

Emergence data and analysis

All emergence counts of the samples, plant height and dry weight were taken at three-day intervals up to nine days. Seedlings without the essential structures, badly damaged, deformed, unbalanced or decayed, were counted as abnormals.

Seedling vigour (Vigour Index)

Speed of emergence was suggested as a vigour indicator of the seedlings and it was calculated using the following equation (Maguire, 1982):

$$\times = \frac{\text{Number of normal seedlings}}{\text{Days of first count}} + - + \frac{\text{Number of normal seedlings}}{\text{Days of final count}}$$

where, $\times$ is the seedling vigour.

Data gathered were, percent emergence, number of abnormals, length of radicles, height of plant and dry weight of seedlings.

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RESULTS AND DISCUSSION

The radicle growth pattern of the seed stored in different treatment combinations varied. Seeds stored in cold air treatments developed long curly radicle that resulted in abnormal seedlings. Seeds having long radicle were difficult to separate since they were very delicate. Some radicle grew upwards, before it grew normally downward leading to crooked seedlings. Almost all treated seeds had elongated radicle. However, in some of them the tips rotted after 10 days storage.

Pre-germinated cucumber seeds stored in cold air appeared to have free moisture. The radicle colour was primarily yellowish white and 60% of them produced 5—8 mm long radicles (Table 1). Seeds stored with corn starch in aluminium bags produced a distinct odour at both temperatures and changed into brownish colour. These seeds exuded a creamy coloured, highly viscous solution when pressed with fingers. However, seeds stored in cold air produced almost perfect plant stand within 5 days.

The necrosis damages in root tips were possibly due to cell damage caused by the accumulation of ethanol under anaerobic conditions. These necrotic damages were also observed by Frazier *et al.* (1982) in stored pre-germinated snapdragon seeds and they suggested that the damages were due to the low oxygen diffusion rate and pH changes in the medium. These damages could also be attributed to the activity of anaerobic enzymes which results in the production of CO_2 and little amount of C_2H_4 . Siegel and Rosen (1962) who also reported such damages however, suggested that O_2 diffusion was the more important factor than CO_2 diffusion when the seeds were germinated under water.

Some samples developed distinct odour after the storage. This may be due to the restricted gas exchange. The production of thick, dense creamy coloured solution could be attributed to the tissue damage occurring at low temperatures. Sometimes, this may be due to the various reactions between the stored food of the seeds and the storage medium.

Table 1. Visual assessment of pre-germinated cucumber seeds stored under different treatment combinations up to 20 days

TREATMENT CODE	STORAGE PERIOD (DAYS)							
	5		10		15		20	
	Radicle length (mm)	Seed colour and condition	Radicle length (mm)	Seed colour and condition	Radicle length (mm)	Seed colour and condition	Radicle length (mm)	Seed colour and condition
P1M1T1	2—4	W	2—6	Y	4—7	Y	4—7	Y
P1M1T2	2—4	Y/W	2—6	Y	4—8	Y	4—8	Y
P1M2T1	2—6	Y/W	2—6	W/Y	3—7	Y/W	4—7	Br/Y odour
P1M2T2	2—6	W	3—5	W/Y	3—8	Y/W odour	4—8	Br/Y odour
P1M3T1	3—5	W/Y	4—8	Y	5—8	Y partially dry	5—10	Y partially dry
P1M3T2	3—6	W/Y	5—10	Y/W	6—12	Y dry	6—13	Y
P2M1T1	3—5	W	4—6	Y	5—7	Y	6—8	Y
P2M1T2	3—5	W/Y	4—6	Y	5—7	Y	6—8	Y
P2M2T1	2—4	W/Y	2—5	Y odour	4—6	Y odour	5—8	Br/Y odour
P2M2T2	2—5	Y	3—5	Y/W	4—7	Y odour	5—8	Br/Y odour
P2M3T1	2—4	Y	3—6	Y/W	4—7	Y partially dry	5—8	Y
P2M3T2	2—3	W/Y	5—8	Y/W	5—8	W/Y	6—10	Y

Almost all seeds have 2—3 millimetre long white radicles at the time of storing

W = White; Y = Yellow; Br = Brown

P1 = Glass bottles; P2 = Aluminium envelopes; T1 = 5°C

M1 = Gelatin; M2 = Corn starch; M3 = Cold air; T2 = 10°C

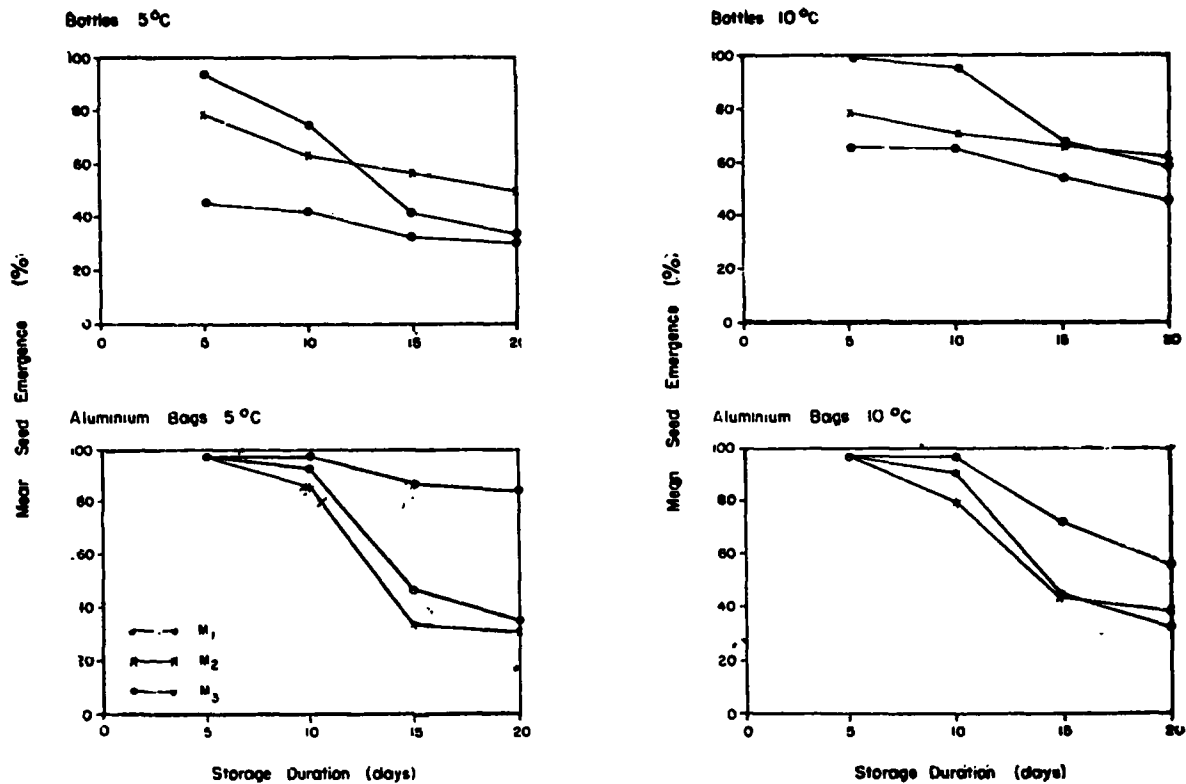


Fig. 1. Relationship between seed emergence and storage duration of pre-germinated cucumber seeds

The discolouration and the drying of the radicle tips could be due to the dehydration of the tissues, and the chilling injury under low temperature near freezing point.

Greenhouse emergence

Fig. 1 shows the relationship between mean seed emergence and storage time of pre-germinated cucumber seeds. Most of the seeds stored in different treatments performed well up to 10 days.

A strong linear relationship (negative) between seed emergence and storage period was observed. Similar finding has been reported earlier by several workers for different seeds (Irwin and Price, 1981; Wurr *et al.*, 1981; Finch-savage, 1981; Gray, 1978). Longer storage duration resulted in a decreased seed emergence. Many factors which caused decrease in seed emergence had been already identified by the earlier workers. The reduction of reserve food and glycolytic activity were some of the suggested reasons. Gray (1985) noted that the dehydrogenase activity increased with increasing period of storage.

Radicle length and abnormal seedlings

The higher the number of seed with long radicle, the higher the number of abnormal seedlings in post-storage seedling emergence of pre-germinated cucumber. The interaction effect of media $\times$ temperature $\times$ storage duration has significantly affected the occurrence of abnormal seedlings (Table 2). An increasing trend in the occurrence of abnormal

Table 2. Interaction effects of storage media $\times$ temperature and storage duration on occurrence of abnormal seedlings in pre-germinated cucumber seeds.

MEDIA	Temperature					
	5°C			10°C		
	Gel (M ₁)	Corn starch (M ₂)	Cold air (M ₃)	Gel (M ₁)	Corn starch (M ₂)	Cold air (M ₃)
Storage duration						
5 days	3.188 _c	3.239 _c	3.188 _c	3.213 _c	3.363 _{b c}	3.525 _{b c}
10 days	3.288 _c	3.258 _c	3.500 _{b c}	3.238 _c	3.462 _{b c}	3.586 _{b c}
15 days	3.484 _b	3.537 _{b c}	3.484 _{b c}	3.530 _{b c}	3.490 _{b c}	3.790 _{b c}
20 days	3.484 _{b c}	3.758 _{b c}	4.401 _a	3.500 _b	3.595 _{b c}	4.481 _a
CV 9.1%						

Means with the same letters are not significantly different when compared by DMRT at 5% level.

The mean number in occurrence of abnormal seedlings of unstored seeds was 2.92

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seedlings was observed when the storage duration and temperature were increased. The longest radicle length was observed among the seeds stored at 10°C in cold air medium treatments for 20 days storage. Most of the abnormal seedlings did not produce a tap root but had a crooked stem. The interaction effects of media $\times$ temperature $\times$ storage duration was significantly affected by the differences in radicle length. Seeds stored in cold air produced long radicle that were entangled with each other after 10 days. It was very difficult to separate them and therefore these seeds were not suitable for fluid drilling. These observations were similar to the findings of Ghate and Chinnan (1986). Some elongated radicle became dry 10 days after storage. Seeds stored in gelatin and corn starch medium had radicles with a reasonable length and were suitable for fluid drilling. Longest radicles were obtained from seeds packed in aluminium envelopes stored in cold air medium at 10°C.

Fig. 2 shows a fairly good relationship ($r=0.66$) between storage duration and radicle length of stored pre-germinated cucumber seeds.

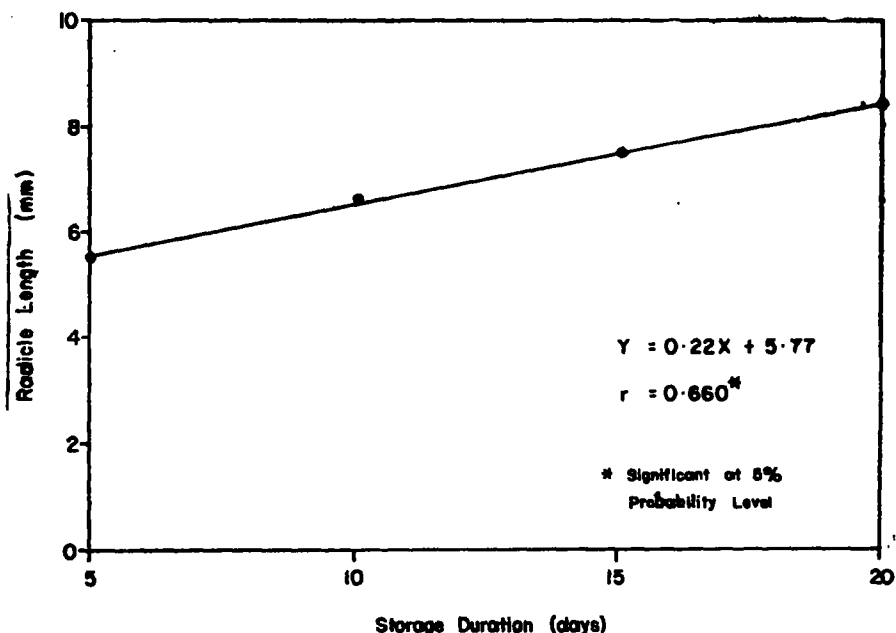


Fig. 2. Relationship between radicle length and storage duration of pre-germinated cucumber seeds

Seeds having radicle longer than 5mm emerged slightly earlier than those with short radicle and tend to produce crooked or abnormal seedlings. When the storage time increases, there was an increase in the radicle elongation which resulted in a higher production of abnormal seedlings.

These findings also indicate that higher seedling establishment can be obtained by sowing pre-germinated seeds, but it could lead to the production of abnormal seedlings when pre-germinated seeds were stored under unfavourable conditions for a long time.

The erratic effects of cold storage on radicle elongation and emergence suggested that there are phases of germination, like radicle growth and emergence which are individually controlled by temperature. Haber and Luippold (1960) showed that initiation of cell division and cell expansion during germination was controlled by separate mechanisms. Therefore, the observations related to radicle elongation agreed with the early findings.

The interaction effect of temperature $\times$ packaging materials $\times$ medium $\times$ duration indicates that no single factor alone can influence the post-storage seed vigour. However, seeds stored in cold air had induced post-storage shoot growth. Results of this experiment indicate that storage of pre-germinated seeds at relatively low temperatures was detrimental to both seed viability and post-storage vigour.

A linear relationship ($r=0.87$) was observed between seedling dry weight and storage duration (Fig. 3). These findings were similar to those of Ghate and Chinnan (1986) and Frazer *et al.* (1982). The possible explanation for these results is that the post-storage vigour is most likely dependent on storage conditions.

Vigour index

Fig. 4 indicates the relationship between vigour index and storage period of pre-germinated cucumber seeds. A clear reduction in vigour index was observed when the storage time was increased compared to unstored seeds. At all times, treated seeds have shown a decreased

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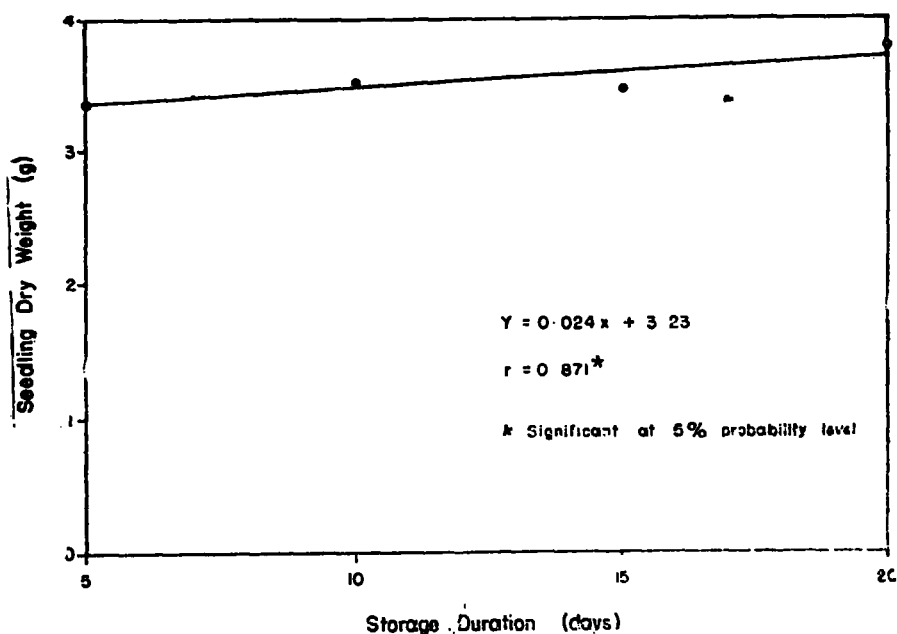


Fig. 3. Relationship between seedling dry weight and storage duration of pre-germinated cucumber seeds

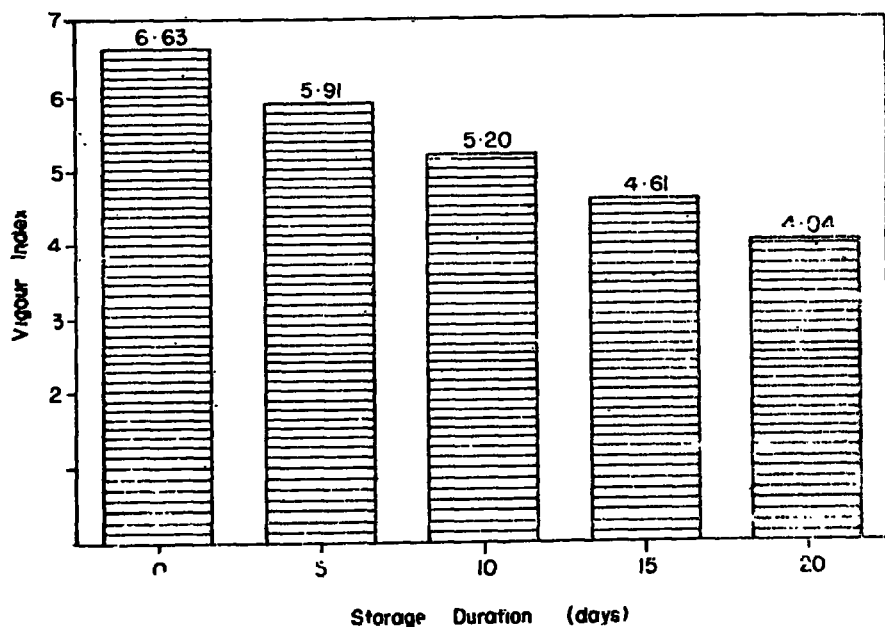


Fig. 4. Relationship between vigour index and storage duration of pre-germinated cucumber seeds stored under different treatment combinations

vigour index compared to unstored germinated seeds. This indicates that packaging methods, storage media and temperature together with storage duration, would play a major role on post-storage seed vigour.

CONCLUSIONS

The results suggest that seeds stored with cold air at 5°C in both packaging materials would help to maintain the viability of pre-germinated cucumber seeds up to 10 days.

A marked reduction in seedling emergence was observed in all storage environments after 10 days storage. Cold air medium produced the longest radicles which are not suitable for fluid drilling. Elongated radicle enhanced the occurrence of abnormal seedlings. Therefore, attempts should be made to reduce radicle elongation during the storage time of pre-germinated seeds.

Media, pH changes, low oxygen diffusion, accumulation of ethanol and various gases like C_2H_4 and CO_2 , mechanical damages, increase of leachates and breakdown of metabolic mechanisms are the suggested factors found to decrease vigour of stored pre-germinated cucumber seeds.

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