

Eco-Physiological Studies on *Citrullus colocynthis* (L.) Schard and *Cucumis prophetarum* (Jusl. ap.) L. in Saudi Arabia. 1. Seed Germination

M.M. Al-Farraj, Ali A. Al-Helal, R.A. El-Desoki and I. Al-Hubshi

*Botany Department, College of Science, King Saud University,
P.O. Box 2455, Riyadh 11451, Saudi Arabia*

ABSTRACT. Water absorbed as percentage of original weight of seeds of *Citrullus colocynthis* and *Cucumis prophetarum* increased markedly during the first experimental four hours and reached constancy thereafter. Percentage water absorbed after 24 hr was 20 and 34 for freshly harvested seeds and seeds stored for one year of *Citrullus* compared to 92% for *Cucumis* seeds.

Seed germination percentage of *Cucumis* at different temperatures increased rapidly during the first four days, the highest being 68% on the fifth day at 25°C.

Freshly harvested seeds of *Citrullus* as well as seeds stored for one year are dormant, while seeds stored for eight years reached their highest germination (50%) at 25°C on the 10th day. However chilling for one month at 4°C or treatment with 500 ppm kinetin (K) stimulated germination of seeds stored for one year where germination was 37 and 23% respectively. Neither gibberellin A₃ (GA) nor mixture of GA and K stimulated the germination of these seeds. Sulphuric acid failed to stimulate germination of freshly harvested seeds.

Citrullus colocynthis and *Cucumis prophetarum* are widely distributed plants in Saudi Arabia (Migahid 1978, Chaudhary and Zawawi 1983, and Collenette 1985).

The intact seed of *Citrullus colocynthis* has been shown to resist germination under various conditions in the lab and high percentage of germination occurred either by removing the seed coat (Koller *et al.* 1963 and Bhanderi and Sen 1975) or by applying mechanical pressure to the testa (Koller *et al.* 1963). Seed coats seem to inhibit seed germination and this inhibition may be due in part to the resistance of the testa to embryo expansion (Koller *et al.* 1963 and Bhanderi and Sen 1975) or to the secretion of substances which inhibit germination (Bhanderi 1974). However, the exudate of the testa did not inhibit the germination of decoated seed of *Citrullus*.

Light and temperature are major factors that affect seed germination of desert and semidesert plants (Harrington 1916, Koller *et al.* 1963, Bhanderi and Sen 1975, and Mahmoud 1985).

In regard to *Citrullus* it seems that there is disagreement amongst the different investigators about the optimal temperature for germination (Koller *et al.* 1963 and Bhanderi and Sen 1975).

In this study several experiments were carried out to elucidate the time course of water uptake and of germination percentage of *Citrullus* and *Cucumis* seeds at different temperatures and to assess the effect of chilling and of hormones on seed germination of *Citrullus*. Both chilling and hormones are known to break seed dormancy of many plant species (Grime *et al.* 1981, and Mayer and Poljakoff-Mayber 1982).

Materials and Methods

Materials

Citrullus and *Cucumis* seeds were collected from the central region of Saudi Arabia and were stored in closed containers at room temperature. Gibberellin A₃ (GA) was obtained from United States Biochemical Corporation, Cleveland, USA. Kinetin (K) (6-furfurylaminopurine) was obtained from BDH Chemicals Ltd., Poole, U.K.

Chilling

Large quantities of seeds were kept at 4°C in a closed container until use.

Imbibition

Twenty seeds were weighed dry and then soaked in distilled water and after a period of time, seeds were blotted dry on filter paper, and weighed again (four replicates were used for each treatment). Imbibition was expressed as the percentage of water absorbed to original seed weight

$$\left(\frac{\text{wet weight} - \text{dry weight}}{\text{dry weight}} \times 100 \right).$$

Sulphuric Acid Treatment

Eighty seeds (20 seeds × 4 repliate) were soaked in concentrated sulphuric acid for prescribed periods of time (15, 30, 45 or 60 min), then they were washed several times with distilled water weighed and allowed to imbibe water for 24 h at room temperature. Percentage imbibed water was measured as above.

Germination

Large quantities of seeds were allowed to imbibe water overnight, then they were distributed 10 per petri-dish over the surface of two layers of Whatman No. 1 filter paper moistened with distilled water. Four petri-dishes were placed in an incubator at the appropriate temperature under darkness. Radicle emergence was taken as a sign of germination. The number of germinated seeds was counted daily and calculated as percentage of total seeds.

Hormone Treatment

Eighty seeds were soaked in either GA or K solution for 48 h and were germinated as indicated above.

Statistical Analysis

F test and Duncan test were used to analyse the data.

Results

The results presented in Fig. 1 show that water uptake by *Citrullus* and *Cucumis* seeds was maximal during the first four hours. The results also show that after 4 hrs of imbibition the percentage of water absorbed to original weight of *Cucumis* seeds was 3 times that of *Citrullus* seeds.

The percentage of water absorbed of freshly harvested *Citrullus* seeds after 24 h (Fig. 2) was low (20%), while in case of seeds stored for one year it was 34% and for seeds stored for eight years it was 32% (Fig. 1). Treatment of freshly harvested seeds with concentrated sulphuric acid for 15 min significantly (at 99% confidence) reduced water uptake as compared to control, but when the seeds were treated longer than 15 min (30, 45 or 60 min), water uptake showed no significant (at 95% confidence) increase as the period of treatment increased. The results presented in Fig. 2 show, also that chilling the seeds at 4°C and freezing at 0°C for two days significantly (at 99% confidence) increased water uptake of the seeds as compared to the control.

The results in Fig. 3 show the percentage of seed germination of *Cucumis* at different temperatures in darkness. No germination was observed at 45°C. The germination percentage at 15°C and 35°C was more or less the same, both tending to be significantly lower (at 95% confidence) than that at 25°C. At 25 and 15°C the percentage of seed germination increased considerably in the first five and eight days respectively, thereafter remaining constant. At 15°C, the percentage of seed germination increased markedly in the first 4 days.

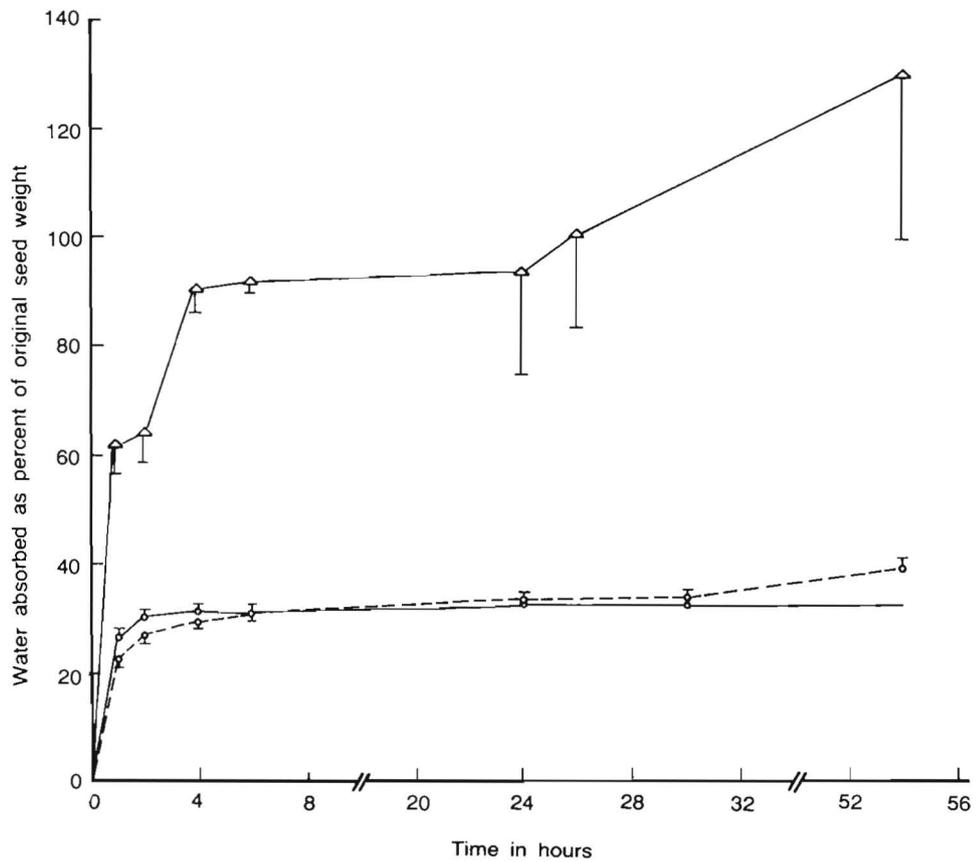


Fig. 1. Imbibition of water by *Citrullus colocynthis* and *Cucumis prophetarum* seeds at 25°C.
 ▽—▽ *Cucumis prophetarum* seeds had been stored at room temperature for 1 year.
 ○---○ *Citrullus colocynthis* seeds had been stored at room temperature for 1 year.
 ○—○ *Citrullus colocynthis* seed had been stored at room temperature for 8 years.

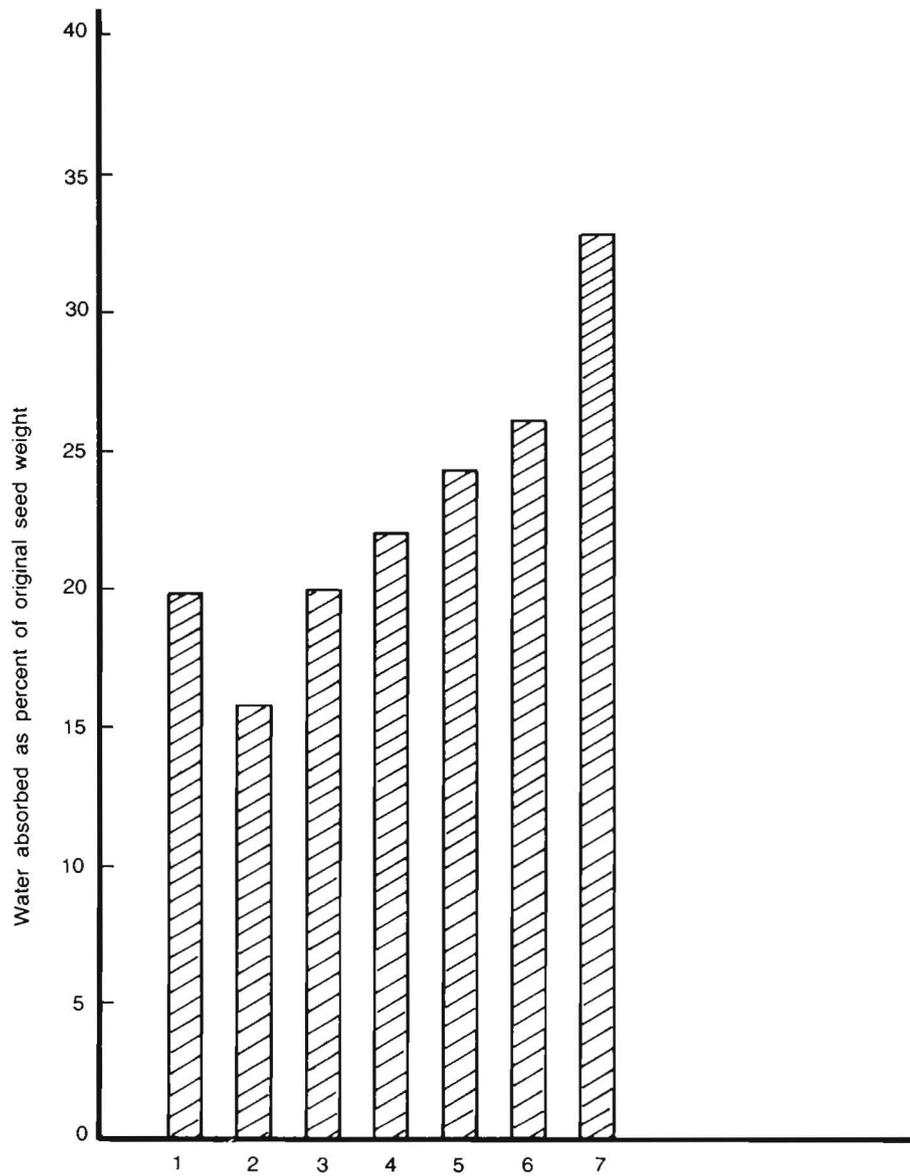


Fig. 2. Effect of treatment with sulphuric acid and chilling on the imbibition of water (at 25°C for 24 h) by freshly harvested *Citrullus colocynthis* seeds.

1- Control

2-15 min in acid

3-30 min in acid

4-45 min in acid

5-60 min in acid

6-2 chilled for 2 days at 4°C

7-2 chilled for 2 days at 0°C

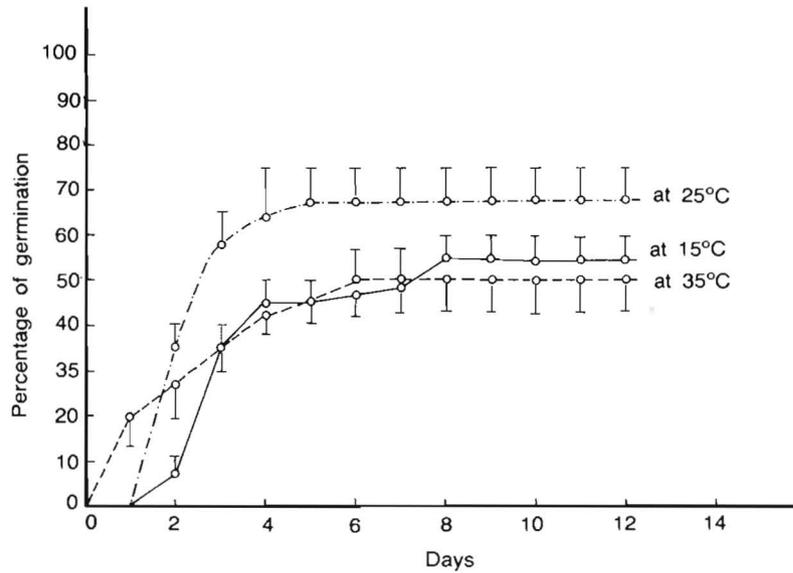


Fig. 3. Percentage of seeds germination of *Cucumis prophetarum* at different temperatures. Seeds had been stored at room temperature for one year.
N.B.—No germination occurred at 45°C.

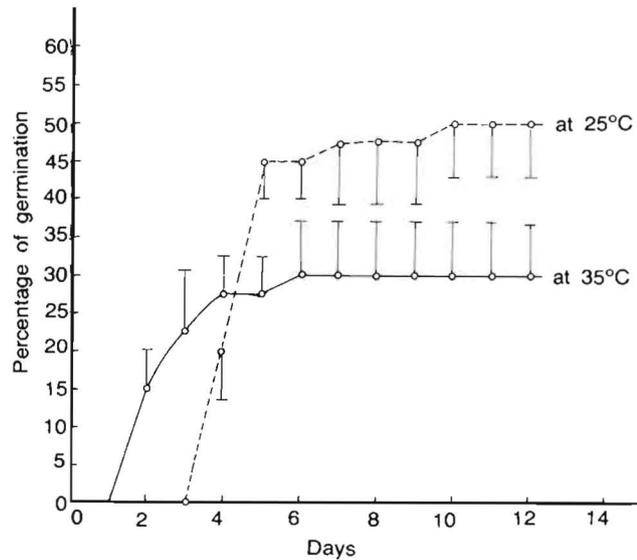


Fig. 4. Percentage of seed germination of *Citrullus colocynthis* at different temperatures. Seeds had been stored at room temperature for 8 years.
N.B.—No germination occurred at 15 and 45°C.

The seeds stored for one year at room temperature did not germinate at any of the temperatures tested above.

The results in Fig. 4 show the effect of temperature on germination of *Citrullus* seeds which had been stored at room temperature for eight years. No germination was observed at 15 and 45°C. The highest percentage of germination occurred at 25°C although 30% of the seeds germinated at 35°C. At 25°C the percentage of germination reached constancy on the 10th day, at 35°C on the 6th day.

Seeds of *Citrullus* which had been stored for one year did not germinate at any temperature (15, 25, 35 and 45°C) (Fig. 5). However, germination occurred when these seeds were either chilled for one month at 4°C or treated with 500 ppm kinetin (Fig. 5). Chilling for 2 months or treated with 500 ppm GA or mixture of 500 ppm GA + 500 ppm K did not stimulate germination. Also chilling had almost no effect on the percentage of germination of seeds which had been stored for eight years (Fig. 5).

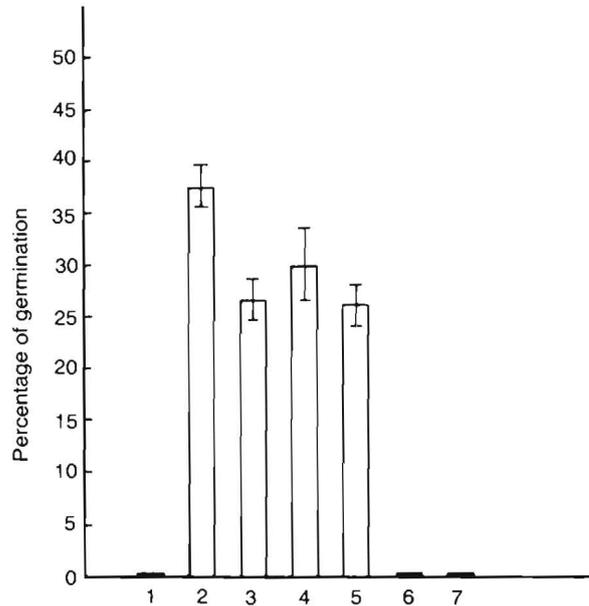


Fig. 5. Effect of kinetin, chilling and sulphuric acid on seed germination (at 35°C for 12 days) of *Citrullus colocynthis*.

1. One year-stored seeds
2. One year-stored seeds chilled for 30 days at 4°C
3. One year-stored seeds soaked in 500 ppm kinetin
4. Eight years-stored seeds
5. Eight years-stored seeds chilled for 30 days at 4°C
6. One year-stored seeds chilled for 2 months at 4°C
7. One year-stored seed soaked in a mixture of 500 ppm kinetin + 500 ppm GA

N.B. — Freshly harvested seeds treated with sulphuric acid for 15, 30, 45 or 60 min did not germinate.

No germination was observed for freshly harvested seeds of *Citrullus* at 35°C (the only temperature used). Treatment of the seeds with sulphuric acid for 15, 30, 45 or 60 min did not break seed dormancy of these seeds (Fig. 5).

Discussion

Water uptake by seeds of *Citrullus* and *Cucumis* (Fig. 1) is similar to that reported for pea seeds (Guardiola and Sutcliffe 1971 and Bain and Mercert 1966). The low water content of *Citrullus* seeds after soaking for a long time might be due to a hard seed coat, and there are several reports indicating that hard seed coat is a barrier for imbibition especially in legumes (Hamly 1932, Hagon and Ballard 1969, Ismail 1983, and Mahmoud 1985). Koller *et al.* (1963) suggested that seed coat of *Citrullus* is not a barrier for water uptake but they did not present data for water imbibition of soaked seeds.

In deserts, where rainfall is limited, it may be beneficial for seeds to germinate at low seed water content, this would ensure their early establishment. The germination of *Citrullus* seeds at low seed water content might suggest the high adaptation of this species to arid environment.

Sulphuric acid has been shown to break seed dormancy due to impermeable seed coat (Ismail 1983 and Mahmoud 1985). The inability of this acid (Fig. 5) to break dormancy of *Citrullus* seeds may be due to the fact that the dormancy of these seeds is attributed to the resistance of the testa to embryo expansion, and not due to impermeability of the seed coat to water. The results showed that seeds stored for eight years imbibed almost the same amount of water as seeds stored for one year (Fig. 2) but the former seeds had 50% germination at 25°C while the latter were unable to germinate at any tested temperature. Also, treatment of freshly harvested seeds with H₂SO₄ improved their water uptake but did not stimulate their germination.

The stimulation of germination of *Citrullus* seeds by dry storage (Fig. 4) agrees with that reported for various seeds (Grime *et al.* 1981) and these authors suggest that afterripening may function as a mechanism for preventing premature germination in the dry habitats. However, this does not seem to be the case for *Citrullus* since Koller *et al.* (1963) and Bhanderi and Sen (1975) reported that dormant intact seeds can be germinated by removing the testa and this indicates that the embryo does not require a storage periods for maturation. The stimulation of germination by long storage period might be attributed to changes in seed coat reducing its resistance to embryo expansion. Chilling and hormone treatment might act in this way in breaking seed dormancy of this species.

The results showed that seeds of *Citrullus* and *Cucumis* germinated under a

wide range of temperatures (Fig. 3 and 4). Similar results have been reported for several species (Ismail 1983, Mahmoud *et al.* 1984, Abulfatih and Bazzaz 1985, and Mahmoud 1985) and this has been considered a thermal adaptation of desert plants to their environment. Although, there is intensive work on the effect of temperature on seed germination of desert plants, there is limited information concerning the physiological and biochemical adaptation of desert seeds to arid environment.

References

- Abulfatih, H.A. and Bazzaz, F.A.** (1985) Laboratory studies of germination and growth in plant species associated with an elevation gradient in south west Saudi Arabia, *Arab Gulf J. scient. Res.* **3**: 449-459.
- Bain, J.M. and Mercert, F.V.** (1966) Subcellular organization of the cotyledons in germinating seeds and seedlings of *Pisum sativum* L., *Aust. J. Biol. Sci.* **19**: 69-84.
- Bhanderi, M.C.** (1974) A report on growth regulators in the seed coat of old and fresh seeds of *Citrullus colocynthis* (Linn.) Schard., *Geobios* **1**: 145-146.
- Bhanderi, M.C. and Sen, D.N.** (1975) Ecology of desert plants and observations on their seedlings. IV. Seed germination and seedling in *Citrullus* species, *Acta Bot. Acad. Sci. Hung.* **24**: 411-416.
- Chaudhary, S.A. and Zawawi, N.A.** (1983) *A manual of weeds of central and eastern Saudi Arabia*, Ministry of Agriculture and Water Regional Agriculture and Water Research Center, Riyadh.
- Collenette, S.** (1985) *An illustrated guide to the flowers of Saudi Arabia*, MEPA, Scorpion Publishing Ltd., London.
- Grime, J.P. Mason, G., Curtis, A.V., Rodman, J., Band, S.R., Mowforth, M.A.G., Neal, A.M., and Shaw, S.** (1981) A comparative study of germination characteristics in a local flora, *J. Ecol.* **69**: 1017-1059.
- Guardiola, J.L. and Sutcliffe, J.F.** (1971) Control of protein hydrolysis in the cotyledons of germinating pea (*Pisum sativum* L.) seeds, *Ann. Bot.* **35**: 791-807.
- Hagon, M.W. and Ballard, L.A.T.** (1969) Reversibility of strophiolin permeability to water in seeds of subterranean clover (*Trifolium subterraneum* L.), *Aust. J. Biol. Sci.* **23**: 519-528.
- Hamly, D.H.** (1932) Softening of the seeds of *Melilotus alba*, *Bot. Gaz.* **93**: 355-373.
- Harrington, G.T.** (1916) Agricultural value of impermeable seeds, *J. Agri. Res.* **6**: 761-796.
- Ismail, A.M.** (1983) The influence of seed size and the dormancy on germination behaviour of *Prosopis juliflora* (Sw.) DC. grown in Qatar, *Arab Gulf J. scient. Res.* **1**: 29-40.
- Koller, D., Poljakoff-Mayber, A., Berg, A. and Diksin, T.** (1963) Germination-regulation mechanisms in *Citrullus colocynthis*, *Amer. J. Bot.* **50**: 597-603.
- Mahmoud, A.** (1985) Germination of *Cassia italica* from Saudi Arabia, *Arab Gulf J. scient. Res.* **3**: 437-447.
- Mahmoud, A., El-Shiekh, A.M. and Abdul Baset, S.** (1984) Germination ecology of *Rhazya stricta* Decne, *J. Coll. Sci., King Saud Univ.* **15**: 5-25.
- Mayer, A.M. and Poljakoff-Mayber, A.** (1982) *The Germination of Seeds*, Pergamon Press, Oxford.
- Migahid, A.M.** (1978) *Flora of Saudi Arabia*, 2nd ed., Riyadh University Publications.

(Received 30/05/1987;
in revised form 04/04/1988)

دراسات بيئية - فسيولوجية على نباتي الحنظل وشرى الذئب في المملكة العربية السعودية : ١ - إنبات البذور

محمد ماجد الفراج و علي عبدالمحسن الهلال و رمضان الدسوقي
إبراهيم الحبش

قسم النبات - كلية العلوم - جامعة الملك سعود - ص. ب ٢٤٥٥ الرياض ١١٤٥١
المملكة العربية السعودية

اثبتت الدراسات المختلفة لقياس تشرب بذور الحنظل وشرى الذئب للماء وكذلك تأثير التخزين على إنبات بذور الحنظل وتأثير درجات الحرارة المختلفة على إنبات بذور كل من النباتين، على أن معدل تشرب بذور الحنظل وشرى الذئب يكون سريعاً خلال الأربع ساعات الأولى من بدء التجربة ثم يصل إلى معدل ثابت بعد ذلك .

لقد لوحظ إن معدل تشرب بذور الحنظل حديثة الحصاد والمخزونة لمدة عام واحد قد وصلت إلى ٢٠٪ و ٣٤٪ بعد أربع وعشرين ساعة من بدء المعاملة مقارنة بـ ٩٢٪ لبذور شرى الذئب .

والنسبة المثوية لإنبات شرى الذئب عند درجات حرارية مختلفة ازدادت بشكل سريع خلال الأيام الأربعة الأولى وبلغت أعلى نسبة لها في اليوم الخامس وهي ٦٨٪ عند درجة حرارة ٢٥°م . كما أوضحت الدراسة إن بذور الحنظل المحصودة حديثاً والمخزونة لمدة عام واحد كانت كامنة في حين إن البذور المخزونة لمدة ٨ أعوام قد أعطت أعلى نسبة إنبات وصلت إلى ٥٠٪ عند درجة حرارة ٢٥°م في اليوم العاشر من بدء المعاملة .

أظهرت الدراسة أيضاً أن المعاملة بكل من الصقيع لمدة شهر واحد تحت درجة حرارة ٤°م واستخدام هورمون الكاينيتين (CK) قد استحث إنبات بذور الحنظل المخزونة لمدة عام واحد حيث بلغت نسبة الإنبات ٣٧ و ٢٣٪ على التوالي .

أما معاملة هذه البذور بمحلول جبرلين (GA) والخليط من محلول جبرلين (GA) وهورمون (CK) فلم يستحثا على الانبات، كما إن معاملة ابذور المحصودة حديثاً بحامض الكبريتيك قد فشلت في الحث على الإنبات.