

Hydropriming and Osmopriming Effects on Cumin (*Cuminum Cyminum L.*) Seeds Germination

E. Neamatollahi, M. Bannayan, A. Souhani Darban, and A. Ghanbari

Abstract—In production of medicinal plants, seed germination is very important problem. The treated seeds (control, hydro priming and $ZnSO_4$) of Cumin (*Cuminum cyminum L.*) were evaluated at germination and seedling growth for tolerance to salt ($NaCl$ and Na_2SO_4) conditions at the same water potentials of 0.0, -0.3, -0.6, -0.9 and -1.2MPa. Electrical conductivity (EC) values of the $NaCl$ solutions were 0.0, 6.5, 12.7, 18.4 and 23.5 dSm^{-1} , respectively. The objective of the study was to determine factors responsible for germination and early seedling growth due to salt toxicity or osmotic effect and to optimize the best priming treatment for these stress conditions. Results revealed that germination delayed in both solutions, having variable germination with different priming treatments. Germination, shoot and weight, root and shoot length were higher but mean germination time and abnormal germination percentage were lower in $NaCl$ than Na_2SO_4 at the same water potential. The root / shoot weight and R/S length increased with increase in osmotic potential in both $NaCl$ and Na_2SO_4 solutions. $NaCl$ had less inhibitor effect on seedling growth than the germination. It was concluded that inhibition of germination at the same water potential of $NaCl$ and Na_2SO_4 resulted from salt toxicity rather than osmotic effect. Hydro priming increased germination and seedling growth under salt stress. This protocol has practical importance and could be recommended to farmers to achieve higher germination and uniform emergence under field conditions.

Keywords—Priming, Germination, $NaCl$, $ZnSO_4$, Na_2SO_4 .

I. INTRODUCTION

CUMIN (*Cuminum cyminum L.*) is a member of Umbelliferae and annual plant which originated in the Iran, Egypt, Turkistan and East Mediterranean. But, it is widely cultivated in Iran, China, India, Morocco, South Russia, Japan, Indonesia, Algeria and Turkey; specially, in arid and semi-arid regions [33]. Iran is one of the most important cumin exporters in the world market [13]. Leaf shape, short leaves, color and

surface cover of plant parts are representative adaptation of cumin to drought conditions [16]. Furthermore, the plant is relatively salt resistant and has no much needs of soil fertility [10]. But in production of medicinal plants, seed germination is very important problem. The seeds are occasionally sown in seedbeds having unfavorable moisture because of the lack of rainfall at sowing time [3], which results in poor and unsynchronized seedling emergence [22]. A major constraint to seed germination is soil salinity, a common problem in irrigated areas of Iran, with low rainfall [14]. Soil salinity may affect the germination of seeds either by creating an osmotic potential external to the seed preventing water uptake, or through the toxic effects of Na^+ and Cl^- ions on the germinating seed [15]. Salt and osmotic stresses are responsible for both inhibition or delayed seed germination and seedling establishment [2]. Under these stresses there is a decrease in water uptake during imbibitions and furthermore salt stress may cause excessive uptake of ions [21]. Seed priming has been successfully demonstrated to improve germination and emergence in seeds of many crops, particularly seeds of vegetables and small seeded grasses [4]. The beneficial effects of priming have also been demonstrated for many field crops such as wheat, sugar beet, maize, soybean and sunflower [23, 28, 15, 26]. [8] reported beneficial effect of a hydration-dehydration seed treatment on germination of sunflower. [24] reports that primed Brassica seeds may reduce the risk of poor stand establishment in cold and moist soils. However, [29] stress that KNO_3 effectively improved germination, seedling growth and seedling vigour index of the seeds of sunflower varieties with low germination. The aims of the present study were to determine factors responsible for failure of germination of cumin seeds under saline conditions due to the toxic effects of $NaCl$ and Na_2SO_4 by comparing seed germination under a range of osmotic potentials due to $NaCl$ and Na_2SO_4 . Furthermore, the study examined the possibilities to overcome salt stress by seed treatments with hydro priming or treatment with $ZnSO_4$.

II. MATERIALS AND METHODS

In order to determine the impact of different primes on germination of Cumin seeds, an experiment was conducted at Zabol University in 2008. Seeds were primed with various

E. Neamatollahi is agronomy Msc student in Zabol University from Iran (e-mail: Ehsan1_neamatollahi@yahoo.com).

M. Bannayan is assistant professor in Ferdowsi University of Mashhad, Faculty of Agriculture, Mashhad, Iran (e-mail: bannayan@um.ac.ir).

A. Souhani Darban is assistant professor in Mashhad Branch, Azad University, Iran (e-mail: Souhani@yahoo.com).

A. Ghanbari is assistant professor in Zabol University of Zabol, Faculty of Agriculture, Zabol, Iran (e-mail: Ghanbari@uz.ac.ir).

materials, including hydroprime seeds which were primed with distilled water, osmoprimed seeds which were treated with different chemical factors as NaCl, Na₂SO₄, ZnSO₄. for produce solutions with various osmotic potential we used of Michel and Kaufmann (1973) and Money (1989). All three different osmopriming provide employed in order to osmotic levels of 0.0, -0.3, -0.6, -0.9, -1.2 MPa. Initially seeds were disinfected by Sodium hypochlorite (NaOCl) to disinfect the seeds. Seeds were in sodium hypochlorite (1.5 per) for one minute and then washed away with distilled water. After disinfecting seeds were put in disinfected petry dish. Each petry dish contained 25 seeds. After 24 hours of priming seeds were washed with distilled water and then dried and in kept laboratory room at temperature of 25°C for two hours. After dried seeds located in petry dishes and treated with distilled water at temperature of 25°C for seven days. The experimental design was randomized completely block design, with three replications. The differences between the means were compared using Duncan values (P < 0.01). Three replicates of 25 seeds were put between double layered rolled Anchor germination papers with 10 ml of test solutions. The papers were replaced every 2 days to prevent accumulation of salts. The rolled paper with seeds was put into sealed plastic bags to avoid moisture loss. Seeds were allowed to germinate at 25±1°C for 7 days. Germination was considered when the radicles were 2 mm long. Germination percentage was recorded every 24 h for 7 days. Root length, shoot length were measured after the 7th day.

III. RESULTS

A significant three-way interaction (seed treatment, solution and stress) was found (P < 0.01, 60 df.) for all investigated characters. The germination rate and germination percentage decreased by increasing in osmotic potential in both NaCl and Na₂SO₄ solution and maximum germination rate and percentage were obtained at NaCl and Na₂SO₄ level providing 0 Mpa in hydropriming treatment (Table I).

TABLE I
GERMINATION RATE

MPa	Seed treatments					
	control (untreated)		Hydropriming		ZnSO ₄	
	1	2	1	2	1	2
0	11.9	11.9	18.1	18.1	11	11
-0.3	10.6	9.2	16.3	12.5	10.47	8.7
-0.6	10.0	7.3	14.1	10.7	9.8	7.8
-0.9	8.8	6.8	13.9	8.6	9.6	6.0
-1.2	3.1	1.3	10.4	8.2	8.25	3.4

1: NaCl, 2: Na₂SO₄

The root length decreased by increasing in osmotic potential in both NaCl and Na₂SO₄ in control but in Hydropriming and ZnSO₄ prime, NaCl and Na₂SO₄ increased by increasing in osmotic potential until -0.3 Mpa and then decreased by increasing in osmotic potential. Best treatment in root length was NaCl -0.3 Mpa in hydropriming (Table II).

TABLE II
GERMINATION PERCENTAGE

MPa	Seed treatments					
	control (untreated)		Hydropriming		ZnSO ₄	
	1	2	1	2	1	2
0	68	68	84	84	72	72
-0.3	62	56	80	80	71	69
-0.6	45	35	63	60	57	55
-0.9	34	11	54	23	44	19
-1.2	12	7	20	16	16	15

1: NaCl, 2: Na₂SO₄

The shoot length, root weight and shoot weight were decreased by increasing in osmotic potential and best treatment in three characters was NaCl and Na₂SO₄ with 0 Mpa in hydropriming (Tables III, IV, V and VI).

TABLE III
ROOT LENGTH (CM)

MPa	Seed treatments					
	control (untreated)		Hydropriming		ZnSO ₄	
	1	2	1	2	1	2
0	2.2	2.2	2.1	2.1	1.8	1.8
-0.3	2.1	1.4	3.8	2.3	2.6	2.1
-0.6	1.4	1.4	2.5	1.9	2.2	1.7
-0.9	1.0	0.2	1.4	0.8	1.6	0.6
-1.2	0.7	0.0	1.1	0.0	0.9	0.0

1: NaCl, 2: Na₂SO₄

TABLE IV
SHOOT LENGTH (CM)

MPa	Seed treatments					
	control (untreated)		Hydropriming		ZnSO ₄	
	1	2	1	2	1	2
0	1.8	1.8	2.2	2.2	1.9	1.9
-0.3	1.5	1.4	2.0	1.9	1.8	1.7
-0.6	0.9	0.9	1.9	1.8	1.7	1.2
-0.9	0.8	0.0	1.1	0.1	1.0	0.0
-1.2	0.0	0.0	0.7	0.0	0.4	0.0

1: NaCl, 2: Na₂SO₄

TABLE V
ROOT WEIGHT (MG PLANT⁻¹)

MPa	Seed treatments					
	control (untreated)		Hydropriming		ZnSO ₄	
	1	2	1	2	1	2
0	2.3	2.3	2.5	2.5	2.4	2.4
-0.3	1.9	1.8	2.2	2.1	2.0	2.0
-0.6	1.4	1.4	1.9	1.8	1.7	1.7
-0.9	1.1	0.8	1.5	1.4	1.2	1.1
-1.2	0.4	0.3	0.9	0.9	0.5	0.4

1: NaCl, 2: Na₂SO₄

TABLE VI
SHOOT WEIGHT (MG PLANT⁻¹)

MPa	Seed treatments					
	control (untreated)		Hydropriming		ZnSO ₄	
	1	2	1	2	1	2
0	1.3	1.3	1.6	1.6	1.4	1.4
-0.3	0.9	0.9	1.3	1.2	1.1	1.0
-0.6	0.5	0.5	0.9	0.9	0.7	0.7
-0.9	0.2	0.2	0.5	0.7	0.7	0.3
-1.2	0.0	0.0	0.3	0.3	0.2	0.2

1: NaCl, 2: Na₂SO₄

The root/ shoot weight and R/S length increased with increase in osmotic potential until -0.9 Mpa but decreased in -1.2 Mpa both NaCl and Na₂SO₄ solution (Fig. 1).

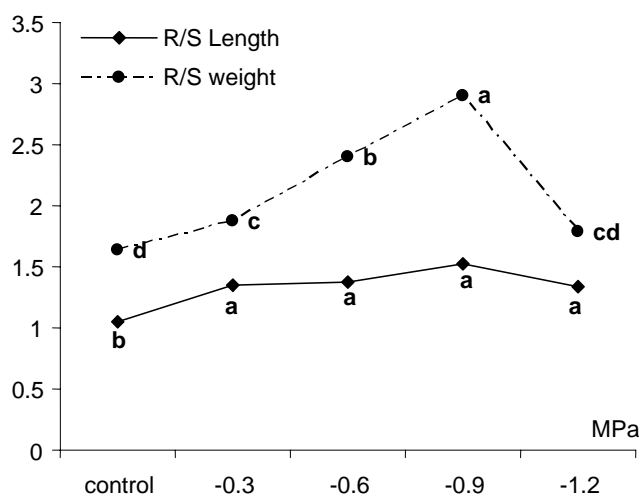


Fig. 1 Root/Shoot length (cm) and weight (mg) of cumin seedlings treated with Zn₂SO₄, hydropriming and control (untreated) at salt stress of NaCl and Na₂SO₄

IV. DISCUSSION

Hydropriming clearly improved both rate of germination and mean germination time both under salt stress conditions. Furthermore, hydro priming resulted in increase of normal germination. The results are in line with the findings of [32] in Brassica and [30] in mustard. [12] indicated the beneficial effects of hydro priming on aged or unaged seeds with respect to germination and percentage of normal seedlings in cauliflower. Furthermore, [26] reported that increasing drought stress resulted in increasing abnormal seedlings in sugar beet. It is concluded that superiority of hydro priming on germination could be due to soaking time effects rather than Zn₂SO₄ treatment. Because, hydro primed seeds compared to Zn₂SO₄ treated seeds were allowed to imbibe water for a longer time and went through the first stage of germination without protrusion of radicle. [1] reported that higher duration of exposure to seed treatment resulted in higher cumulative germination in wild sunflower and [5] found that hydro priming was the most effective method for improving seed germination of onion, especially when the seeds were hydrated for 96 h compared to 48 h. The beneficial effects of Hydro priming on germination were found in this study. Zn₂SO₄ shortened MGT, however, final germination was higher from Hydro priming, suggesting toxicity of Zn₂SO₄ due to ion accumulation in the embryo [7]. Seeds always germinated better in NaCl than Na₂SO₄ at the equivalent water potential in line with earlier observations made for soybean by Khajeh[15]. This may be due to the uptake of Na⁺ and Cl⁻ ions by the seed, maintaining a water potential gradient allowing water uptake during seed germination. Lower germination percentage obtained from Na₂SO₄ compared with NaCl at equivalent water potential in each priming method suggest that adverse effects of Na₂SO₄ on germination were due to specific ion accumulation rather than osmotic effect. These results

agree with [21] in cowpea, [7] in watermelon, they affirmed that drought or salinity may influence germination by decreasing the water uptake and toxicity of ions. Under salt stress, Na⁺, Cl⁻ and SO₄²⁻ may be taken up by the seed and toxic effect of NaCl and Na₂SO₄ might appear. However, our findings at high salinity concentration of 23.5 dSm⁻¹ showed that decrease in germination percentage was significant. The main effect of seed treatments was an increase in germination rate; however, post-germination growth was also increased. Hydro priming improved seedling fresh weight under osmotic stress. Considering both seed treatments, it was concluded that hydro priming improved root growth and gave the highest root length in both solutions. [11] reports that root and shoot growth significantly decreased by osmotic stress at -0.6MPa and above induced by PEG 6000. [21] found that seedling growth of cowpea was inhibited by both NaCl and PEG, but higher inhibition occurred due to PEG. [31] proposed that emergence force and seedling growth were strengthened by hydro priming in watermelon. Seedling growth severely diminished with increased drought stress and genetic differences were found in sugar beet [26].

ACKNOWLEDGMENT

This experiment was supported by Zabol University.

REFERENCES

- [1] J. Akinola, A. Larbi, G. Farinu, and A.A. Odunsi, Seed treatment methods and duration effects on germination of wild sunflower. *Exp. Agric.* 36, 63–69, June 2000.
- [2] M. Almansouri, J.M. Kinet, and S. Lutts, Effect of salt and osmotic stresses on germination in durum wheat (*Triticum durum* Desf.). *Plant Soil* 231, 243–254, May 2001.
- [3] S.V. Angadi, and M.H. Entz, Water relations of standard height and dwarf sunflower cultivars. *Crop Sci.* 42, 152–159, July 2002.
- [4] K.J. Bradford, Manipulation of seed water relations via osmotic priming to improve germination under stress conditions. *Hort. Sci.* 21, 1105–1112, June 1986.
- [5] R. Caseiro, M.A. Bennett, and J. Marcos-Filho, Comparison of three priming techniques for onion seed lots differing in initial seed quality. *Seed Sci. Technol.* 32, 365–375, Jan 2004.
- [6] M.J. Coons, R.O. Kuehl, and N.R. Simons, Tolerance of ten lettuce cultivars to high temperature combined with NaCl during germination. *J. Am. Soc. Hort. Sci.* 115, 1004–1007, 1990.
- [7] I. Demir, and H.A. Van De Venter, The effect of priming treatments on the performance of watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai) seeds under temperature and osmotic stress. *Seed Sci. Technol.* 27, 871–875, 1990.
- [8] C. Dharmalingam, and R.N. Basu, Maintenance of viability and vigour in sunflower. *Seed Res.* 18, 15–24, 1990.
- [9] R.H. Ellis, and E.H. Roberts, Towards a rational basis for testing seed quality. In: Hebblethwaite, P.D. (Ed.), *Seed Production*. Butterworths, London, pp. 605–635, 1980.
- [10] M.M. El-Fouly, Micronutrients in arid and semiarid areas: level in soils and plants and needs for fertilizers with reference to Egypt. *Proc. 15th Coll. Int. Potash Inst. (Bern)*, p.163, 1983.
- [11] M. El-Midaoui, H. Serieys, Y. Griveau, M. Benbella, A. Talouizte, A. Berville, and F. Kaan, Effects of osmotic and water stresses on root and shoot morphology and seed yield in sunflower (*Helianthus annuus* L.) genotypes bred for Morocco or issued from introgression with *H. argophyllus* T.&G. and *H. debilis* Nutt. *Helia* 26, 1–16, 2003.
- [12] Y. Fujikura, H.L. Kraak, A.S. Basra, and C.M. Karssen, Hydropriming, a simple and inexpensive priming method. *Seed Sci. Technol.* 21, 639–642, 1993.
- [13] M. Kafi, Cumin (*Cuminum cyminum*) Production and Processing. Ferdowsi University of Mashhad press. PP: 195, 2002.

- [14] M.D. Kaya, A. Ipek, and A. Ozturk, Effects of different soil salinity levels on germination and seedling growth of safflower (*Carthamus tinctorius* L.). *Turk. J. Agric. For.* 27, 221–227, 2003.
- [15] M. Khajeh-Hosseini, A.A. Powell, and I.J. Bingham, The interaction between salinity stress and seed vigour during germination of soybean seeds. *Seed Sci. Technol.* 31, 715–725, 2003.
- [16] S. Kizil, N. Arslan, and A. Ipek, A research on adaptation of different cumin (*Cuminum cyminum* L.) lines in diyarbakir ecological conditions. *Agricultural Science Journal.* 9(3): 340–343, 2003.
- [17] M.B. McDonald, Seed deterioration: physiology, repair and assessment. *Seed Sci. Technol.* 27, 177–237, 1990.
- [18] V. Mehra, J. Tripathi, and A.A. Powell, Aerated hydration treatment improves the response of Brassica juncea and Brassica campestris seeds to stress during germination. *Seed Sci. Technol.* 31, 57–70, 2003.
- [19] B.E. Michel, Evaluation of the water potentials of solutions of polyethylene glycol 8000 both in the absence and presence of other solutes. *Plant Physiol.* 72, 66–70, 1983.
- [20] B.E. Michel, M.R. Kaufmann, The osmotic potential of polyethylene glycol 6000. *Plant Physiol.* 51, 914–916, 1973.
- [21] B. Murillo-Amador, R. Lopez-Aguilar, C. Kaya, J. Larrinaga-Mayoral, and A. Flores-Hernandez, Comparative effects of NaCl and polyethylene glycol on germination, emergence and seedling growth of cowpea. *J. Agron. Crop Sci.* 188, 235–247, 2002.
- [22] S.S Mwale, C. Hamusimbi, and K. Mwansa, Germination, emergence and growth of sunflower (*Helianthus annuus* L.) in response to osmotic seed priming. *Seed Sci. Technol.* 31, 199–206, 2003
- [23] C.A. Parera, and D.J. Cantliffe, Presowing seed priming. *Hort. Rev.* 16, 109–141, 1994.
- [24] S.C Rao, S.W. Aker, and R.M. Ahring, Priming Brassica seed to improve emergence under different temperatures and soil moisture conditions. *Crop Sci.* 27, 1050–1053, 1987.
- [25] S. Rehman, P.J.C. Harris, W.F. Boume, and J. Wilkin, The effect of sodium chloride on germination and the potassium and calcium content of Acacia seeds. *Seed Sci. Technol.* 25, 45–57, 1996.
- [26] S.Y. Sadeghian, and N. Yavari, Effect of water-deficit stress on germination and early seedling growth in sugar beet. *J. Agron. Crop Sci.* 190, 138–144, 2004.
- [27] R.S Shivankar, D.B. Deore, and N.G. Zode, Effect of pre-sowing seed treatment on establishment and seed yield of sunflower. *J. Oilseeds Res.* 20, 299–300, 2003.
- [28] B.G Singh, and G. Rao, Effect of chemical soaking of sunflower (*Helianthus annuus* L.) seed on vigour index. *Indian J. Agric. Sci.* 63, 232–233, 1993.
- [29] B.G. Singh, Effect of hydration-dehydration seed treatments on vigour and yield of sunflower. *Indian J. Plant Physiol.* 38, 66–68, 1995
- [30] K. Srinivasan, S. Saxena, and B.B. Singh, Osmo- and hydropriming of mustard seeds to improve vigour and some biochemical activities. *Seed Sci. Technol.* 27, 785–793, 1999.
- [31] J.M. Sung, and K.Y. Chiu, Hydration effects on seedling emergence strength of watermelon seed differing in ploidy. *Plant Sci.* 110, 21–26, 1995.
- [32] J.M. Thornton, and A.A. Powell, Short term aerated hydration for the improved of seed quality on Brassica oleracea. *Seed Sci. Res.* 2, 41–49, 1992.
- [33] R. Tuncturk, and M. Tuncturk, Effects of different phosphorus levels on the yield and quality components of cumin (*Cuminum cyminum* L.). *Research Journal of Agriculture and Biological Sciences*, 2(6): 336–340, 2006.