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Evaluation of seed priming methods to improve seed vigour of onion (*Allium cepa cv. aggregatum*) and carrot (*Daucus carota*)

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An experiment was conducted to standardize the best methodology and method of priming, specific to each crop seed viz., onion and carrot. Four methods of priming viz., hydropriming, sand matricpriming , halopriming and osmopriming were evaluated by screening a range of durations and concentrations .The observation of parameters viz., i) percentage of radicle protrusion ii) days for 50 % germination iii) days for maximum germination iv) speed of germination and v) germination percentage revealed that the best methodology varied with the crop species . For onion, sand matric priming (24 h in 80% WHC of sand) recorded the highest improvement of 44 ,43 ,40 ,58 and 7 percent over control, respectively for the above parameters. For carrot, hydropriming (24 h in water at double the volume of seed) recorded the highest improvement of 10, 22, 35, 11 and 12 percent, respectively over control. The experiment underscored that inorder to harness maximum potential of seed priming, the most suitable method and the methodology should be adopted, specific to each crop species.

Introduction

Priming consists of a regulated hydration, in water or osmotic solutions that permits the improvement of some metabolic processes but prevents germination. Advantages obtained during priming are retained after seed dehydration. These benefits include increased seed vigour with rapid and uniform germination and seedling development (Bray, 1995). The common ecological observation is that, after dispersal from the parent plant, the seeds fall into the surface litter of the soil, where they may be able to survive for long periods either continuously or intermittently imbibed, therefore, with high water content (Villiers and Edgecumbe, 1975). Lourdes *et al.* (2001) hypothesized that priming exists in nature and increases the chances of successful seedling establishment from the soil seed bank of different plant

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communities. Laboratory priming treatment would imitate natural seasonal changes that take place in the soil, and the physiological processes including priming would constitute an acclimation mechanism of the plants to their environment. Thus priming effects could be an expression of processes that evolve in the soil seed bank.

Proper standardization of the seed priming method and methodology for individual crops is the most important determinant of success of the seed priming treatment. Smith and Cobb (1991) concluded that the priming response was dependent on the duration of the treatment and the osmotic potential of the solution rather than a specific salt. According to Frett *et al.* (1991) optimum priming conditions (priming agent, treatment duration, water potential of the priming solution etc.) should be assayed for each cultivar. McDonald (1999) stated that debate continues as to the ideal priming technique, moisture and oxygen conditions for optimum priming response. Since the response to a given priming treatment can vary between crop species, the optimal priming treatment is determined by trial and error (Bradford, 1986). However, limited attempts are made to compare the crop specific efficacy of all the popular methods of priming *viz.,* hydropriming, sand matric priming, halopriming and osmopriming, by evaluating different durations and concentrations of the media.

A firm, moist soil is required around the onion seed even under the optimum conditions, onion seed takes 10 to 14 days to germinate. When soils are cold and wet germination may take up to 30 days. Crusty soils can reduce plant numbers especially where seed vigour is not strong. Carrot seed is also slow to germinate depending on soil and weather conditions and in some production years germination is low accompanied by an increased number of abnormal seedlings. Delayed and erratic emergence is a serious problem with fertilizer utilization, post emergence weed control and uniform harvesting of crops (Mereddy *et al*., 2000). In seed beds where the soil is drying or the structure is deteriorating, increased speed of germination is very beneficial and will contribute towards a greater and more uniform plant population. Against this background an experiment was conducted to compare the priming methods and methodologies to optimize the best priming methodology to improve uniformity, speed and percentage of germination of onion and carrot seeds.

Materials and methods

Seeds of onion cv Co 5 and carrot cv. New Kuroda with 8 per cent moisture content, were submitted to priming experiments. Seeds of both crop species were subjected to i) hydropriming ii) sand matricpriming iii) halopriming and iv) osmopriming, under room temperature and dried back to

the original moisture content. In hydropriming, osmopriming and halopriming seeds were soaked in priming media of double the volume of seed. This ensured that seeds remained immersed in the media, so as to avoid precocious germination during the treatment period. The methodology followed is detailed below.

Hydropriming

Seeds (10 g) were soaked in water of double the volume of seed. Onion seeds were soaked for 8, 12, 24, 36 and 48 h, whereas carrot seeds were soaked for 24, 36, 48, 60 and 72 h followed by shade drying.

***Sand matricpriming* (SMP)**

The seeds of each crop were weighed upto 10 g with four replications. 7 kg of sand to which water was added @ 180, 240 and 300 ml Kg^{-1} of sand to create water holding capacities (WHC) viz., 60, 80 and 100 per cent, respectively. The seeds were mixed with sand of respective WHC, placed in perforated plastic covers, and placed deep in the tray filled with sand of the same WHC. This ensured uniform seed-substrate contact. The seeds were observed daily for protrusion of radicle. The maximum duration for radicle protrusion (48 h for onion; 5 days for carrot) was observed in 80 per cent WHC for both crops. Subsequently, 10 g of seeds were placed in perforated plastic covers and burried in sand with 80 per cent WHC. Seed samples were retrieved after 8, 12, 24, 36 and 48 h for onion and 1, 2, 3, 4 and 5 days for carrot and shade dried to original moisture content.

Halopriming

Halopriming treatment was conducted with two salts *viz.,* KNO_3 and NaCl. The salt solutions were prepared in the concentrations *viz.,* 3, 5, 10 and 15% in which 10 g of onion seeds were soaked for 8, 12, 24, 36 and 48 h, whereas the carrot seeds were soaked for 24, 36, 48 60 h and 72 h. After priming, the seeds were removed from the solutions, rinsed in running tap water and shade dried.

Osmopriming

Osmopriming was done using polyethylene glycol 6000 (PEG 6000) solution. Solutions with osmotic potential of -.0.25 and -0.5 MPa were prepared by dissolving 68.2 and 136.5 g of PEG 6000 in one liter of water, respectively

(Nienow and Bujaski, 1991). Onion seeds were soaked in the respective solutions for 8, 12, 24, 36 and 48 h whereas, carrot seeds were soaked for 1, 2, 3, 4 and 5 days. After soaking, the seeds were removed, rinsed in distilled water and shade dried.

The seeds primed by different methods for different durations and shade dried were subjected to germination test with four replicates of 100 seeds in paper medium The untreated seeds of onion and carrot served as control to compare the performance of primed seeds. The test conditions were 25 $\pm$ 2^0C and 95 $\pm$ 5% RH, illuminated with fluorescent light. The seeds were checked daily .The seeds showing less than 3.0 mm protrusion were expressed as percentage of protrusion of the radicle. The days required for 50 % protrusion of radicle (Heydecker and Coolbear, 1977) and maximum (100 %) germination was derived (Mauromicale and Cavallaro, 1995). The speed of germination was calculated according to Maguire (1962). The number of normal seedlings were counted after 12 and 14 days for onion and carrot, respectively and expressed as germination percentage.

Data were analyzed using an analysis of variance (ANOVA) as a factorial combination of treatments. Means were separated on the basis of least significant difference (LSD) only if F test of ANOVA for treatments was significant at the 0.05 or 0.01 probability level. Percentage data were arcsine transformed before analysis.

Results and discussion

The seeds of onion and carrot showed significant differences in seed germination as well as speed of germination irrespective of the seed priming methods. For onion seeds, among 8, 12, 24, 36 and 48 h of hydropriming , a steady increase in percentage of radicle protrusion , days for 50% germination, days for maximum germination, speed of germination, germination percentage, and upto to 24 h which was 6, 34, 20, 29 ,and 5 percentage higher than control , respectively (Fig. 1). Observations on carrot recorded a steady increase upto 36 h, there after a decline in seed quality was discernible. It recorded a percentage improvement was 10, 22, 25, 11 and 12 respectively, over control for the above parameters (Fig. 2). Osmopriming of onion seeds (-0.25 and -0.5 MPa) for 8 h alone was capable of improving the seed germination as well as speed of emergence. However, no improvement was observed in any of the duration of priming when the PEG 6000 solution of -0.5 MPa was used. Carrot seeds benefited from osmopriming, after 2 days with -0.25 MPa only in terms of speed of germination. Further it was found that -0.5 MPa is determental to carrot seeds since seed performance was lower than control irrespective of duration of priming. Results on halopriming with KNO_3 and NaCl for a range

of five durations of soaking proved that onion seeds could benefit from halopriming (12 h) with both KNO_3 and NaCl (3%). The improvement recorded in percentage of radicle protrusion, days to 50% and 100 % emergence, speed of emergence and germination percentage was 18, 42, 17, 29 and 4 for KNO_3 (3%, 12 h) which was superior to NaCl (3%, 12 h) (Fig. 3). However, carrot seeds benefited from 3 % KNO_3 (24 h) alone that too only interms of speed of emergence while the final germination percent was lower than control (Fig. 4). Alvarado *et al.* (1987) observed that tomato seeds primed in KNO_3 solution germinated more rapidly at 15^{o}C as compared to seeds primed in PEG 8000 solution. Cantliffe (1991) reported that while priming lettuce seeds in one per cent K_3PO_4 for 20 h in the dark reduced thermo dormancy, the addition of 100 mg of cytokinin per liter of priming solution further increased germination percentage. Singh *et al.* (2004) reported that between hydropriming and halopriming, hydropriming for 16-18 h recorded highest emergence and germination percent. He observed that halopriming with 3% KNO_3 for 3 days damaged the seed as it deteriorated in terms of emergence and final germination percent. Salt solution priming of onion seeds was less beneficial to germination than PEG priming, salt solutions were found to be toxic to sorghum seeds and thus not suitable for priming (Haigh and Burlow, 1987). Sand matric priming (80% WHC) was tried for 8, 12, 24, 36 and 48 h for onion. Among the durations maximum improvement in speed in emergence and germination percentage was attained after 24 h which was 58 and 7 percentage higher than the control. Carrot seeds recorded increase in speed of emergence as well as germination percentage upto 2 days thereafter the detrimental effects were recorded in the seed performance. In SMP, solid carrier regulates the imbibition of water by the seeds. It is highly effective in improving the emergence and stand establishment of many crops (Khan, 1992). Mereddy (2000) reported that finely ground SMP agents did not improve germination compared to the larger sized formulations, which is in conformity with the present studies. Conway and Mereddy (2001) reported that SMP could improve field emergence of both varieties of okra experimented.

The comparison of optimum duration in each priming method revealed that the best method of priming for onion seeds is sand matricpriming (80% WHC, 24 h) where as, for carrot seeds, hydropriming (36 h) in double the volume of seed was adjudged best interms of all the parameters studied . The results of the present experiment revealed that optimization of priming method and duration of treatment depends largely on the crop species. Similarly, the comparison of optimum duration of each priming method made by Venkatasubramanium and Umarani (2007) revealed that for tomato seeds, hydropriming for 48 h (in double the volume of seed) was optimum where as,

for chilli and egg plant seeds, sand matricpriming at 80% water holding capacity of sand for three days was best in terms of rate and uniformity of germination. Nirmala and Umarani (2007) found that for okra, sand matric priming (3 h in 60% WHC of sand) was found to be the best , while for beet root , hydro priming (12 h in double the volume of seed) was optimum. The results of the present study endorse that "the timing of the initial imbibition period is critical because as the germination and growth proceed the resistance to drying of the embryo decreases. On the other hand the degree of the effect of treatment is claimed to be high, when the embryo is in more advanced stage of germination at the time of drying hence, the optimum duration of treatment should be a compromise between the two conflicting tendencies" (Bewley and Black, 1978). The concentration of the osmoticant or the water holding capacity of the matrix also has profoundly influenced the effectiveness of the priming method. In the case of halopriming, the choice of the salt employed is important and it has to be crop-specific. The experiment revealed that KNO_3 is detrimental to okra seeds and NaCl does not suit beetroot irrespective of the concentrations and duration of soaking.

Mechanisms by which seed priming improves germination performance have been discussed by several workers. Seeds complete first two phases of germination during the priming process hence primed and dehydrated seeds enter immediately into phase III of imbibition once rehydrated during sowing (Bradford, 1986). The reduction in time of imbibitions required for the onset of RNA, protein synthesis and polyribosome formation and increase in total amount of RNA and protein synthesized (Khan *et al*., 1978). Increase in DNA content as a result of activation or synthesis of enzymes of nucleic acid or both was reported by Coolbear *et al*. (1980). Knyple *et al.* (1980) reported that rearrangement of cell membrane structure lost during seed drying and increase in membrane integrity. During the natural process of ageing damage in membranes and DNA leads to a loss of seed quality, this damage can be repaired during a pre-sowing treatment (Villiers and Edgcumbe, 1975; McDonald, 1999)

Thus, it is envisaged that for onion seeds sand matricpriming (80% WHC, 24 h) is the best treatment where as, for carrot seeds, hydropriming (36 h) in double the volume of seed is optimum. The above priming treatments can serve as an effective tool to invigourate the seeds since, the treated seeds can be dried to original moisture content and stored or transported with out loosing the advantage of the treatments.

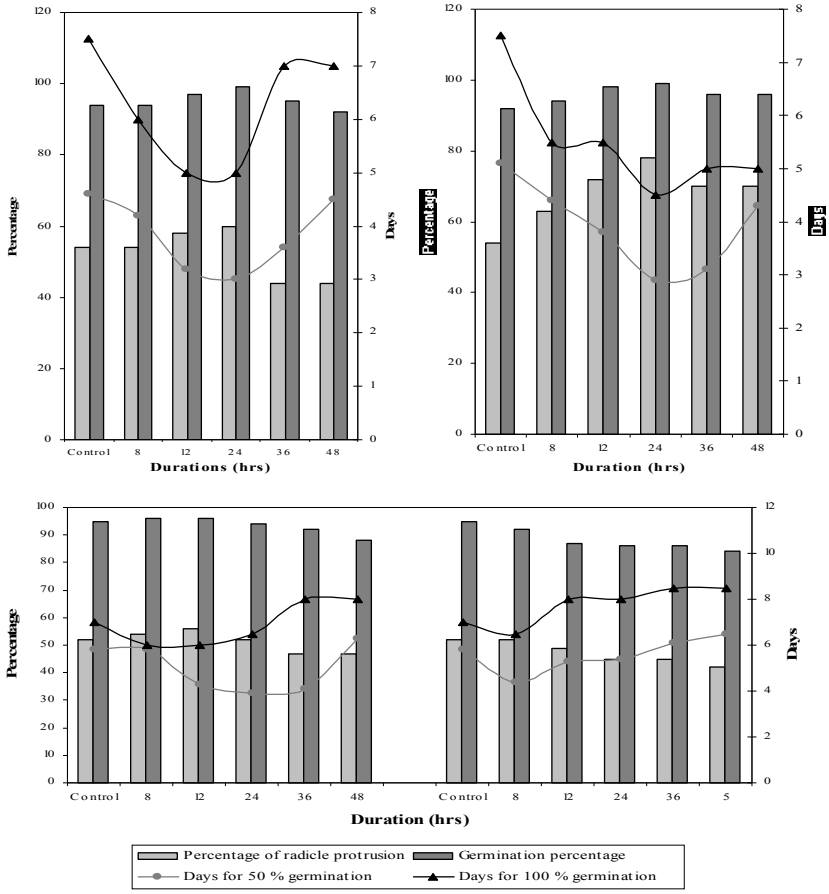

Fig. 1. Effect of priming on onion seeds. A = hydropriming, B = sand matric priming, C = osmoriming.

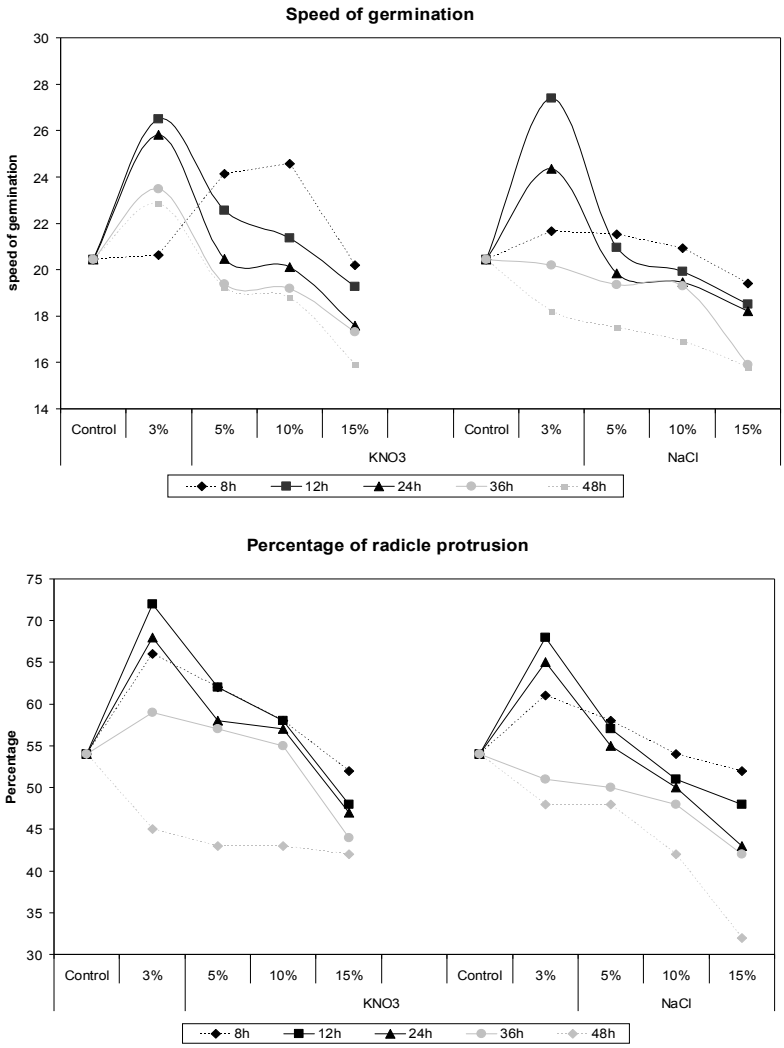

Fig. 2. Influence of concentrations and durations of halo priming on onion seeds.

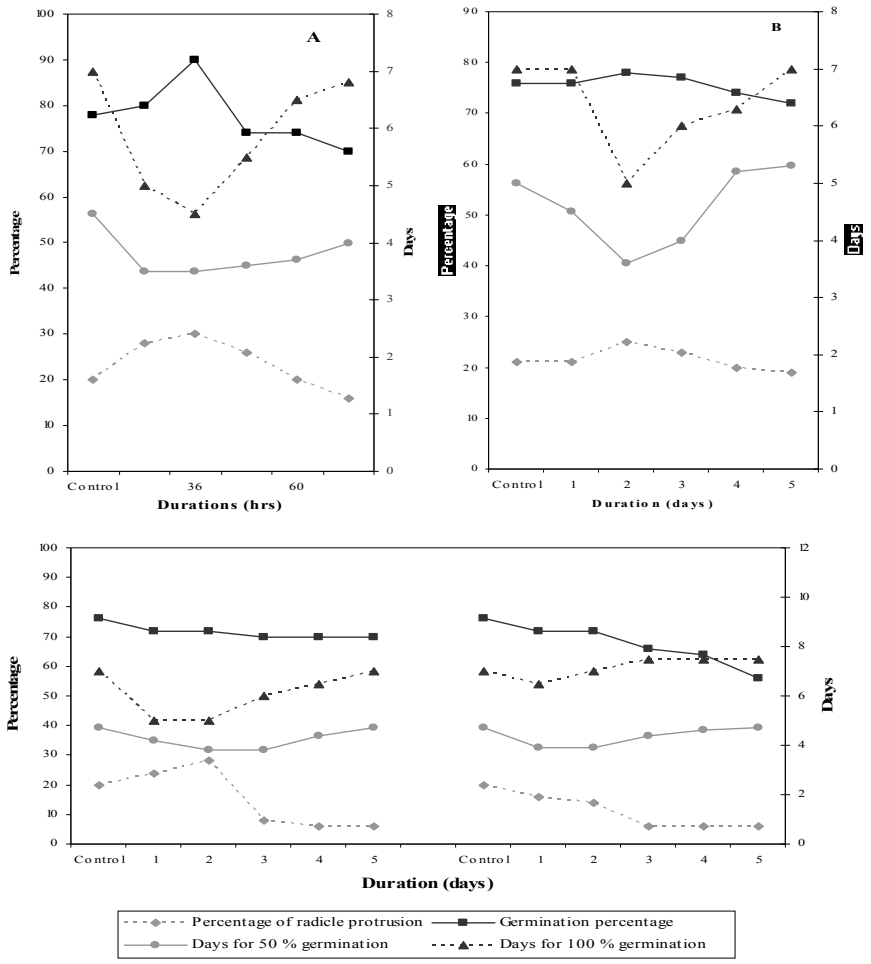

Fig. 3. Effect of duration of priming on carrot seeds. A = hydropriming, B = sand matric priming, C = osmopriming.

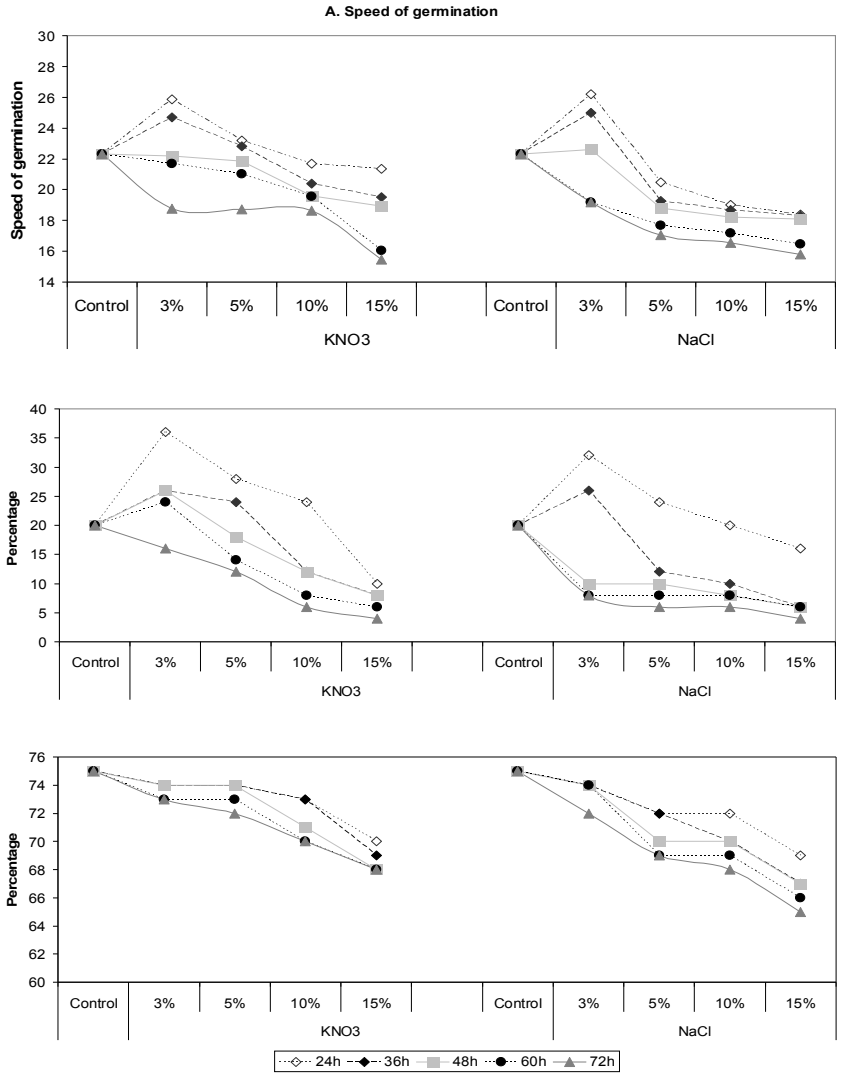

Fig. 4. Influence of concentrations and duration of halo priming on carrot seeds.

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