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Review article

RESPONSE OF MEDICINAL PLANTS TO SEED PRIMING: A REVIEW

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ABSTRACT

Medicinal plants were considered as rich sources of components which can be used in pharmaceutical industry. Often seed germination of medicinal plants and their seedling establishment are difficult in the field. A simple way to improve seed germination and seedling establishment and consequently field performance of medicinal plants is seed priming. During priming, seeds are partially hydrated, so that pre-germinative metabolic activities proceed, while radicle protrusion is prevented, then are dried back to the original moisture level. Therefore, primed seeds are physiologically closer to germination and growth after planting than unprimed seeds. Various pre-hydration or priming treatments have been employed for invigoration of medicinal plants. This review describes some effects of seed priming on germination parameters, filed performance and essential oil of medicinal plants under favorable and unfavorable conditions.

INTRODUCTION

Medicinal plants play a critical role in the development of human cultures around the whole world [29]. Recently, these plants gained a considerable importance in agricultural production, pharmacy and exportation because of their use as a raw material for the pharmaceutical industry [1]. Most of the medicinal plants have some problems in seed germination and stand establishment in the field [49]. Since germination and seedling establishment are critical stages in the plant life cycle [11], offering the solutions for improvement of seed germination and seedling establishment will help to better performance in cultivation of medicinal plants. One of the simple techniques which can improve seedling vigor and establishment and consequently field performance of plants is seed priming or physiological advancement of the seed [37]. This method is successful in small seed plants such as many medicinal plants that have great economic value with quick and uniform emergence requirement [15].

Understanding of seed priming

The term "priming" is used to describe a seed pre-sowing treatment. During priming seeds are partially hydrated and then they are dried in the next step. In general, water uptake by dry seed under optimal conditions during germination can be divided into three phases. Phase I, where imbibition is rapid that is largely as a consequence of the matric forces exerted by the seed. This phase occurs in dormant or non-dormant, viable or non-viable seeds. During first phase, DNA and mitochondria are repaired and proteins are synthesized using existing messenger ribonucleic acid (mRNA) [37]. Phase II is the lag phase, where there is very little net gain of water but considerable metabolic activities that prepare viable non-dormant seeds for radicle emergence. In this phase, the syntheses of mitochondria and proteins by new mRNA occur. Phase II is also called activation phase [8]. In phase III (final phase) water uptake increases and coupled with radicle elongation [6]. In primed seeds phases I and II of water uptake are passed, but seeds do not enter the third phase of water uptake. This hydration is sufficient to permit pre-germinative metabolic events but insufficient to allow radicle protrusion [7].

Types of priming

There are different methods of seed priming: 1) hydro-priming or soaking seeds in water; 2) halo-priming or hydration in inorganic salt solutions; 3) osmo-priming or soaking seeds in solutions such as polyethylene glycol (PEG); 4) thermo-priming or treatment of seeds with low or high temperatures [4]; 5) matri-priming or treatment of seeds with solid matrices, such as hydrated sand [32], peat and vermiculite [46]; 6) bio-priming or coating seeds with bacteria, e.g. *Trichoderma* spp. [39] and *Pseudomonas aureofaciens* [48]. In addition, seeds may be primed with plant growth regulators [42].

Seed priming and germination

Seed priming improves seed germination of medicinal plants. Hoseini *et al*. [31] suggested that seed priming techniques in two landraces of lemon balm increase antioxidant enzymes such as cation eskorbate. These enzymes reduce lipid peroxidation in germination time. So the germination percentage increases. It was also reported that pre-sowing chemical treatments enhance and improve seed germination in *Heracleum candicans* [35]. Ganji Arjenaki *et al*. [18] reported that osmo-priming with PEG-6000 increased percentage and rate of germination and radicle and shoot lengths in marigold (*Calendula officinalis*). Fariman *et al*., [16] also found that seed priming enhances percentage and rate of germination in *Echinacea purpurea*. Earlier germination of primed seeds may be due to increase in activity of enzymes such as amylase, protease and lipase which have great role in breakdown of macromolecules for growth and development of embryo [12]. It has been reported that resultant effect of priming depends on duration of seed soaking [22] and priming methods [19]. Aliabadi *et al*. [3] showed that the highest seedling vigor, germination percentage and seedling dry weight were achieved by hydro-priming after 12 hours in Basil (*Ocimum basilicum* L). It has been concluded that applying sulfuric acid for 15 minutes as pre-treatment on *Salvia mirzayanii* seeds show the highest positive effect on percentage and rate of germination [27]. According to Fredj *et al*. [17], the best germination percentage of coriander (*Coriandrum sativum*) was obtained by soaking seeds in NaCl at 4 g L^{-1} for 12 hours. Hoseini *et al*. [30] evaluated the response of fennel (*Foeniculum vulgare*) to different priming treatments (gibberellic acid with a dosage of 500ppm, hydro-priming with 24 hours duration and nitrate potassium 3%). They reported that the highest germination percentage was obtained by hydrated seeds with KNO3. The seedling length and weight in KNO3 and GA3 treatments were the highest in comparison with the other ones. According to Dhoran and Gudadhe [13], seed priming by GA3 at 50 ppm in *Asparagus sprengeri* was better than IAA, IBA, NAA in inducing germination and root growth. Takhti and Shekafandeh [44] found that germination rate of hydro-primed and osmo-primed (different concentrations of NaCl and ZnS) seeds was higher than that of control (seeds without treatment) in thorn jujub (*Ziziphus spina-christi).* The highest germination rate occurred in ZnS solution with an electrical conductivity (EC) of 8dS/m which was higher than that in ZnS solution with an EC of 16dS/m. It means that high concentration of ZnS had adverse effect on the germination rate. Iqbal and Ashraf [33] reported that although priming improves the rate of germination, the effectiveness of different priming agents varies with different concentration of priming solution and crop species.

Seed priming and field performance

Seed priming techniques are used to reduces emergence time, accomplish uniform emergence and better allometric (changes in growth of plant parts over time) in many horticultural and field crops [4]. It has been reported that hydro-priming increased percentage and rate of seedling emergence and seedling dry weight in *Echium amoenum* [14]. According to Tzortzakis [47], pre-sowing treatments increase fresh weight of seedlings in endive (*Cichorium endivia*) and chicory (*Cichorium intybus*). Goss [26] also found that the use of water and potassium nitrate (1%) as seed primers improves the emergence percentage and initial seedling establishment of moringa. This is in agreement with the results of another research about two landraces of the 'Balady' cumin [45]. Rapid emergence of seedlings could lead to the production of vigorous plants. In addition, improvement of seedling emergence percentage could help to establish optimum plant population density under a wide range of environmental conditions [28]. According to Ghassemi-Golezani *et al*. [20], percentage ground cover (PGC) of borage (*Borago officinalis* L.) was improved as a result of seed priming, particularly hydro-priming. It has been reported that high ground cover of plants from primed seeds was related with the early emergence and well establishment of these seedlings [22]. Since, there is a linear relationship between percentage ground green cover and light interception [9], it can be used as a reliable index to estimate yield potential of the plants under favorable and adverse environmental conditions [21].

It has been reported that seed priming with gibberellic acid increases seedling growth and leaf area of *Anthemis pseudocotula* Boiss [40]. The beneficial effects of seed priming on leaf area have also been reported in pumpkin (*Cucurbita maxima*) [43]. Karthikeyan et al. [36] reported that bio-priming with *Azospirillum brasilense* and *Pseudomonas fluorescens* increased plant height, root length, number of leaves and alkaloid contents in two varieties 'rosea' and 'alba' of *Catharanthus roseus*. It has been reported that priming with SA can be used as an appropriate strategy to improve photosynthetic parameters of safflower [34]. Shabbir *et al*. [41], found that different priming techniques improve growth and yield of Fennel (plant height, number of leaves per plant, fresh and dry weight per plant, number of umbels per plant, seeds per umbel, 1000-seed weight, seed yield, biological yield and harvest index).

They observed that the plants from primed seeds with CaCl2 (2.2%) produced the maximum grain yield compared with KCl (2.2%) treatment. Ghassemi-Golezani *et al*. [23] reported that seed priming with NaCl can be used to promote grain yield of isabgol (*Plantago ovata* Forsk) which ultimately can enhance mucilage production. It has been indicated that seed priming with KNO3 and GA3 improve essential oil percentage of fennel [30].

Advantages of seed priming under stress

Effects of seed priming persist under sub-optimal conditions. Chen *et al*. [10] found that seed priming of spinach by PEG at -0.6 MPa at 15°C for 8 days enhanced stress tolerance by improving germination performance at sub-optimal and supra-optimal temperatures and under water stress of -0.8 and -1.2 MPa. Ahmadian *et al*. [2] suggested that hydro-priming increases germination and seedling growth under salt stress in cumin. Movaghatian and Khorsandi [38] reported that seed priming by salicylic acid (0.00001 mM) improved all germination characteristics (percentage and rate of germination, radical and plumule lengths and seed vigor) in ajowan (*Carum copticum*) under salt stress.
Ghassemi-Golezani *et al*. [24] found that reductions in ears and grains per plant due to salinity in isabgol were largely compensated by seed priming, especially by KNO3. Aymen and Cherif [5] indicated that with increasing salinity, emergence traits (total emergence and mean emergence time), growth parameters (plant height and shoot fresh and dry weights) and mineral contents (K+ and Ca2+) decreased, but to a less degree in primed seeds. They observed that seedlings from primed seeds had higher emergence and growth rate than control under different salinity levels. Gholami *et al*. [25] reported that hormonal-priming alleviated negative effects of drought stress on emergence percentage, morphological characteristics, 1000-seed weight and yield of essential oil, chlorophyll contents and antioxidant enzymes in basil.

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