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Seed quality enhancement techniques in medicinal and aromatic crops

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Abstract
Indians have been using the Ayurvedic (medicinal and aromatic crops) systems of medicine for many generations and they contain one or more substances that can be used for therapeutic, aromatic and/or culinary purposes as components of cosmetics, medicinal products, health foods and other natural health products. Seed quality plays an important role in the production of medicinal and aromatic crops unlike in others as these crops possess seed dormancy and seed inhibitors thus possessing reduced seed quality. These associated seed inhibitors also are known to decrease the viability during seed storage resulting in their poor storability. In this scenario "seed enhancement" through various techniques offer a great potential in getting success full seed germination and optimum field establishment thus enhancing the quality of the product and production of these commercially important crops. The central objective of such enhancement techniques is to further improve seed performance by treating with specific additives/chemical/organics/botanicals *etc.* under very specific regimes.

Keywords: quality seed, seed enhancement, medicinal and aromatic crops

Introduction

India has been considered as a treasure house of valuable medicinal and aromatic plant species. Ministry of Environment and Forests have identified and documented over 9500 plant species considering their importance in the pharmaceutical industry. In the present context of 'back to nature' in health care, it is relevant that these valuable plant species are not only preserved but also their cultivation developed in order to meet the entire demand of the domestic industries as also to exploit the bright prospect for export. A shift from collection to the cultivation of medicinal & aromatic plants will also ensure purity, authenticity and sustainable supply of raw materials required for herbal drugs, including polyherbals.

The diverse Agro-climatic situations in the region offer excellent scope for growing different horticultural crops like fruits, vegetables, spices, plantation crops, medicinal and aromatic plants. Medicinal and aromatic plants constitute a major segment of the flora, which provides raw materials for use in the pharmaceuticals, cosmetics and drug industries. The indigenous systems of medicines, developed in India for centuries, make use of many medicinal herbs.

Ancient, natural health care, tribal practices, Ayurveda, Sidha and Unani are the part of traditional medicine (Pokharkar *et al.*, 2011) [1]. Indians have been using the Ayurvedic systems of medicine for many generations (Bapat *et al.*, 2012) [2]. Medicinal plants are so important for health care of human beings in respect to ancient medicine system. Maximum of the traditional medicines are based on herbs, which are used by almost 80 (%) of the world's populations.

Medicinal plants play a critical role in the development of human cultures around the whole world (Hassan, 2012) [3]. 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 (Abou-Arab and Abou, 2000) [4]. Most of the medicinal plants have some problems in seed germination and stand establishment in the field (Zare, *et al.*, 2011) [5]. Since germination and seedling establishment are critical stages in the plant life cycle (Cheng and Bradford, 1999) [6], 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 (McDonald, 2000) [7]. This method is successful in small seed plants such as many medicinal plants that have great economic value with quick and uniform emergence requirement (Ellis and Roberts, 1981) [8].

Seed quality is the major decisive factor governing stand establishment of any crop and thus bears immense importance and bears utmost priority in case of high value, low volume crops and for high volume low value crops in general for enhanced productivity and production as well. A number of diverse materials/treatments at varying doses have been used to increase the rate and uniformity of seedling emergence in wheat and rice, which are generally categorized for seed enhancement. Seed enhancement may be defined as post-harvest treatments that improve germination and seedling growth or facilitate the delivery of seeds and other inputs/materials required at the time of sowing smoothly. Seed enhancement technology predominantly possess a central objective to further improve seed performance by treating with specific additives/chemical/organics/botanicals etc under very specific regimes and with the aid of certain planting equipments to grow uniform crop obviously to harness higher productivity and production (Halmer, 2006) [9]. Good-quality seed has a significant potential of increasing on-farm productivity and enhancing food security (Afzal, 2013) [10]. Seed quality is the foundation for profitable production and marketing (Burris, 1980) [11] (Tatipata, 2009) [12]. High-quality seeds are genetically and physically pure, vigorous and free from insect pests and pathogens (Halmer, 2003) [13]. High-quality seeds with enhanced vigour contribute nearly 30% of the total production. Plant uniformity is an expression of high seed quality achieved by high vigour of seeds (Ellis, 2004) [14]. Seed quality is influenced by several factors during seed development, such as maturation, harvesting, drying, cleaning, grading, packing and storage. Farmers and growers are constantly looking for high-quality seeds to ensure uniform field establishment and increased production (Ventura *et al.*, 2012) [15].

Importance of medicinal plants are

Medicinal crops provide better returns than traditional crops because they

- Have very high domestic and export demand
- Fetch better prices in the market
- Could be stored for a long time, and sold at a time when better prices prevail in the market
- Are the largely drought tolerant, and not easily grazed by animals
- Have low incidence of pest attacks and diseases
- Require minimum resources, therefore the cost of cultivation is lower compared to the traditional crops
- Could be raised as inter-crops, along with traditional crops, and also on degraded lands.

Importance of Aromatic Plants

Aromatic plants are from a numerically large group of economically important plants. These are increasing demand for essential oils, aroma chemicals drugs and pharmaceuticals in the world market since two decades. Aromatic compounds are present in plants i.e. in root, wood, bark, foliage, flower, fruit, seed etc.

1. Aromatic plants produce essential oils, perfumes and flavours are in use with our civilization since several thousand years.
2. Due to Vast area and varied agro-climatic condition, it can be commercial cultivated in different part of India successfully.
3. Essential oils and aroma chemicals are indispensable in various human activities.
4. They are adjuncts of cosmetics, soaps, pharmaceutical preparation, perfumer confectionery, ice-cream, aerated waters, disinfectants, agarbatti *etc.*
5. Some of the important aromatic plants like Lemon grass, Citronella, Palmarose, Vetiver, Geranium, Lavender, Dawana *etc.* have great demand in our country.

Why we need to seed quality enhancement in	
Aromatic plants	**Medicinal plants**
➢ Poor seed germination ➢ Long-time seed dormancy ➢ Poor acclimatization ➢ To enhance health status of seeds ➢ Handling of seeds ➢ Availability of quality seeds ➢ Conservation	➢ To overcome the various problems of seed germination because of higher seed dormancy (Thick seed coat or waxy coating on the seeds, Immature / Rudimentary embryo) poor seed set and seed viability. ➢ To facilitate easy handling for mechanical sowing as most of medicinal seeds are small in size. ➢ To preserve their gene pool from extinct condition through domestication and multiplication. ➢ To determine the quality standards under seed enforcement law.
The main problem is Hard seedcoat, as a consequence of dormancy, germination is very low	

Techniques employed for the testing seed quality of aromatic and medicinal plants

Seed quality enhancement in aromatic crops: The rationale for pre-sowing seed enhancement techniques is to mobilize the seeds own resources and to augment them with external resources to get maximum improvement in field stand establishment and yield. To achieve this, several physical, physiological and biochemical treatments are available at present to give value addition to seeds.

Treatment	Seed treatment and their influence on seed quality	Crop	Reference
Seed dormancy breaking treatments	Seeds were soaking in 1% sodium hypochlorite (NaOCl)	*Carum carvi*	Hradilik J & Cisarova H (1975) [16]
GA_3 treatment	Seeds are soaked in GA_3	*Saussurea lappa*	Arora R & Bhojwani SS (1989) [17]
Seed pelleting	Hydro priming for 12 h recorded highest seedling vigour, germination percentage and seedling dry weight	*Ocimum basilicum* (Basil)	Hosseein and Kasra (2011) [18]
	Seed soaking in cold water record highest germination percentage.	*Catharanthus roseus* (Periwinkle)	Shylaja *et al.* (1997) [19]
	Water soaking for 18-24 h enhanced the seed quality of aged seed lot.	*Tagetes erecta* (Mexican marigold)	Pramila *et al.* (2013) [20]

	Hydro priming for 12 h improved the germination and dry matter production	*Trigonella Foenum-* Graecum (Fenugreek)	Hosseein and Kasra (2011) [21]
Acid Scarification	Fresh seeds were immersed in concentrated sulphuric acid (H_2SO_4)	*Rheum webbianum*	Gautam *et al.*, (2016) [22]
Seed Priming (soaking in) with growth regulators	Soaking in 100 ppm GA_3 for 6 h improved the germination	*Andrographis paniculata* (Kalmegh)	Fathima *et al.* (2003) [23]
	Soaking in 50 ppm GA_3 for 3 h recorded maximum vigour	*Asparagus sprengeri* (Foxtail fern)	Dhoran and Gudadhe (2012) [24]
	Soaking in 200 ppm IAA for 6 h recorded higher germination	*Cassia obtusifolia* (Nesavu)	Arulmozhi (2012) [25]
	Soaking in 200 ppm Ethrel for 6 h recorded maximum seedling growth	*Gymnema sylvistre* (Gymnema)	Harakumar (1997) [26]
	Soaking in 1 per cent KH_2P0_4	*Withania somnifera* (Ashwagandha)	Velmurugan *et al*. (2003) [27]
Priming (soaking) with inorganic salts	Soaking in 50 to 100 mM KNO_3 recorded the maximum germination compared to control	*Aconitum balfourii* (Indian Atees)	Pandey *et al.* (2000) [28]
	Soaking in 130 mM thiourea recorded early germination	*Aconitum heterophyllum*	
	1 per cent sodium nitrate enhanced plant height, root length and other yield parameters.	*Withania somnifera* (Ashwagandha)	Kattimani and Reddy (2001) [29]
Seed priming with organic products	25 per cent coconut water for 6 h enhanced nursery emergence.	Bixa orellana (Achiote)	Navamaniraj (2005) [30]
Hydration treatments	Soaking in prechilling at 4ºC for 10 days stimulated germination and reduced the germination time	*Descurainia sophia*	Tavili *et al.* (2010) [31]
	Prechilling (4ºC) for 10 days improved germination	*Descurainia Sophia* (Flixweed)	Tavili *et al.* (2010) [32]

Seed quality enhancement in aromatic crops: One of the main problems that prevent sustainable use of medicinal plants, native to the arid lands is that they readily germinate within the native environment, but fail to show good germination under laboratory conditions (Gupta, 2003) [33] or when cultivation is attempted.

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) (McDonald, 2000) [7]. 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 (Bradford, 1995) [34]. In phase III (final phase) water uptake increases and coupled with radicle elongation (Bewley and Black, 1994) [35]. 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 (Bradford, 1986) [36].

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; 5) Matri-priming or treatment of seeds with solid matrices, such as hydrated sand, peat and vermiculite (Taylor, *et al*., 1998) [37]; 6) Bio-priming or coating seeds with bacteria, e.g. *Trichoderma* spp. and *Pseudomonas aureofaciens* (Warren and Bennett, 1999) [38]. In addition, seeds may be primed with plant growth regulators (Subedi and Ma, 2005) [39].

Seed priming and germination

Seed priming improves seed germination of medicinal plants. Hoseini *et al*. [40] 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. It was also reported that presowing chemical treatments enhance and improve seed germination in *Heracleum candicans* (Joshi and Dhar, 2003) [41]. Ganji Arjenaki *et al*. [42] 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*. [43] 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 (Dell-Aquila and Tritto, 1990) [44]. It has been reported that resultant effect of priming depends on duration of seed soaking (Ghassemi-Golezani, *et al.*, 2008) [45, 46, 47] and priming methods. Aliabadi *et al*. [48] 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. According to Fredj *et al*. [49] 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*. [50, 51] 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 KNO_3. The seedling length and weight in KNO_3 and GA_3 treatments were the highest in comparison with the other ones. According to

Dhorhan and Gudadhe [52], seed priming by GA_3 at 50 ppm in *Asparagus sprengeri* was better than IAA, IBA and NAA in inducing germination and root growth. Takhti and Shekafandeh [53] 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 8 dS/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 [54] 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.

Sl. No.	Treatment	Seed treatment and their influence on seed quality
1.	Seed Fortification	Seeds are soaked in water or dilute solutions of bioactive chemicals, such as micronutrients, growth regulators, vitamins and proteins.
2.	Seed Infusion	Impregnation of seeds with bioactive chemicals of organic in nature chemicals through organic solvents instead of water.
3.	Seed Fumigations	Fumes are released in seed storage by burning of volatile solvents or atomization of fungicides that on combustion are sublimed or evaporated with lethal effect on fungal pathogen. *eg. Methyl bromide, Ethylene dibromide, etc.*
4.	Seed pelleting	The application of solid materials to seeds in sufficient quantity to make the pelleted seed
5.	Irradiation	Seeds in hydrated state to light in order to break seed dormancy or to improve the rate of germination.
6.	Synthetic seeds	Artificially encapsulated somatic embryos, shoot buds, cell aggregates, or any other tissue that can be used for sowing as a seed.

The technology designed to combine the advantages of clonal propagation with those of seed propagation and storage. Also be as channel for new plant lines produced through biotechnology advances.

Conclusions and future prospects

Seed enhancements have a wide range of commercial applications from improved crop stands through better germination rates and seedling vigour effective in crop stress management, and improved crop yields together with efficient use of resources such as fertilizers, water and seeds. Sustainable crop production requires the adoption of low-cost and environment friendly seed enhancement techniques. Biological seed enhancement with bacteria and fungi is one of the most appropriate techniques in disease control and growth promotion which can be exploited by seed industry.

The biochemical pathways by which these techniques affect different processes regulating growth and development need to be elucidated. Longevity of primed seeds during storage remains a problem, which needs to be re-addressed, and work should be extended on other physical or biological seed treatments for their storability. Nutrient priming with micronutrients not only help to overcome seedling constraints but can also be applied as a complementary approach for biofortification to harvest grains high in Fe, Zn and Mn. Priming invokes stress tolerance and improves performance of varieties. The integration of molecular approaches with seed enhancement may significantly contribute to enhances seed vigour and better plant stand.

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