



## REVIEW PAPER

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**Introduction of seed treatment techniques (seed priming)**

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**Abstract**

The increasing population of the world and everlasting demand for food on one hand, and the limitations present on expanding farmlands on the other hand provokes incentives for scientists to innovate more efficient methods for making improvements in crops production. For meeting this need, numerous methods have been developed that can be classified in two general groups: crop production and crop eugenic. Applying these methods is a complicated practice because the activity of plants depends on many factors including climatic conditions, soil, plant-specific factors and existing interactions between each. However, many exploratory researches are dedicated to this field now. One of the most common approaches that have been adopted by many countries is pre-farming treatment. The previous century was the age of dominance for chemical treatments. Although these methods proved to be efficient in increasing the productivity of crops, they had harmful side effects on environment. So, the focus of scientists and scientific researches has shifted toward the biophysical methods.

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## Introduction

### *Definitions and terminology*

Seed treatment can be generally defined as all operations that are executed on seeds after taking them from mother plant. These practices are aiming at several targets including facilitating automated planting of some seeds like tobacco and sugar beet, making improvements in managing pests and diseases like brown rust, and increasing the productivity, improving sprouting and emergence of buds that are carried out through seed coating, seed treatment with solution of sea water and lime, and seed priming methods respectively. Several terms are used for seed treatment including Seed Priming, Seed Treatment, Osmo Priming, and Osmo Condition Matrix priming Matrioconditioning. Priming is a form of pre-farming treatment in which the seeds are pre-soaked and then left to be dried for a while during which the sprouting process begins but the roots have not been emerged yet (Murungu *et al.*, 2004). Taylor *et al.* (1998) use a more wide term namely seed enhancement which involves pre-soaking hydration, coating technologies, and seed conditioning (Figure 1).

### *Techniques used for seed treatment*

#### *Pre-Soaking hydration*

Treatments of water absorbing type include uncontrolled (those methods in which seeds have a free access to water without any environmental limitations) and controlled (methods in which the content of humidity is adjusted and emergence of roots is prevented) systems. Three different techniques are used for controlled absorption of water: priming with solutions, solid matrix, and manual controlled water (Taylor *et al.*, 1998).

#### *Seed Coating technologies*

Applying a film coating on the surface of seeds. Coating may be utilized as a delivery system due to variations in their size, shape and color. Often, some problems emerge in discrimination of seeds and accuracy of planting because of small-size seeds, so they are covered with a coating which is useful for protecting seeds from pests as well. Seeds coating

technologies include two methods: pelleting and coating (Taylor *et al.*, 1998) (Figure 2).

#### *Seed Coating Technology*

A process in which a thin and consistent layer of a special material covers the surface of seed; by doing so a suitable living environment is provided around the budding area and an advanced movement in critical growing stages will be activated. This technique was applied for the first time in 1977 and in Canada. Obviously, the coating technology is not able to make any changes in genetic traits of seeds. However, regarding to the financial advantages of this process, coated seeds are considered valuable products. This process is worth to be offered to farmers who farm forages and oilseeds (Gustafson, 2006).

In fact, coating technologies are the most effective, simplest, and safest methods in seeds improvement. 1) Pre-germination: once the sowing operation is accomplished, it takes several weeks or months for knots to be formed by rhizobia bacteria. However, through seed coating technology the bacteria are close enough to budding area that lead to an early knot forming. 2) Nutrients: in seed coating process seeds are provided with a healthy environment in which the growing energy during the initial stages will be increased. 3) Protection against stress, animals, birds, and fertilizers: most of the rodents and birds cannot identify the coated seed as an edible material (Gustafson, 2006). Using polymeric seed coating technique increases the percentage of germination through direct fertilizing of the soil (Tilley and John, 2010).

#### *Smart Seed Coating techniques*

Maize planters know for sure that every minute is critical during the planting period. Often, the favorable period in which the conditions of both weather and soil are suitable for planting is very short. In traditional methods farmers sow the seeds in cold soil during spring season and wait until the conditions become suitable, but when the young plant come out it is weak and vulnerable to cold

weather and may die. Smart seed coating techniques have been developed for the purpose of solving this problem (Houghton, 2004) (Figure 3).

Advantages of Smart Seed Coating techniques: 1) early farming 2) the coating takes the form of a rigid shell around the seed. When the seeds are put into the cold soil, no water can penetrate into this shell. So, there will be no budding unless the temperature reaches to 55 degrees Fahrenheit when the shell loses its shape and allows penetration of water. This process is reversible and repeatable, thus will be able to protect the seed against cold weather. It can regulate the water absorption until the seed is provided with enough water to sprout and grow. Consequently, the maize seed which is planted early will wait for favorable conditions and this in turn will lead to a consistent and perfect stability (Houghton, 2004).

#### *Seed Pelleting or rounding*

The seeds of the economically valuable crops like sugar beet and lettuce are usually pelleted after coating for the purpose of improving the yield of sowing and their appearance. The pelleting process is mostly performed by clay or organic-based fillers. Besides, the filler may contain improving materials or may be rigid enough to resist against being worn during sowing. The pelleted seeds must be decomposed immediately after planting so don't prevent the seed from sprouting. The irregular seed takes the shape of a symmetrical hemisphere during pelleting process (Gustafson, 2006). The obtained results from the relevant studies have indicated that using polymers in pelleting process increases the potassium content in crops, and also their anti-fungus characteristics minimize any potential damage to plant (Antonio and Antunes, 2007) (Figure 4).

#### *Seed Conditioning*

This method deals with increasing the seed quality by physical criteria. The seeds collected from farmlands are rarely pure and are usually mingled with other undesirable substances including low-

quality, pest-affected, and smashed seeds, weeds, and solid particles which must be removed from seeds pile (Taylor *et al.*, 1998).

#### *Events that happens during priming process*

According to Rashid *et al.*, (2004) the germination process accomplishes in three phases: 1) Water absorption by seed, 2) Delaying phase, 3) Radicle growing through emergence of testa.

During the first two phases, seeds are tolerant of drought but once the third phase started they become highly intolerant of drought. Normally, the seeds sprout when the seed water potential reaches to the critical physiological level (0-2 Mega Pascal). Seeds with a penetrable seed coat usually pass three phases for being sprouted. During the first phase, they absorb water. When the water penetrates into the seed and reaches to embryo, the second phase begins during which the stored hormones and enzymes will be activated and stimulate in turn the physiological growing. Ultimately, growing of the radicle begins in third phase. Through priming operations, replication of DNA, increasing of protein and RNA synthesis, accessibility to more ATP, quick growing of embryo, repair of damaged sections of the seeds, and reducing of metabolites leaking into the seeds are all provided during the delaying phase. Performing seed priming, during G<sub>2</sub> and S stages of mitosis the replication accomplishes and nucleus content becomes double but there is not any cell division yet and this condition will advance budding by one stage in later soaking operations. On the other hand, quick absorption of water leads to rupture of cell membrane, celluloid death of cotyledons and embryo axis of cells, and reaction of oxygen. The efficiency of seed priming can be attributed to augmentation of four-string DNA nucleus in radicle meristem (Lanteri *et al.*, 1996).

#### *Positive effects of seed treatment*

1) In regions where manual farming is a common method seeds may be placed either too deep or too close to surface, so durability of seeds and stability of plant will be achieved through treatment. 2) In cold

areas where the farming period is short, using priming can lead to an early emergence of plant and hence, it will be provided with a proper opportunity to gain tolerance against cold weather. 3) In regions where there is a delay in farming, seed treatment is recommended to compensate for this postponement. 4) In regions where there is a limited access to water resources, seed treatment will come in handy for having a cost-effective irrigation. 5) Seed treatment causes an increase in performance and also a decrease in waste of water due to early establishment of plant during the winter. 6) Seed treatment enhances the tolerance of plant for any unfavorable conditions. 7) Seed treatment can make improvements in the processes of germination and seedling emergence of new plants. 8) It enhances the root growing. 9) As a dynamic technology (increase in speed and consistency in emergence), it leads to a high vitality and better performance in flowering plants. 10) Enabling adjusting factors of plant growing, it makes changes in growing, physiologic processes, enzyme activities, and absorption of nutrients which can resist nonliving stresses. 11) It breaks sleeping period in some seeds like lettuce (Chastokolenko, 1984).

#### *Negative effects of seed treatment*

A significant decline can be observed in life span of treated seeds comparing to untreated ones (Bruggink *et al.*, 1998). Van-Pijlen *et al.*, (1996) proved that the deleterious impacts of seed treatment during storage time weaken repairing activity of DNA due to advancement in cellular cycle. Increase in fat peroxidation due to existing active agent of auxin in absence of protective mechanisms, lowers the durability of treated seeds (Bruggink *et al.*, 1998).

#### *Approaches in seed treatment*

The methods used in seed treatment can be broadly classified into two main categories: biophysical and biochemical treatments (Chastokolenko, 1984).

#### *Biochemical Methods*

Chemical treatments are conducted through several ways including treatment by pure water (Hydro-

priming), treatment by osmotic solutions (Osmo-priming), treatment by applying growing adjusters, and solid matrix priming (Chastokolenko, 1984).

#### *Treatment by growing adjusters*

Adjusters of plant growing include mineral substances which make very slight modifications in physiological processes. Reportedly, they have a little impact by their own. Simultaneous activity of two or more of these materials is required for a physiological effect to happen (Dubinov *et al.*, 2000). The most common adjusters are Cycocel, Ethephon, Gibberellic, Cytokinin, and Indol Acetic Acid (IAA). In cereal adjusters of growing are mostly used for the purpose of increasing the durability of plant against cold weather (Gusta *et al.*, 1994) and also for postponing the aging process (Nooden and Letham, 1993). Auxins like IAA, IBA, NAA, and 2-4-D are used for stimulation and improvement of root forming through applying on the soil and also for seed priming (Decastro *et al.*, 1995). Koranteng and Matthews, (1982) found that applying 20 g/ml $\mu$  of Gibberellic during the initial stage of growing in barley can lead to a significant increase in stalk forming, the number of spike, and seed yield. Ma and Smith, (1992) also observed the similar results from applying Cycocel and Ethephon in growing stage of barley. Hoseini *et al.*, (2013b) found that seed treatment by GA<sub>3</sub> with content of 50 ppm carried out prior to planting, can improve root length, budding proportion, vigor of plant, particularly for fennel seeds of low quality.

#### *Treatment by osmotic solutions*

The results obtained by Basra *et al.*, (1989) proved the effects of treating maize seeds by polyethylene glycol or potassium salts like KNO<sub>3</sub> and K<sub>2</sub>HPO<sub>4</sub> on speeding the germination process in cold temperatures like 10 degrees Celsius. Misra and Dwivedi, (1980) reported a 15% increase in wheat performance when the seeds are treated by 2.5% potassium chloride solution for 12 hours prior to be planted. Paul and Chouh-hary, (1991) conducted a similar examination using 0.5-1% potassium chloride and their findings indicated a significant increase in

performance-related attributes of wheat seeds. Chiu *et al.*, (2002) observed acceleration in germination process rate of wheat seeds which have been treated by polyethylene glycol solution. Hardegee and Van-Vactor, (2000) conducted an experiment the focus of which was on examining the variety of reactions in PEG-primed *Elymus* seeds to changing temperatures. In higher temperatures (treating temp. 30-36°C) seed treatment causes a decrease in the whole percentage of budding in some seed masses. Windauer *et al.*, (2007) performed priming operation on *Lesquerella Fendleri* seeds using 2 mp polyethylene glycol. They concluded that when seeds are primed the sprouting process occurs more quickly in both lab and land conditions furthermore, treated seeds are more consistent than untouched ones. Positive effects of osmo priming on sprouting and growing have been reported in several plants including barley (Abdolrahmani *et al.*, 2007) cucumber (Ghassemi-Golezani and Esmaeelpoor, 2008) and rape seed (Ghassemi-Golezani *et al.*, 2010) (Ghassemi-Golezani *et al.*, 2011). Analysis of variances in experimental data indicated that there is a meaningful relationship between osmo priming and the rate of plant sprouting. The highest rate of sprouting and solid weight of plant was observed in osmo priming by potassium nitrate (Yildirim and Bilge, 2010).

#### *Seed treatment by distilled water*

Singh and Agrawal, (1977) reported that when seeds are soaked in distilled water, the rate of nitrogen absorption increase by 11 kilograms per hectare. Murungu *et al.*, (2004) examined the influences of typical priming (12 hours) on maize seeds for two successive years. Although the effect of seed treatment didn't not yield similar results in both years it leads to quantifiable effects on growing, flowering time, and ripening. On the other hand Harris *et al.*, (2001) reported more growing and durability, earlier flowering, and higher performance in treated seeds of maize. In another study Rashid *et al.*, (2006) found that soaking of barley seeds in water results in better performance of straw and seed. Giri and Schillinger, (2003) concluded that

soaking of wheat seeds in water for 12 hours causes improvements in the germination process. In another study conducted by Demir-Kaya *et al.*, (2006) considering hydro-priming effects on sunflower seeds, the results indicated that it accelerates the germination process in dry conditions and shortens the germination period. Tajbakhsh *et al.*, (2004) investigated different treating methods on onion and the obtained results indicated that hydro-priming in high humidity leads to shortening the average germination time. Kaur *et al.*, (2002) found that priming of pea by water and mannitol (4%) for 12 hours in 25°C can increase the number and biomass of plants knots. Hydro-priming improves the power of germination in plants of sesame species and speeds the germination and solid weight of the plant in lab conditions (Eskandari, 2011). Hydro-priming of bean seeds in water for 7-14 hours can improve the plant performance (Ghassemi-Golezani *et al.*, 2010).

#### *Solid Matrix Priming*

This kind of treatment includes mixing the seeds with solid substances of high capacity for keeping water (like soft coal, Ground Leonardite Shale, and dried moss) in water. In this method the seeds potential for absorbing water is controlled by physical and chemical characteristics (Yamamoto *et al.*, 1997; Hartz and Gaprile, 1995). Hartz and Gaprile, (1995) tried this method in the case of sweet maize and proved its impact on plant emergence in cold conditions. However, their findings were inconsistent with farm conditions. For the purpose of identifying the influences of this type of priming on Turfgrass species, Yamamoto *et al.*, (1997) performed farm examinations and complementary budding evaluation. Treatments of solid matrix type shorten the required time for the emergence of plant and also improve the final emergence.

#### *Biophysical Methods*

Nowadays, the requirements of future food safety and minimizing the destructive effects on the environment necessitate development of biological energy sources and also biological stimulators for the

purpose of promoting the level of energy in living things including both plants and animals. Therefore, biophysical treatments can provide reliable solutions in this regard. Transforming the existing energy inside the membrane (regardless of its source) into electricity and increasing the electrical potential of membranes, biophysical methods increase their energy. Biophysical stimulation of seeds and plants is accomplished through increasing the energy, intensifying the interaction of materials, activating the growing process, and ultimately increasing the operating processes. These methods make no change in physiological paths which are controlled by genetic regulations. Thus, using these methods with an appropriate rate will not lead to genetic alterations. Biological stimulation realized by these methods promotes the vitality and durability of plants in unfavorable climatic conditions hence, there will be little need for chemical fertilizers and in turn their negative impacts on the environment will be minimized. Applying electricity, magnet, unicolor lights, beams, and ultrasound waves can widely stimulate the plants growing. This technique is called electroplanting which can reinforce growing, increase performance and improve quality. Besides, this technique is useful for protecting plants against diseases and pests and also for obviating the needs for providing fertilizers and pesticides. Therefore, farmers can harvest more and better crops by spending less time and money (Vasilevski, 2003).

Here are some advantages of these methods regarding to meeting environmental requirements: 1) less operations on soil, so more protection of soil, 2) using less pesticides for removing soil and water pollution, 3) less need for using cultivating machineries, so more clean air, 4) reinforcing plants vitality in and adaptability for unfavorable conditions provides opportunities for developing more lands covered by plants and hence soil erosive processes will be significantly decreased (Vasilevski, 2003).

#### *Wave entrapping systems*

In 1925 an innovative technique was developed for the first time in France. By this technique the existing energies in atmosphere were accumulated and then utilized for reducing the parasitic pollution of soil (Vasilevski, 2003).

#### *Electrostatic systems*

These experiments were launched since 1746. In those days researchers exposed plants to electrostatic currents produced by generator and this process resulted in an increase in their growing rates. Many researchers have obtained desirable outcomes by applying these methods (Vasilevski, 2003).

#### *Direct currents*

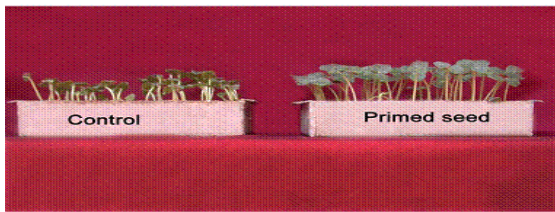
In 1840, a technique was developed in New York by which direct currents were generated by connecting copper and zinc plates beneath the ground. This process could multiply the production of tomatoes by several times. During the years between 1918 and 1921, farmers could increase their crops performance through using electrical solutions containing nutrients. Different studies have reported that when the soil is exposed to permanent weak currents the population of its bacteria increases by 150%. In 1966 researchers succeeded in killing the pests of avocado and orange trees by using direct current. Many studies have provided evidence for the fact that stable electrical currents can increase the absorption rate of NPK. Direct currents advance sprouting process by eliminating the sleeping period in seeds. Their effects are more significant when they are applied on seeds with lower budding capabilities (Vasilevski, 2003).

#### *Alternative currents (AC)*

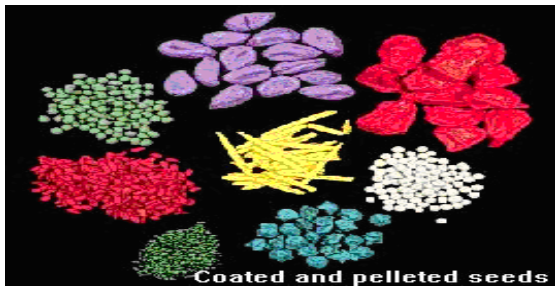
Alternative currents in most cases lead to better sprouting and stronger settlement of plants. Seed treatment through utilizing alternative currents reinforces the required energy for sprouting. It has been reported by several studies that during treatment operations applying the electrical field method, the fertility of pollinium seeds goes up at the beginning and down afterwards. Desirable outcomes



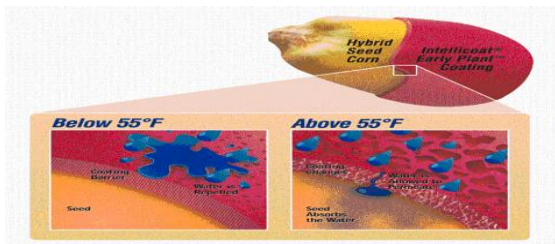
have been achieved in the case of maize and tomato (Vasilevski, 2003).



**Fig. 1.** primed seeds in comparison with control seeds (Ref: Internet).



**Fig. 2.** Coated and pelleted Seeds (Ref: Internet).



**Fig. 3.** Smart seed coating reaction to temperature (Houghton, 2004).



**Fig. 4.** Coated seeds in comparison with pelleted seeds in sugar beet (Ref: Internet).



**Fig. 5.** Seed Priming with Laser (Ref: Author)

#### Sound waves

It has been found that sound waves are capable of stimulating the growing process in plants. Frequencies of 4-5 kHz have detectable influences on

increasing the rate of budding, enzymes activities and respiration. Protoplasm has a descending flow rate during evening and early morning. This rate can be accelerated by sound frequency generators. It can occur when the generators are placed in 5 feet distance and activated for 30 minutes. Duration of exposing and quality of frequencies are varied in different plants. If the frequencies are too long, they may rupture the cellular tissue and lead to cells death. However, it has been reported from several studies that sudden increase in sound waves promotes the performance level, adds better taste to fruits, and provides more bright colors for flowers (Vasilevski, 2003). Yaldagard and Mortazavi, (2008) claimed that ultra sound waves can raise the percentage of budding in barley. Besides, such treatment causes a decline of 30-45% in budding time which can be attributed to metabolic changes in treated seeds. Applying ultra sound waves on wheat, carrot, maize, rice, tomato, and sunflower makes plants to advance their emergence 5 to 10 days earlier than untouched ones (Aladjadjiyan, 2002).

#### Radiation of unicolor lights and beams

It has been proved that using blue light reinforce budding, vitality, growing rate, stalk length, and leaves growing in plants. In the presence of blue light, pores are wider open, respiration and photosynthesis rates are higher, and hence more chlorophyll will be produced. Numerous studies have been conducted for investigating the effects of rays like UV, gamma, and laser (Vasilevski, 2003). The influence of laser beams on increasing the budding rate and seeds stimulation has been identified in recent studies (Podleony, 2002). An increase in percentage of budding in red clover was detected in treatment through laser radiation (Wilczek *et al.*, 2004). One of the positive effects of laser biostimulation is the increased concentration of photosynthetic pigments in leaves (Sacata *et al.*, 2012) (Figure 5). Gamma rays can have meaningful effects on average budding time, while higher doses postpone the budding process and so have no significant effect on budding (Abdul *et al.*, 2010). Investigated the effects of pre-sowing seed

treatments with gamma ray on the germination, emergence and seedling establishment of wheat had positive results (Hegazi and Hamideldin, 2010).

#### *Magnetic fields*

Many researchers have investigated the effects of magnetic fields on living organisms, particularly on sprouting and growing processes of plants (Chastokolenko, 1984). The obtained results indicate that magnetic fields modify the membrane characteristics, affect mitosis, and make some alterations in cellular metabolism. Magnetic field in certain cases influence growing characteristics and different activities of cells including amount of mRNA, genes manifestations, proteins biosynthesis, enzyme activities, and metabolism of meristem cells, and hence leads to some modifications in functions of organisms and tissues (Chow and Tung, 2000; Goodman *et al.*, 1995). Stimulation of plants through magnetic field can improve quality and quantity of crops and many studies from all over the world have provided evidence proving its influence (Vasilevski, 2003). Several experiments have supported the influence of magnetic field on sprouting, root length, and plant growing rate. Various researchers have studied and reported that magnetically treated maize, wheat, sunflower, barley, corn, beans, tomato, fruits and mushrooms etc. showed high performance in terms of germination, seedling establishment, plant growth, height, yield, mass per spike as well as shoot and root length and assimilation of fresh and dry matter (Jamil *et al.*, 2012). Iimoto *et al.*, (1996) found that applying a magnetic field of 4mT provided inside-the-bottle conditions can create useful effects for CO<sub>2</sub> absorption in potato offshoots. The experiments that have been conducted in the very field indicate that in treatment by magnetic field, the amount of strasis enzymes will increase during the sprouting process (Vakharia *et al.*, 1991). The outcomes form several examinations show identify magnetic field as an agent which affect metabolism in normal cells and have stimulative effects on mitosis as well (Belyavskaya *et al.*, 1999). It has been found that magnetic fields have varied influences and this variation depends on severity,

frequency, duration of treating operation, genotype and biological system (Blank and Goodman, 1996; Goodman *et al.*, 1995). Seeds treatment by magnet S pole increases growing and budding rate and create large leaves. The earth magnetic field has a direct effect on growing rate of some plants. Provided evidences by experiments show that wheat growing rate increase by about 5 times under such conditions (Gusta *et al.*, 1994). Feqenabi, (2007) claimed that magnetic field increases the amount of CGR, LAR, and LAI in safflower. Hoseini *et al.*, (2013a) found that magnetic field with power 75 mT can increase essential oil concentration in lemon balm for 2.2 times.

Using priming methods would increase the plant growth, yield and quality. Taking advantage from beneficial aspects of biophysical methods with no environmental pollution, this technique protects the plant against diseases and pests and decreases the use of fertilizers and pesticides. So the farmers can reach a crop with more quality and quantity with expensing less time, cost and effort. In addition, different seed treatment techniques help to reinforcement and support sustainable agriculture.

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