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Seed Treatments Commonly Used for Better Field Establishment of Crop Seed: A Review

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Abstract

Seed treatment is the application of physical, chemical, or biological agents to seeds prior to sowing in order to suppress, control or repel pests. One of the advantages of seed treatment is that, it breaks and prevents seed dormancy. Seed dormancy and germination are strongly influenced by phytohormones, which are highly dependent on plant growth regulator levels. This paper reviewed the most common seed treatments used for crop field establishment. Seed treatment technology relies on pre-sowing physiological, biological and chemical seed treatments. Under light environmental conditions, seed treated with (phytohormones, Gibberellic acid (GA), Benzyiladenine (BA), and potassium nitrate (KNO3) germination rate was higher than under dark conditions. GA increased germination percentage by 53 and 42% under light and dark conditions respectively, when compared to non-primed treatment. Similarly, seed primed with KNO3 increased germination percentages by 44 and 33% under light and dark environmental conditions respectively. Trichoderma is effective in enhancing crop growth and physiological processes. Seed treated with hot water (physical seed treatment) provides effective control of seed-borne fungal infections and improves seed germination. This paper reviewed various pre-sowing seed treatment methods widely used to improve crop germination, growth and field establishment.

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Crop, Germination, Seed Dormancy, Seed Treatment, agricultural productivity.

Introduction

Seed is a basic and critical input for persistent growth in agricultural productivity and production since ninety percent of the food crops are grown from seed (Pepukayi, 2015). Seed plays a great role in agricultural sector especially in developing countries like Ethiopia.

The seed-borne, early season diseases and insects create devastating consequences if not managed timely. Emphasis on present day agriculture is to produce more with limited land, water and labor (Sharma *et al.*, 2015).

Seed treatment refers to the exposure of the seeds to certain agents physical, chemical or biological which are not employed to make the seeds, pest or disease free only but treated to provide the possibility of pest and disease control also, when needed during germination and emergence of young plant and early growth of the plant (Forsberg *et al.*, 2003). Seed treatments are used to improve the yields of many different crops by providing the protection from pre and post-emergent insects, diseases and enhance uniform stand of crops (Sharma *et al.*, 2015). Poor crop stand is a result of germination asynchrony due to seed dormancy. One of the advantages of seed treatment is to break and prevent from seed dormancy. Seed dormancy and germination are strongly under the control of phytohormones and the germination responses for growth regulators depends strongly on levels plant growth regulators (Pepukayi, 2015).

Seed can be treated mechanically, chemically and biologically. Physical seed treatment (dry or aerated heat, hot water, radiation etc.) and using natural crop protection agents/microbial inoculants could be an alternative to chemical seed treatment methods in crop production. Moreover, pre- sowing physiological treatments (seed priming, fluid drilling etc.) for seed enhancement have a pivotal role in seed treatment technology. Biological seed treatments are made up of renewable resources and contain naturally occurring active ingredients targeting protection against soil-borne pathogens, alleviate a biotic stress and increase plant growth (Schwinn, 1994). The chemical control via soil/foliar application has its limitation such as high cost selectivity effect on target organisms, development of pest resistance, resurgence of pests, pollution of food and feed, health hazards, toxicity towards plants and animals, environmental pollution etc (Rahman *et al.*, 2008). However, being treating seed physically, physiologically and chemically in optimum have a great role for breaking dormancy, germination, yield and better field establishment. Therefore, the objective of this paper is to review and discuss seed treatments commonly used for better field establishment of crop seed.

Methods of Seed Treatments

Physical seed treatments

Considering the side effects of chemicals on ecosystem and organism, some alternative methods were evolved and are being used presently for treating seeds (Jindal *et al.*, 1991; Elwakil, 2003; Aladjadjiyan, 2007). In agrochemicals, they are less suitable to be used as it degrades land, environment (Chapman and Harris, 1981; Vasilevski, 2003). Thus, it is important to investigate the use of sustainable methods, such as physical methods in this century (Amein *et al.*, 2011). The physical methods were an aerated steam treatment (AS) (Forsberg *et al.*, 2002), a hot water treatment (HW) (Nega *et al.*, 2003) and an electron treatment (EL) (Jahn *et al.*, 2005).

Hot water treatment is a very age old practice to control many seed-borne diseases by using temperatures hot enough to kill the organism but not quite hot enough to kill the seed and it is still being used as a very effective alternative (Floyd, 2005; Muniz, 2001). This method of treating seed continue to be a standard method of pathogen elimination which is more eco friendly and effective compared to chemical treatments, however they can cause the loss of seed viability (Meah, 2004).

Treatment for the fungal disease blackleg and the bacterial disease black rot of crucifers is a classic example of hot water treatment (Walker, 1923; Napoles *et al.*, 1991). Hot water treatment can be damaging or not practical for seeds of peas, beans, cucumbers, lettuce, sweet corn, beets and some other crops (Nega *et al.*, 2003).

Thermal seed treatment has been practically applied in different ways. A simple way of thermal treatment is solarization, where the seeds are heated by irradiation from the sun (Luthra, 1953), which is sometimes applied in warm countries, but is of little interest in industrial agriculture due to low precision and difficulties with large-scale application.

Hot, humid, air, or “aerated steam”, treatment has been proposed as a way of avoiding the problems inherent in hot water treatment and as applied in a fluidized bed it has shown potential for large-scale seed sanitization in practice (Forsberg *et al.*, 2002).

Basically, the thermal treatment method used consists of two phases: The heating phase, where the seeds are heated for a certain time with air having a certain temperature and relative humidity calculated for good disinfestations, followed by a cooling phase that interrupts the treatment process before seeds are injured. The devices were constructed to permit precise control of important parameters (temperature, air humidity, treatment time, air flow and treatment and cooling durations) (Sharma *et al.*, 2015).

Radioactive irradiation has also in a few cases been reported to be successful (Cuero *et al.*, 1986; Bagegni *et al.*, 1990), but has not been widely used because exposures sufficient to control pathogens often also kill the seeds. Different types of electromagnetic radiation such as gamma ray (Harwalkar *et al.*, 1995), high energy electrons (Sitton *et al.*, 1995), ultrasonic radiation (Nagy *et al.*, 1995), microwave (Stephenson *et al.*, 1996; Anna Aladjadjiyan, 2010) and UV radiation (Gupta and Chaturvedi, 1987; Bhaskara Reddy *et al.*, 1995, 1998; Therdetskaya and Levashenko, 1996) have been used as alternative seed treatment agents for management of microbial infestations.

Seed treatment using emersion techniques

Seed emersion methods are those where seeds are steeped for varying periods of time in aqueous or solvent based liquids at ambient or raised temperatures with or without the addition of chemicals to eradicate seed borne organism (Black and Bewley, 2000; Martin and Woodcock, 1983; Rajesh Kumar *et al.*, 2012).

Conventional fungicide seed treatments, such as aqueous suspensions and powders, have been used to improve germination and seedling vigor. It is a non selective treatment for controlling any seed borne fungi and in addition giving protection against some soil borne pathogens (Singh *et al.,* 2000). On the other hand antibiotics also applied to the surface of seed have not been sufficiently penetrative to be effective against bacteria mainly located within the seed coat tissue.

Chemical seed treatments

Chemical seed treatment is very common and worldwide practiced, due to its wide spectrum ability to control plant diseases and pests taking less time and a number of automatic treatment machineries with high level of accuracy are available which makes it less labor intensive work (Nameth, 1998). It can be fungicides or insecticides, which applied to seed, to control diseases of seeds and seedlings; insecticides are used to control insect pests. Some seed treatment products are sold as combinations of fungicide and insecticide. Typically, chemical seed treatments do not offer benefits associated with root development, drought proofing or crop yield (EcoChem, 1998). It can be pre sowing seed treatment where seeds are soaked in water, mineral solutions viz., CaCl2, ZnSO4, cobalt sulphate/chloride, K2SO4, KH2O4, CuSO4, sodium molybdate, boric acid, manganous sulphate and other (Mariappan *et al.*, 2013) or growth regulators viz., ascorbic acid, kinetin, benzyl adenine, GA, CCC and other (Agboola, 2003 and Kumaran *et al.*, 1993) alone or in combination found to speed up germination process, increased germination rate and seedling vigor, improved resistance to water and salinity stress and increased crop yields (Pandey and Sinha, 1995; Krishnaveni *et al.,* 2010).

Seed dressing is the most common method of seed treatment and seeds are dressed with modern pesticides in which chemicals may be applied as dry powder or in the form of slurry (Upadhyaya, 2013). Dressings can be applied at both farm and industries. Seed coating is another chemical seed treatment which requires a special binder with a formulation to enhance adherence to the seed. Coating requires advanced treatment technology by the industry (Arias-Rivas, 1994; Upadhyaya, 2013). The earliest methods of treating seed with fungicides were relatively crude. The first method used involved piling the seed to be treated on a solid surface and then dusting the top of the pile with the fungicide (Mathre *et al.*, 2001; Taylor *et al.*, 2008).

Seed pelleting is the most sophisticated seed treatment technology, resulting in changing physical shape of a seed to enhance pelletibility and handling. Pelleting requires specialized application machinery and techniques and is the most expensive application (DPPQS, 2007). Because in seed coating chemical is in direct contact with seed thus the phytotoxic chemicals are not applied with this method and to overcome this drawback seed pelleting is a good alternative. The original purpose of pelleting was to increase the apparent seed size and weight to alter seed shape for precision planters. In addition to this, pelleting also provides the opportunity for greater loading of material around the seeds and the spatial orientation of active ingredient can be varied within the pellet (Halmer, 1988; Upadhyaya, 2013). In priming studies with carrot (*Daucus carota* L.), improvements in seed germination were marked at 35C, with 74% vs. 11% germination for primed and control seed lots, respectively. Priming was also effective in over-coming lettuce thermo dormancy and improving stand establishment in hot weather (Valdes *et al.*, 1985). Priming can increase crop uniformity by reducing the time needed for stand establishment and minimizing the exposure to soil crusting, unfavorable temperatures and soil-borne diseases (Alvarado *et al.*, 1987).

Biological seed treatments

Treatment of seed with beneficial micro-organisms including fungi and bacteria (species of Trichoderma, Pseudomonas, Bacillus, Rhizobia etc.) ameliorates a wide variety of biotic, a biotic, and physiological stresses to seed and seedlings (Mastouri *et al.*, 2010). Inoculation of seeds with such biological agents in combination with priming (Biopriming) potentially able to promote rapid and more uniform seed germination and plants growth (Moeinzadeh *et al.*, 2010) and in several cases, has been reported to enhance and stabilize the efficacy of biological agents (Callan *et al.*, 1990, 1991; Harman *et al.*, 1989 and Warren and Bennett, 1999). A primary cause of seedling stand reduction in many crops is pre-emergence damping-off or seed-rotting induced by soil-borne pathogens.

Table.1 Effect of Mancozeb+ Carbendazim mixture and *Trichoderma viride* as seed treatment on the growth and chlorophyll content of barley.

Treatments	Plant Length	Plant fresh Weight(g)	Plant dry Weight(g)	No. of spiklet (g)	No. of rains/spike	Total chlo**ro**phyl**l** (mg/g)
Control	99.50c	31.93c	10.30c	18.5c	40.5c	1.88c
Mancozeb+Carbendazim (300pm)	113.95a	37.76a	16.54a	23.1a	46.51a	2.18a
T.viridia(10^6conidia/ml)	108.65b	34.12b	13.93b	21.85b	43.3b	2.01b
LSD (P<0.005)	4.89	2.11	1.20	1.12	2.14	0.10

Table.2 Total seed borne infection and percent seed germination of three varieties of maize after different level of hot water treatment.

Treatment		Total seed-borne infection	Germination (%)	Seeds failed to germinate
Barnali				
48 ^{0}c		57.67b	64.33b	35.67
50	0_c	41.32c	71.00a	29.00
52	0_c	40.99c	54.33d	45.67
Control		199.98a	60.00c	40.00
Khai				
48 ^{0}c		53.34b	69.66a	30.34
50	0_c	30.34c	60.66b	39.34
52	0_c	25.67d	54.66c	45.34
Control		96.67a	54.00c	46.00
Mohor				
48 ^{0}c		55.65b	63.67b	36.33
50	0_c	50.33b	82.67a	17.33
52	^{0}c	30.33c	63.33b	36.67
Control		125.00a	51.67c	48.33

Fig.1 Effects of seed priming, light and darkness on germination rate.

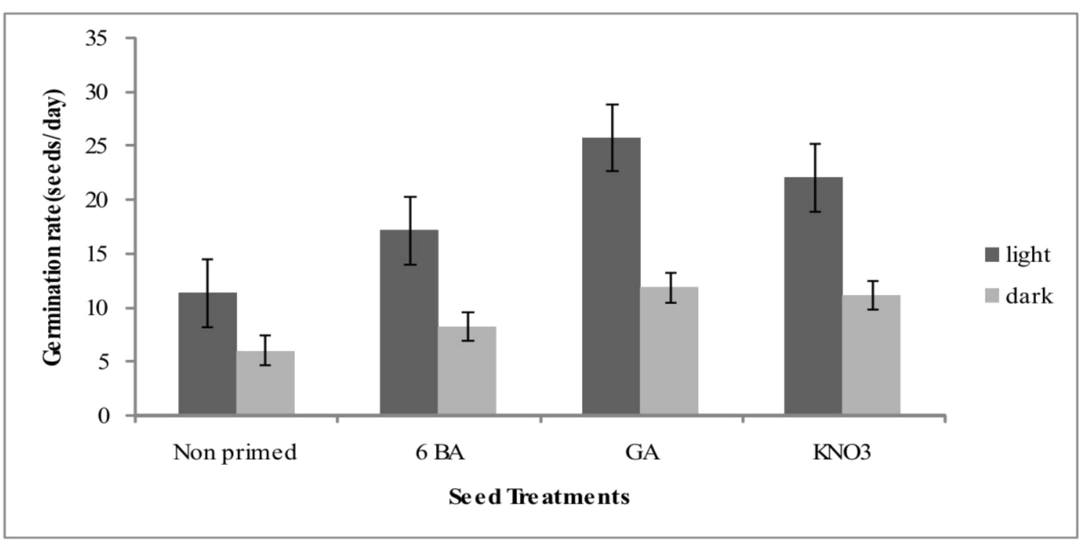

Table.3 Percent reduction of total seed-borne infection and Percent increase of seed germination over control in an average of three maize varieties after the seed treated with different level of hot water.

Treatment		Percent reduction of total seed-borne Infection	Percent increase of seed germination
48°C		60.47	19.31
50	0_c	71.07	29.37
52	0_c	76.99	4.01
Control		-	-

Damping-off may be particularly severe when poor-quality seed is sown under adverse soil temperature and moisture conditions (Harman and Stasz, 1986; Herner, 1986). Frequently encountered seed-rotting pathogens include *Pythum* spp., *Rhizoc-tonia solani* Kuhn, and *Fusarium spp*. (Harman and Stasz, 1986). A comprehensive review of biological seed treatments is not within the scope of this paper; rather, we will attempt to provide an over-view of the range of bio control agents currently under study for use in seed treatments and to examine methods by which more consistent bio-logical seed protection may be achieved.

As indicated on the above graph, the interaction effect of phytohormones and environmental condition were significantly ($p<0.001$) affected the germination rate. Hence a higher germination rate was achieved in hormone treated seed lots imbibed in light compared to darkness with GA and KNO3 achieved the highest germination rate than BA treatments. According to the result, GA was improved the germination percentage by 53% and 42% under light and dark condition respectively, compared to non primed treatment. Similarly, seed primed with KNO3 was increased the germination percentage by 44% and 33% under light and dark environmental condition respectively. The differences in germination percentages among GA, KNO3, 6-BA, non primed all imbibed in light and darkness may be due to molecular interactions within the seeds, although it is possible that differences in seed quality resulting from environmental factors such as nutrition status and growing conditions of the parent plants may also have been accountable. According to the result of this study, it is evident that pre-sowing seed treatment with all priming agents alleviated the secondary dormancy, induced suppression of germination irrespective of the conditions, except that BA shown a reduction in germination percentage and rate under dark conditions. Priming with both gibberellins (GA) and potassium nitrate (KNO3) improved the percentage and rate of germination in the photo-dormant cultivar (Graph 1). Different Scholars reported that seed priming increased rate and percentage of final seedlings and improved the field establishment (Sharma, 2015).

Trachoderma viride was found that significantly effective in increase plant length, fresh weight, dry weight, number of spikelet's, number of grains and chlorophyll content barley over control (Table 1). Application of seed protectants such as fungicides and bioagents helps in producing better emergence and vigorous seedlings (Lukman, 2018). Furthermore, study conducted on the effect of different levels of hot water treatment on seed borne mycoflora of three varieties of maize result revealed that, seeds treated with hot water of 50 ºC gave good results for controlling seed borne fungal infections and germination of the seeds. Thus, 50ºC temperature of hot water may be used effectively for controlling seed-borne pathogens and maintaining rational germination percentage of maize seeds and field establishment (Table 2 & 3). Though hot water seed treatment reduced seed-borne infection in certain cases decreased germination percentages of the seeds. Similar results were also obtained from different crops by Winter *et al.*, (1994). From this study, I reviewed that both fungal incidence and germination parentages of the seeds 50ºC temperature was effective for controlling seed borne mycoflora of maize. This result closely agreed with the report of Nega *et al.*, (2003) and Muniz (2001). Pre- treating seed physically through hot water is for good germination percentage and good field establishment (Rahman, 2018).

Conclusion

Seed can be treated through physical (Hot water treatment, Dry heat treatment, Aerated heat treatment and Radiation treatment).Seeds treated with hot water of 50 ºC gave good results for controlling seed borne fungal infections and improve germination of the seeds. In addition seed can also be treated biologically through using different beneficial micro-organisms including fungi and bacteria (Trichoderma, Pseudomonas, Bacillus, Rhizobia) and seed which was treated through Trachoderma can improve the germination percentage, vigor and field establishment of the crop. Furthermore, one of the common seed treatment methods is chemical seed treatment (seed dressing) by which different insecticides, fungicides and hormones like GA, KNO3and BA are used. Seed treated with GA and KNO3 achieved the highest germination rate than BA and non-priming seed. According to the experiment result, GA was improved the germination percentage by 53% and 42% under light and dark condition respectively, compared to non-primed treatment. Similarly, seed primed with KNO3 was increased the germination percentage by 44% and 33% under light and dark environmental condition respectively. However, sometimes chemical seed treatments has limitation of high cost selectivity effect on target organisms, development of pest resistance, resurgence of pests, pollution of food and feed, health hazards, toxicity towards plants and animals, environmental pollution. Overall, treating seed chemically, physically and in biological methods before sowing can improve the germination, growth and field establishment of the crop and reduce seed pathogen.

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