JUST AGRICULTURE
multidisciplinary e-Newsletter

Enhancement of Seed Germination Seed Vigour-I Seed Vigour-II and Disease Incidence in Solanaceous Crops by Hot Water Hot Air and Microwave Seed Treatment

Romika Thakur
Department of Seed Science and Technology, Dr.Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan

ARTICLE ID: 44

Abstract:

Most of Solanaceous crops are cultivated as rainy season crop. High rainfall hinders the seed germination and enhances the process of disease infection. Chemical seed treatment have resulted in lower seed germination and higher seed borne diseases as compared to hot water hot air and microwave seed treatment. Thermo-physical treatments have not any environmental and health hazards as compared to chemical treatment. Most of reviewers found that hot water seed treatment at 49°-50°C for duration ranges for 30 -60 minutes, hot air treatment at 72°C- 74°C for 36 - 48 hours and microwave seed treatments at 10- 15 seconds resulted in higher germination and other seed quality parameters. Temperature of hot water hot air and microwave seed treatments is inversely proptional to duration. Seed treatments at higher temperature with low duration and *vice –versa* have resulted in higher seed germination and other seed quality parameters. Seeds treated with thermo-physical methods can use for nursery raising but out of all these treatments such as hot water hot air and microwave, hot water seed treatment have resulted in higher germination.

Hot water seed treatment and their mode of action

Heat treatments of hard coated seeds also make the seed permeable to water and induce the germination (Baskin, 2003). The hot water treatment of seeds has resulted in the removal of seed coat-related dormancy and enhanced the rate of germination due to activation of the physiological and biochemical mechanism of seeds (Wahab, 2011). When compared to chemical seed treatments, thermophysical seed treatments promote the physiological and biological activity of seeds, resulting in higher seed germination and fruit yield characters while having no harmful impact on the environment (Singh *et al*., 2019). Hot water seed treatment activates two major groups enzymatic activity heat shock proteins

JUST AGRICULTURE
multidisciplinary e-Newsletter

(HSPs) and pathogenesis-related (PR) proteins. HSPs are responsible for the thermotolerance of seeds (Waggoner, 1917). Heat treatment activates PR proteins and enzymes like chitinase, β-1, 3 glucanase significantly and increased the activity of an antifungal compound. These antifungal compounds filled those gaps which serve as an entry point of a pathogen. Hot water seed treatment eradicates externally or internally seed-borne diseases but the seeds must be dried after treatment to prevent the damage caused by imbibed water in seeds (Aggarwal and Sinclair, 1997). Hot water treatment of tomato seeds at 48°C and 52°C had no detrimental effect on germination percent, germination rate and seed vigour including seedling radical length and shoot length and seedling dry weight (Divsalar*et al*., 2014). According to Singh *et al*. (2019), hot water seed treatment in capsicum seeds at 50 to 52°C for 30 minutes obtained the best outcomes in germination rate, seedling height, seedling dry mass, seed vigour index-I and seed vigour index-II in comparison to control seeds. Alamgir and Hussain (2005) reported that hot water treatment of seeds lead to the higher seedling length and the variation in seed coat thickness was observed one of the reasons for seedling length differences. Seeds of okra treated with hot water at 52°C for 30 minutes showed a increase in number of fruit, fruit weight, seed germination and vigour index of the seedlings and a decrease in the incidence of mycoflora on seeds (Begum *et al*., 2012). Pre-sowing hot water seed treatment at100°C for 10 minutes had the best effect to overcome physical seed dormancy of tropical spp. like *Albizzialebbek*and resulted in increased germination rate (Sharma *et al*., 2008). Babadoost*et al*. (2020) reported that hot water seed treatment of pumpkin seeds infected with *Xanthomonascucurbitae* at 55°C for 15 minutes significantly increased seed germination, vigour and number of fruits per plant, vine length and fruit weight.

Microwave seed treatment and their mode of action

Microwave radiations inhibit pathogen growth at optimum temperature and duration and resulted in the reduction of host-pathogen interaction (Friesen, 2014). Based on dielectric heating mechanism, microwave seed treatment activates various enzymes involved in seed germination thus improves the process of germination by increasing biological components synthesis (Radzevicius*et al*., 2013). Buffler (1993) studied the mode of action of microwave radiation and reported that the heating effect of microwave radiation is based on the law of attraction between the charged particles and polar molecules. The attraction between charged

JUST AGRICULTURE
multidisciplinary e-Newsletter

particles and polar molecules had released energy in the form of heat and the amount of heat absorbed by seed depends upon the dielectric properties of the seed and resulted in disinfection of the seed. Microwave radiation thermal involves dipole rotation and ionic polarization mechanism to heat the biological dielectric material (Bouraoui*et al*., 1993). Chen *et al*. (2009) reported that microwave radiation activates enzymatic activity to maintain the turgidity of the cell membrane and significantly increased plant resistance. Polar molecules of water interact with the microwave radiation with higher frequency resulting in the generation of heat which caused the evaporation of water molecules from seeds (Jiao *et al*., 2012). Kanwal*et al*. (2018) found that microwave radiation of legume crop seeds for 20 seconds and 30 seconds influenced the germination rate, speed of germination, number of pods, pod yield effectively and reduced the root rot fungi like *Macrophominaphaseolina*, *Rhizoctoniasolani and Fusarium* spp.

Hot air seed treatment and their mode of action

Seed treated with hot air required long-duration exposure and it is reported that after hot air treatment, seeds must be rehydrated to enhanced germination (Grondeau*et al*., 1992). High temperature caused cell death and due to which metabolic processes in embryo responsible for germination were also reduced. Seedling length and dry weight variation observed due to inhibition of seeds supply with assimilates necessary to synthesize the storage compounds required during the germination process (Powell, 2006). Hot air seed treatment of legumes and large seed crops at specific temperature and duration, however, decreased some of the seed-borne diseases without any seed damage. Viruses have been categorized by Nyland and Goheen (1969) based on their capacity to tolerate heat. Heat treatments reduced the availability of RNA molecules in seeds, preventing virus packing and suppressing virus movement in the plant, and resulting in virus-free new growth regulation McGee (1981) reported that hot air seed treatment affects seed viability due to long heat duration exposure and concluded that hot air seed treatment should be conducted with a proper wrapping of seeds in seed bags to maintain seed viability. Murugesan*et al.* (2008) reported that increase in the hot air temperature activated the process of aerobic respiration in seeds which utilized the endosperm of seeds and resulted in declined germination percent. Seeds of *Solanum gilo*treated with hot air at 60^{o}C for 40 minutes influence the seed germination rate (Umechuruba*et al*., 2013).Schelin*et al*. (2003) treated the seeds of

JUST AGRICULTURE
multidisciplinary e-Newsletter

Balanitesaegyptiaca with hot air at 60°C, 80°C, and 100°C for 15, 30 and 60 minutes and reported that hot air at 60°C and 80°C for 15 minutes improved the germination of seed due to leaching of inhibitors from seeds.

Hot water seed treatment and their mode of action in controlling disease incidence

Hot water seed treatment activates pathogenesis related antifungal compounds and these antifungal compounds filled those gaps which serve as an entry point of a pathogen. According to Nega*et al*. (2002) seeds of carrot, cabbage, celery, parsley and lettuce treated with hot water at 50°C for the duration of 30 minutes reduced seed-borne diseases like *Septoria* spp., *Peronospora* spp., *Alternaria* spp., *Phoma* spp. significantly without affecting germination. Bari *et al*. (2003) reported that mungbean seeds treated with hot water at 55°C to 80°C for duration of 20 minutes resulted in reduced seed infection with pathogens. Rahman *et al*. (2008) treated the seeds of maize with hot water at different temperatures from 48°C to 52°C and found that hot water treatments at 50°C for 15 minutes increased the seed germination and significantly reduced the infection of seed-borne pathogens *likeBipolarismaydis, Cuvularialunata, Fusarium* spp. from seeds. Braga *et al*. (2010) found that tomato seeds treated at 55°C for 30 minutes resulted in reduction of fungi like *Rhizopus*spp., *Aspergillus* spp., and *Cladosporium*spp. without any loss to seed quality parameter. Missanjo*et al*. (2014) reported that hot water seed treatment of *Acacia polyacantha* seeds had shown the enhanced rate of germination and growth parameter at the nursery stage. Hashim*et al*. (2019) studied the effect of hot water treatment in rice seeds and found that hot water seed treatment at 50°C for 15 minutes significantly resulted in eradication of blast pathogen from rice seeds.Carrot seeds treated with hot water at 50°C for 30 to 40 minutes had shown a decrease in *Alternariaradicina* without affecting the germination of seeds (Babadoost*et al*., 2020).

Microwave seed treatment and their mode of action in controlling disease incidence

Microwave radiation reduced the pathogen inoculums internally and externally from seed surface due to dielectric heating mechanism on morphological characteristics of fungal cell and they also observed that single celled spores of *Colletotrichumlindemuthianum*were more sensitive than multicellular spores of fungus (Cavalcante and Muchovej, 1993). Gaurilcikiene*et al*. (2013) treated the wheat seeds with microwave radiation at different duration from 5 to 20 minutes and found that infection of *Tilletia caries* fungus had reduced

JUST AGRICULTURE
multidisciplinary e-Newsletter

with increased duration of microwave radiations. Knox *et al*. (2013) reported that the microwave treatment at 15seconds, 30seconds and 45seconds effectively reduced the *Fusarium* spp. and *Microdochiumnivale* fungus infection from wheat seeds. Taheri *et al*. (2018) found that fungus*Ascochyta*spp. penetrate the seed coat and reside inside the embryo of lentil seeds and microwave radiation for 60 seconds effectively penetrated inside the seed coat and reduced the seed infection without affecting the seed composition.

Hot air seed treatment and their mode of action in controlling disease incidence

In hot air seed treatment, seeds are exposed to higher temperature and higher temperature must lead to death of fungus and viruses from seed surface externally. Hot air seed treatments are based on dry heat mechanism and sterilize the seed surface externally. Hot air seed treatment sterilizes the seed surface externally and leads to degradation of virus RNA particles. The reason can be viruses RNA tolerate higher temperature but after treatment higher temperature falls down to lower temperature and leads to degradation of RNA viruses particles. Forsberg *et al*. (2002) studied the effect of hot air seed treatment in a thin layer and fluidized bed on barley seeds infected with *Pyrenophorateres* and found that hot air seed treatment had effectively eradicated the seed-borne pathogen of barley and resulted in improved plant. Ling (2010) treated the tomato seeds with hot air and found that thermophysical hot air treatment at 72°C or 80°C for 48 to 72 hours reduced seed-borne Pepino Mosaic Virus with the least effect on seed germination as compared to hot water treatments and chemical treatments.Gama *et al*. (2014) treated the seeds of fennel with hot air at 70°C temperature for different durations and found that thermophysical treatment at 70°C for 12 days was effective to control the infection of *Alternaria*spp. fungus. Sun *et al*. (2015) found that hot air seed treatment of melon at 75°C for 72 hours was effective to eradicate the bacterial fruit blotch caused by *Acidovoraxcitrulli* from seeds. Shi *et al*. (2016) treated cucumber seeds with hot air at 70°C for 40 to 90 minutes and evaluated that hot air treatment at 70°C for 90 minutes had reduced the activity of internally seed borne pathogen.

Methodology of hot water seed treatment

Seeds treated with hypochlorite solution for 10 minutes.Seeds wrapped in muslin cloth and wrapped seed placed in beaker of water.Beaker containing wrapped seed in muslin cloth placed in thermostatic hot water bath for required period. Close the lid of hot water bath and

JUST AGRICULTURE
multidisciplinary e-Newsletter

take out the seed from hot water bath after required period. After treatments seeds are shade dried.

Methodology of hot air seed treatment

The seeds were wrapped in kraft paper bags and subjected for heating to different treatment combination at different temperature durations in hot air oven. At the end of the treatments, seeds were taken out, cooled down to normal temperature and used for seed quality parameter tests.

Methodology of microwave seed treatment

Seeds were placed in a sterilized Petri plates and subjected to different period of exposure at micro power level 900 watt and at different micro power level. After the treatment, seeds were taken out and used for seed quality parameters.

Perspective of Study

Use of chemicals in controlling seed borne diseases such as damping off, ungerminated seeds, Phomposis blight and viruses have resulting in environmental pollution and health hazard. Therefore, effect of hot water hot air and microwave seed treatment has studied and found that thermo-physical treatments has resulted in better seed germination and other seed quality parameters and served as antimicrobial against plant pathogenic fungi without any environmental pollution. Thus it is recommended that hot water hot air microwave seed treatment has proved effective against plant pathogenic fungi without environmental pollution and farmers have no need to pay high prices for chemicals. In comparison to hot water, hot air and microwave seed treatment, hot water seed treatment has resulted in better seed germination and found effective against controlling seed borne disease like damping off, Phomposis blight.

Conclusion

It concluded that hot water seed treatment microwave seed treatment and hot air seed treatment has shown the best effect on seed germination, seedling length, seedling dry weight seed vigour-I and seed vigour-II in Solanaceous crops but temperature and duration of hot water seed treatment are varied according to crop and therefore there is need to standardized it according to crop. Hot water seed treatment has showed best effect on seed quality attributes and controlling disease incidence like damping off in nursery.

JUST AGRICULTURE
multidisciplinary e-Newsletter

References

Agarwal VK and Sinclair J B. 1997. Principles of Seed Pathology. 2nd ed. CRC Press, Florida. 455p.

Almagir M and Hussain MK. 2005. Effect of pre-sowing treatments on germination and initial seedling development in Albiziasamanin nursery. Journal of Forestry Research **16**:200-04.

Babadoost M and Zhang X. 2020. Eradication of Xanthomonascucurbitae in pumpkin seeds by hot water treatment. ActaHorticultare**1269**:9-16.

Bari ML, Nazuka E, Sabina Y, Todoriki S and Isshiki K. 2003. Chemical and irradiation treatments for killing Escherichia coli on alfalfa, radish and mung bean seeds. Journal of Food Protection**66**:767-74.

Baskin CC. 2003. Breaking physical dormancy in seeds focussing on the lens. New Phytologist**158**:229-32.

Begum M and Lokesh S. 2012. Effect of hot water and ultra violet radiation on the incidence of seedborne fungi of okra. Archives of Phytopathology and Plant Protection **45**:126-32.

Bouraoui M, Richard P and Fichtali J. 1993. A review of moisture content determination in foods using microwave oven drying. Food Research International **26**:179-87.

Braga MP, Olinda de RA, Homma SK, Dias CT and Das S. 2010. Relationships between thermal treatment germination vigor and health of tomato seeds. RevistaBrasileira de Sementes**32**:101-10.

Cavalcante MJB and Muchovej JJ. 1993. Microwave irradiation of seeds and selected fungal spores. Seed Science and Technology **21**:247-53.

Chen R, Hu Z and Zhang H. 2009. Identification of microRNA in wild soyabean (Glycine soja). Journal of Plant Biotechnology **51**:1071-79.

Divsalar M, Shakeri M and Khandan A. 2014. Study on thermotherapy treatment effects on seed germination and vigor of tomato cultivars. International Journal of Plant & Soil Science**3**:799-809.

Forseberg G, Anderson S and Johnson l. 2002. Evaluation of hot air seed treatment in thin layer and fluidized bed for seed pathogen sanitation.Journal of Plant Diseases and Protection **109**:357-70.

Friesen AP, Conner RL, Robinson DE, Barton WR and Gillard CL. 2014. Effect of microwave radiation on dry bean seed infected with Colletotrichumlindemuthianum with and without the use of chemical seed treatment. Canadian Journal of Plant Sciences **94**:1373-84.

Gama JSN, Neto ACA, Bruno de RLA, Junior LRP and Medeiros JGF. 2014. Thermotherapy of treating fennel seeds (*Foeniculum vulgare* Miller) effects on health and physiological quality. *RevistaCienciaAgronomica***45**:842-43.

Gaurilcikiene I , Ramanauskiene J , Dagys M , Simniskis R , Zenonas D and Suproniene S. 2013. The effect of strong microwave electric field radiation on wheat (Triticumaestivum Linnaeus) seed germination and sanitation. Zemdirbyste Agriculture **100**:185-19.

Grondeau C, Ladonne F, Fourmond A, Poutier F and Samson R. 1992. Attempt to eradicate Pseudomonas syringaepv. pisifrom pea seeds by heat treatments. Seed Science and Technology **20**:515-25.

Hashim I, Mamiro D, Mabagala Robert B and Tefera T. 2019. Reduction of initial occurrence of rice blast (Pyriculariaoryzae) inocula on seeds by microbial and hot water seed treatments. Australian Journal of Crop Science **13**:309-14.

Jiao S, Johnson JA, Tang J and Wang S. 2012. Industrial scale radiofrequency treatments for insect control in lentils. Journal of Stored Products Research **48**:143-48.

Kanwal S, Tariq M and Dawar S. 2018. Effect of microwave radiation on plants infected with root rot pathogens. Pakistan Journal of Botany **50**:2389-93.

Knox OGG, Mchugh MJ, Fountain JM and Havis ND. 2013. Effects of microwaves on fungal pathogens of wheat seed. Crop Protection **50**:12-16.

Ling KS. 2010. Effectiveness of chemo and thermotherapeutic treatments on pepino mosaic virus in tomato. Plant Disease **94**:325-28.

McGee DC. 1981. Seed Pathology: Its place in modern seed production. Plant Diseases **65**:638:42.

Missanjo E, Chioza A and Kulapani C. 2014. Effect of different pretreatments to the seed on seedling emergence and growth of Acacia polyacantha. International Journal of Forestry Research **2014**:1-6.

Murugesan P, Mathur RK, Bijimol G and Ravi Kumar M. 2008. Effect of extended dry heat treatment on germination and seedling growth in oil palm (ElaeisguineensisJacq) var. Dura mother palms. Journal of Plantation Crops**36**:45-48.

Nega E, Ulrich R,Werner S and Jahn M. 2002. Hot water seed treatment of vegetable seed an alternative seed treatment method to control seed borne pathogens in organic farming. Journal of Plant Diseases and Protection **110**:220-34.

Nyland G and Goheen AC. 1969. Heat therapy of virus diseases of perennial plants. Annual Review of Phytopathology **7**:331-54.

Powell AA. 2006. Seed vigour and its assessment: In:Handbook of Seed Science and Technology (Basra AS eds). Food Products Press, New York. pp. 603-648.

Schelin M, Tigabu M, Eriksson I, Sawadogo L and Oden P C.2003. Effects of scarification, gibberellic acid and dry heat treatments on the germination of Balanitesaegyptiaca seeds. Seed Science and Technology 31:605-17.

Sharma S, NathaniR,Varghese B, Keshavkant S and Nathani S C. 2008. Effect of hot water treatments on seed germination of some fast growing tropical tree species. Journal of Tropical Forestry **24**:50-53.

Shi Y, Meng S, Xie X, Chai A and Li B. 2016. Dry heat treatment reduces the occurrence of Cladosporiumcucumerinum, Asochytacitrullina and Colletotrichumorbiculare on the surface and interior of cucumber seeds. *Horticultural Plant Journal **2**:35-50.*

Singh SP, Bharat NK, Singh H, Kumar S, Jhakar S and Vijay. 2019. Effect of hot water treatment of seeds on seed quality parameters and seedling growth parameters in bell pepper. Indian Journal of Agricultural Science **89**:133-37.

Sun X, Zefa L, Tang Y, Li L, Tong L, Min Z, Li H,Cheng J and Tian Z. 2015. Effect of dry heat treatment on bacterial fruit blotch and viability of watermelon seeds. *ActaHorticulturae***1105**:97-100.

Taheri S, Brodie G, Gupta D and Reddy H R D. 2018. Effect of microwave radiation on internal inoculums of Ascochyta blight in lentil seeds at different seed moisture content. Society of Agricultural and Biological Engineers **62**:33-43.

Waggoner HD. 1917. The viability of radish seeds RaphanussativusLinnaeus as affected by high temperatures and water content. American Journal of Botany **4**:299-313.

Wahab OD 2011. Effect of Dry Heat Temperature on Seed Germination and Seedling Emergence of three cultivars of Corchorusolitoriouseeds. Botanical Agriculture Project Report. Department of Agronomy and Landscape Design, Babcock University, Nigeria. 32pp.