Seminar report

Can thermoseed replace seed health treatments?

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DECLARATION

I, Riya Mary Mathew (2018 -11- 154), hereby declare that the seminar report entitled ‘Can thermoseed replace seed health treatments?’ has been completed by me independently after going through the reference cited herein and I have not copied from any of the fellow students or previous seminar reports.

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CERTIFICATE

This is to certify that the seminar report entitled ‘Can thermoseed replace seed health treatments?’has been solely prepared by Riya Mary Mathew (2018 -11- 154), under my guidance and has not been copied from seminar reports of seniors, juniors or fellow students.

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1. Introduction

Seed is the most important input of agricultural production on which the efficacy of other agriculture inputs is dependent. Seeds of high quality are required to meet the demand of diverse agro – climatic conditions and intensive cropping systems. It is estimated that quality seed accounts for 20 – 25 per cent of the productivity. Only a good quality seed will respond to the fertilizers and other inputs. The quality of seeds is considered as an important factor for increasing yield. The use of quality seeds helps greatly in higher production per unit area to attain food security of the country. Quality seeds have the ability for efficient utilization of the inputs such as fertilizers and irrigation. Well thought policy, planning, congenial regulatory system, facilities for capacity and structural improvement both in public and private sectors are required for production, processing, preservation, and distribution of sufficient quantity of quality seeds in time to the farmers.

2. Seed quality

The quality of seeds is considered as an important factor for increasing yield. The use of quality seeds helps greatly in higher production per unit area to attain food security of the country. Quality seeds have the ability for efficient utilization of the inputs such as fertilizers and irrigation.

2.1 Importance of quality seed

- Seed is a vital input in crop production;
    - It is the cheapest input in crop production and key to agriculture progress.
    - Crop status largely depends on the seed materials used for sowing
    - Response of other inputs in crop production depends on seed material used
- The seed required for raising crop is quite small and its cost is so less compared to other inputs
- This emphasis the need for increasing the areas under quality seed production
- It is estimated that good quality seeds to improved varieties can contribute about 20 -25% increase in yield.

Seed quality is the degree of excellence in regard to the characteristics like genetic purity, physical purity, germination, moisture content and seed health. Genetic purity refers to the trueness to type of the seed.if the seed possesses all the genetic qualities that breeder has placed in the variety, it is said to be genetically pure. (Hasanuzzaman, 2015)

2.1.a Genetic purity

The genetic purity has direct effect on ultimate yields. If there is any deterioration in the genetic makeup of the variety during seed multiplication and distribution cycle, there would definitely be proportionate decrease in its performance e.g. yield, disease resistance, etc. it is, therefore, necessary to ensure genetic purity during production cycles.

2.1.b. Physical purity

Physical purity of a seed lot refers to the physical composition of seed lots. A seed lotis composed of pure seeds – the seeds of same kind, inert matter, broken grains less than half in size, soil and dust particles, chaff etc., weed seeds and other crop seeds. Higher the content of pure seed the better would be seed quality.

2.1.c. Germination

Seed germination is the ability of a seed when planted under normal conditions to give rise to a normal seedling. High germination and vigour results into raising of an excellent crop having adequate plant population and uniform growth.

2.1.d. Moisture content

Moisture is the most critical factor in the maintenance of seed germination and viability during strorage. The seed must be dried to safe moisture content.

2.1.e. Seed health

Seed health refers to the presence or absence of disease infection or pest attack on seeds and is a major problem in quality seed production. The organisms commonly associated with seed cause diseases and damages to seed, seedlings and crops are Fungi, Bacteria, Viruses, Nematodes and Insects. (Agarwal. 1977)

Seed health is a well recognized factor in the modern agricultural science for desired plant population and good harvest. Seed treatment by chemicals is the best way to keep good seed health condition. But chemicals cause health hazard and environment pollution (Chapman and Harris, 1981). In addition the seed treating chemicals are very expensive and are rot available to our resource poor farmers. Alternative means of seed treatment have drawn the attention of plant pathologist all over the world. In this context use of physical treatment i.e. solar heat hot water treatment, moisture control and seed treatment in vacuum may become an easy and less costly way in controlling seed-borne mycoflora. So, the study was taken to evaluate the effectiveness of hot water treatment for controlling seed-borne mycoflora of maize with maintaining better germination of maize.

3. Seed treatment

Seed treatment refers to the application of certain agents physical, chemical or biological to the seed, prior to sowing in order to suppress, control or repel pathogens, insects and other pests that attack seeds, seedlings or plants (Sharma *et al.*, 2015). Benefits of Seed Treatment are, they prevents spread of plant diseases, protects seed from seed rot and seedling blights, improves germination, provides protection from storage insects,controls soil insects.

Seed treatments are the biological, physical and chemical agents and techniques applied to seed to provide protection and improve the establishment of healthy crops. The benefits of seed treatments are increased germination, uniform seedling emergence, protect seeds or seedlings from early season diseases and insect pests improving crop emergence and its growth. Anthropogenic changes of the soil, water and atmosphere due to the use of different chemical additives for raising plants productivity led to searching alternative ways.

3.1 Chemical seed treatments

Chemical seed treatments are fungicides or insecticides, applied to seed, to control diseases of seeds and seedlings and Insecticides are used to control insect pests. Some seed treatment products are sold as combinations of fungicide and insecticide. Biological seed treatment consists of active ingredients that can include microbes like fungi and bacteria, as well as plant extracts and algae extracts. Now a day’s 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. Typically, chemical seed treatments do not offer benefits associated with root development, drought proofing or crop yield

3.2 Biological seed treatment

Biological substances are applied to the seed in a powder form or as a liquid. Treatment of seed with beneficial micro-organisms including fungi and bacteria (species of *Trichoderma, Pseudomonas, Bacillus, Rhizobia* etc.) ameliorates a wide variety of biotic, abiotic, and physiological stresses to seed and seedlings. 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 and in several cases, has been reported to enhance and stabilize the efficacy of biological agents.

3.3 Physical seed treatment

There is an increasing interest in using physical methods for disease control as alternative to fungicides for the management for seed and soil-borne pathogens, and for integration in disease management programs. They usually do not leave residues or pollute the environment.

Physical, chemical, and biological seed treatments have been proven effective for seed disinfection. However, chemical seed treatment using a single chemical reagent cannot consistently reduce pathogen populations. Fungicide seed treatments reduce the transmission frequency of anthracnose, but do not eradicate pathogens inside the seeds.In physical seed treatment there are thermotherapy, radiation treatments and plasma treatments (Singh and Pandey, 2012).

3.3.a. Radiation treatments

Electromagnetic radiations such as ultraviolet (UV) light, x rays and y rays as well as particulate radiations have been studied in relation to management of post harvest diseases of horticultural crops. Y rays controlled post harvest fungal infections in peaches, straw berries and tomatoes but doses of radiation required to kill pathogens, were found injurious to host tissues. Some plant pathogenic fungi sporulate only when they receive light in the ultraviolet range. It has been possible to control diseases on green house vegetables caused by species of these fungi by covering or constructing the green house with a special UV absorbing vinyl film that blocks transmission of light wavelengths below 390 nm (Singh and Pandey ,2012).

3.3.b. Plasma treatments

Cold plasma treatment is a fast, economic and pollution-free method to improve seed performance and crop yield. It has essential roles in a broad spectrum of developmental and physiological processes in plants, including reducing the bacterial bearing rate of seeds, changing seed coat structures, increasing the permeability of seed coats, and stimulating seed germination and seedling growth. This phenomenon has been demonstrated in several plants such as *Chenopodium album*, *Oryza sativa*, *Triticum aestivum*, *Lycopersicon esculentum* and *Solanum melongena*. In addition, plasma treatment also could improve the physiological metabolism of the plant, such as dehydrogenase activity, superoxide dismutase and peroxidase activities, photosynthetic pigments, photosynthetic efficiency and nitrate reductase activity. Plasma treatment could significantly increase crop yields. (Ling *et al*., 2014)

3.3.c.Thermotherapy

Thermotherapy, simple in principle, consists in heat treatment of plant parts at temperature/time regimes that kill the conserved pathogen and that are only slightly injurious to the host. Heat is applied mainly by water, air, or vapour. The scientific principle involved in heat therapy is that the pathogen present in seed material is selectively inactivated or eliminated at temperatures that are non-lethal to the tissues. The exact mechanism by which heat inactivates the pathogen is not fully understood. However, it is universally accepted that heat cause inactivation and immobilization of the pathogen.

Some of the seed treating procedure do not involve the use of fungicides, the physical agents like hot water or hot air or steam is used to eliminate the seed-borne infection. These methods are successfully used in controlling certain internally seed-borne diseases like loose smut of wheat and systemically infected diseases caused by bacterial, virus and phytoplasma.(Singh and Pandey, 2012).

Solar heat treatment, hot water treatment, dry heat treatment and aerated steam treatment are some of the thermotherapy.

4. Solar heat treatment

Solar heat treatment is the simplest treatment has been devised in India to eliminate the pathogen of loose smut of wheat. Previously the hot water treatment was followed to eliminate loose smut. As the thermal death point of the fungus and the embryo are very close, extensive care should be taken to avoid killing of the embryo. Luthra in 1953, devised a method to eliminate the deep seated infection of *Ustilago nuda*. The method is popularly known as solar heat or solar energy treatment. Luthra's solar energy treatment: The seeds are soaked in cold water for 4 hours in the forenoon on a bright summer day followed by spreading and drying the seeds in hot sun for four hours in the afternoon. Then, the seeds are again treated with carboxin or Carbendazim at 2 gm/kg and stored. This method is highly useful for treating large qualities of the seed lots (Reddy, 1983).

4.1 Effect of solar heat treatments

An experiment was conducted to evaluate the effectiveness of solar heat treatment to control seed borne mycroflora of maize. Three varieties of maize namely Barnali, mohor and shurva were used in the study. Efficacy of four different levels of solar heat viz 3, 6, 9 and 12 hours as evaluated against seven different fungi including three major pathogenic fungi *Bipolaris maydis, Curvularia lunata* ard *Fusarium moniiforme*. Solar heating reduced seed borne infection of maize appreciably seed borne infection was reduced by 54.08, 68.56, 82.10 and 86.99% and germination was increased by 19.41, 22.31, 26. 96 and 28.36 % due to solar heating or maize seeds for 3, 6, 9 and 12 hours respectively. Solar heat treatment for 3 to 4 consecutive day for three hours in each day gave good results for controlling seed borne fungal infections with maintaining better germination of maize seeds (Rahman *et al.,* 2008)

5. Hot water treatment (HWT)

Hot water treatment is widely used for the control of seed-borne pathogens, especially bacteria and viruses. The seeds are dipped for specific period of time in hot water to a particular temperature safe to the seed embryo and deleterious to the associated pathogen. It is useful for low volume high value seeds and effective for internally associated fungi and bacterial pathogens. High temperatures may damage the embryo. The temperature and duration of treatment differs from crop to crop. (Neergard, 1977)

The seeds are soaked in cold water at 20-30^{0}C for 5 hrs to induce the dormant mycelium to grow. Then the seeds are immersed in hot water at 50-54^{0}C for 10 minutes to kill the mycelium. It is very effectively used to eliminate loose smut of wheat. The setts of sugarcane can be treated at 50^{0}C for 2 hrs to eliminate grassy shoot pathogen. The main drawback in the hot water treatment is that the seeds may be killed or loose its germinability, if the period of treatment exceeds the specified time. So this method is replaced by other physical methods like Hot air and Aerated steam treatment wherein the seeds are exposed only to hot air/aerated steam.

5.1 Effect of hot water treatments

An experiment was conducted to control seed-borne mycoflora of maize seeds using Barnali, Khai and Mohor variety. Efficacy of three different levels of hot water viz. 48^{0}C, 50^{0}C, 52^{0}C was evaluated against seven different fungi including three major pathogenic fungi- *Bipolaris maydis, Cuvularia lunata* and *Fusarium* . Seed treatment with hot water affects significantly to reduce seed-borne infection of maize. In an average of three varieties of maize, 60.47, 71.07 and 76.99 % reduction of total seed-borne infection occurred and 19.31, 29.37 and 4.01 % germination increased after the seed treatment with hot water of 48^0C, 50^0C and 52^0C respectively. Hot water treatment with 50^0C temperature for 15 minutes gave good result for controlling seed-borne fungi and maintaining better as well as safe germination of maize seeds.

Table 1 : Per cent reduction of total seed-borne infection and Per cent increase of seed germination in maize with different level of hot water.

Treatment	Percent reduction of total seed-borne infection	Percent increase of seed germination
48^0C	60.47	19.31
50^0C	71.07	29.37
52^0C	76.99	4.01

From the above study it has been observed that seeds treated hot water of 50oC gave good results for controlling seed borne fungal infections and germination of the seeds. So 50oC temperature of hot water may be used effectively for controlling of the seed-borne pathogens and for maintaining rational germination percentage of maize seeds. (Rahman *et al.*, 2008)

6. Dry heat treatment

Dry heat sterilization is one of the old technique to sterilize the glassware and other equipment. In this method, heated air of high temperature and further the process is same as that of conduction method. Heat is absorbed from the surrounding area of the equipment and is moved forward to the next layer, and slowly the whole equipment gets heated and attains sterilization. The time may vary from 1 hour to 2 hours along with the temperature of the 160°C to 170°C respectively. The temperature is higher than the moist heat sterilization process; there are more chances of the microbes to get the kill. Incineration, the high flame are the different types of processes performed under dry heat sterilization. (Neergard, 1977)

6.1 Advantages

- Reliable, nontoxic.
- Low cost and is easy to install.
- As the instrument remains dry after sterilization, there are no chances of corrosion.

- Not harmful to the environment.

As early as 1832, Sinclair suggested that hot air treatment in an oven might control smuts of oats and barley. Gardeners in Scotland while treating the bulbs of different ornamental plants first employed hot water therapy. However, the credit for conclusively demonstrating the therapeutic nature of heat must go to Jensen, who successfully employed hot water treatment for controlling loose smut of cereal grains and suggested that moisture played some role other than heat transfer. This method was followed in Demark and later adopted in US on the recommendation of Swingle in 1892.The oxidation process is involved to destroy the microbes. Though this method takes longer time than the moist heat sterilization as due to the absence of water, high energy is required to break the peptide bonds of the proteins present in the microbes.

6.2.a Effect of dry heat treatments

Dry heat treatment, which has been developed several years ago, is a common physical treatment for seeds and has been applied to various vegetables, including cucurbits (Masaharu et al., 2012), solanaceous crops (Li et al., 2011), Brassica (Song et al., 2011), lettuce (Schmitt et al., 2009), spinach (Dadali et al., 2007), and carrots (Bang etal.,2011). This method can completely inactivate noxious seed borne bacterial pathogens such as *Erwinia*, fungal pathogens such as *Fusarium, Alternaria,* and *Cladosporium* (Jung, 2004), as well as the cucumber green mottle mosaic virus (Kim and Lee, 2000). The present study analyzed the relationship between the conditions of dry heat treatment and the effectiveness of disinfection of seeds infected by *C. cucumerinum, A. citrullina*, and *C. orbiculare.*

Dry heat treatment has been identified as a method for disinfecting seed-borne pathogens in vegetable seeds. This study demonstrated that three seed-borne pathogens of cucumber (*Cladosporium cucumerinum* that causes scabs, *Ascochyta citrullina* that results in gummy stem blight, and *Colletotrichum orbiculare* that induces anthracnose) could be effectively eradicated from cucumber seeds by dry heat treatment. In vitro growth of these three pathogens was inhibited by dry heat treatment at 70 °C for 40 min.These pathogens were inactivated after exposing infected seeds to 70 °C dry heat for at least 90 min. Seed infection was significantly reduced by exposing the seeds to 70 °C dry heat for at least 40 min. Seed moisture content and germination were slightly reduced after 70 °C heat treatment for 40–120 min. Seed vigor remained at a high level after dry heat treatment at 70 °C for 90 min. In conclusion, 70 °C dry heat treatment for 90 min was determined to be the optimal method for eradication of C. cucumerinum, Didymella bryoniae, and C. orbiculare from cucumber seeds. (Yanxia *et al*., 2016).

Table 2:Effect of dry heat treatments on *in vitro* colony growth of fungi

Treatment	Colony diameter of three pathogens (cm)		
	C. cucumerinum	*D. bryoniae*	*C. orbiculare*
Control	3.48	8.50	3.58
55 ^{0}C, 20 min.	3.12	7.75	3.27
55 ^{0}C, 40 min.	3.05	7.55	2.00
55 ^{0}C, 60 min.	2.03	5.95	1.85
60 ^{0}C, 20 min.	3.02	6.23	2.92
60 ^{0}C, 40 min.	2.48	6.00	1.65
60 ^{0}C, 60 min.	1.97	5.33	1.60
65 ^{0}C, 20 min.	2.10	5.65	1.90
65 ^{0}C, 40 min.	1.80	3.97	1.43
65 ^{0}C, 60 min.	1.55	0	0
70 ^{0}C, 20 min.	1.70	1.00	0
70 ^{0}C, 40 min.	0	0	0
70 ^{0}C, 60 min.	0	0	0

The colony diameter of the control was 3.48, 8.50, and 3.58 cm, respectively. The growth of *C. cucumerinum* was completely inhibited after heat treatment at 70 °C for 40 min and 60 min. The growth of *D. bryoniae* was inhibited at 65 °C for 60 min, and 70 °C for 40 min and 60 min.

The growth of *C. orbiculare* was inhibited at 65 °C for 60 min and 70 °C for 20, 40, and 60 min. These results indicated that all three pathogenic isolates could be completely inhibited at 70 °C for 40 min.

Table 3: Effect of dry heat treatments on germination percentage, and vigour of cucumber seeds

Treatment	Germination (%)			Seed vigour index		
	J36	J35	J12	J36	J35	J12
Control	98.14	99.46	100.00	8.81	8.33	8.94
70^0 C 40 min.	97.16	97.13	97.46	9.26	9.03	9.22
70^0 C, 60 min.	96.44	95.18	97.01	9.75	9.56	9.68
70^0 C 90 min.	95.22	93.02	93.21	9.50	9.49	9.59
70^0 C, 120 min.	93.21	92.01	94.18	8.89	8.62	8.79

The cucumber seeds were subjected to dry heat treatment at 70 °C for 40, 60, 90, and 120 min. With the increase in treatment time,the moisture content and germination rate of cucumber cultivars seeds was 6.04%, 5.97%, and 6.02%, respectively, and germination percentage was 98.14%, 99.46%, and 100.00%, respectively .When the seeds were exposed to 70 °C for 90 min, moisture content decreased to 4.12%,4.26%, and 4.08%, and the germination percentage was reduced to 95.22%, 93.02%, and 93.21%, respectively. Although the germination percentage slightly decreased after dry heat treatment for different durations, it remained more than 90.00%. Meanwhile, SVI did not have a significant effect on various dry heat treatments. Based on these results, the 70 °C dry heat treatments were utilized in the subsequent experiments (Yanxia *et al*., 2016).

6.2.b. Effect of dry heat treatments

Another experiment was carried out to study the effects of thermal treatment (hot vapour (100°C)) lasting from 1 to 10 seconds on spring barley (*Hordeum vulgare*) seed fungal infection and germination.

The most common *Fusarium*, *Drechslera*, *Alternaria*, *Penicillium* genera were identified on spring barley seed in their research. The most prevalent fungi in the non-surface sterilized untreated seed were of *Alternaria* (53.8% infected untreated seed) and *Fusarium* (24.8%) genera . *Fusarium* (up to 24.8% of infected seed), *Alternaria* (up to 57.8%), *Penicillium* (up to 31.8%) and *Drechslera* (up to 6.8%) genera fungi were dominant on the spring barley seed tested. It was found that thermal treatment significantly reduced the level of fungal infection. The effect of hot vapour depended on the duration of treatment – with increasing exposure time more seed was disinfested. Pathogenic fungi *Fusarium*, *Drechslera* and saprophytic *Alternaria* were not found on barley seed after a 10 s hot vapour single treatment. Experimental findings suggest that seed can be treated by hot vapour once and the maximum seed exposure time is 6 seconds. Since moisture content of seed treated with hot vapour increases, it is necessary to continue the investigation on management of moist seed.(Dabkevicius *et al*., 2008).

Table 4: Effect of thermal treatment on spring barley seed borne infection

Treatment duration (s)	% of seed infected by			
	Fusarium spp.	Drechslera spp.	Alternaria spp.	Penicillium spp.
0	24.8	3.8	53.8	19.8
1	17.5	5.3	42.8	5.5
2	17.3	4.5	45.0	9.3
3	12.0	3.0	49.3	5.0
4	4.8	1.0	30.3	6.5
5	6.0	0.5	17.5	7.5
6	3.0	0	7.3	6.3
7	0	0	0	1.0
8	0	0	0	0

7. Aerated steam treatment

Aerated steam is defined as a mixture of air and steam. A constant amount of air conditioned to a predetermined temperature with steam is recirculated until the system reaches thermal equilibrium. The use of aerated steam is safer than hot water and more effective than hot air in controlling seed home infections. The heating capacity of water vapour is about half that of water and 2.5 times that temperature control and no damage to seed coat of legumes (Cochran, 1978)

PLATE 1: Aerated steam treatment chamber

7.1 Aerated steam treater

An aerated steam (AST) system utilizes the efficiency and uniformity of heat transfer through a moist environment as well as the flexibility of a recirculating air system.

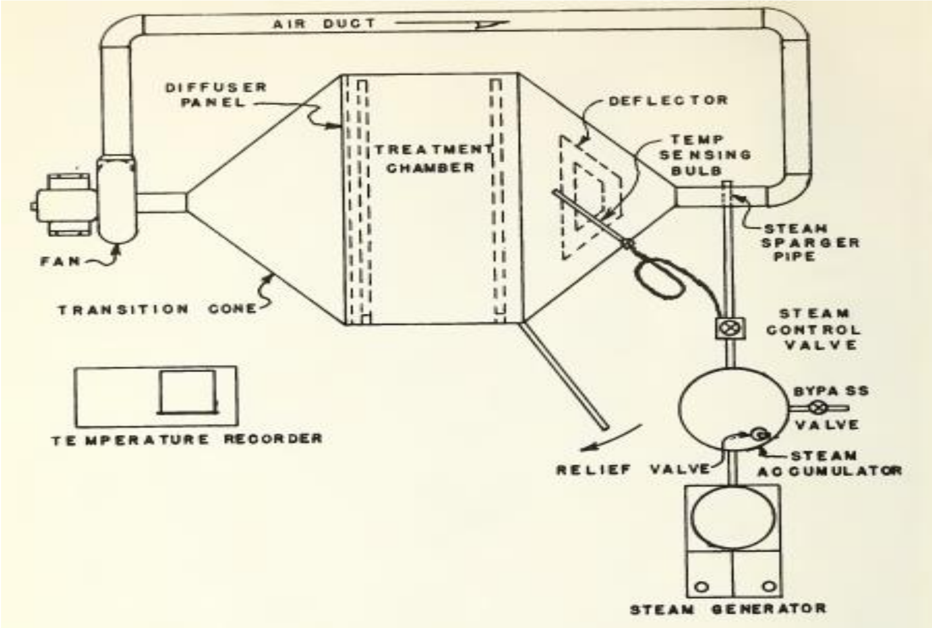


Figure 1: Aerated steam treater

AST system consists of a treating chamber, a recirculating air system, a steam generator and a method of controlling the amount of steam applied to the system. Recirculation at a rate of approximately eight times the empty volume of the treatment chamber per minute is adequate to minimize the blast effect of higher velocities and also suspend the steam within the turbulent air throughout the chamber. The steam can be generated with a portable steam generator with a rated capacity of 100 gallons per hour. Steam from the generator is stored in an accumulator where the generator pressure pulses are cushioned.

The accumulator collects condensate and other foreign materials from the steam and discharges it through a steam trap. Steam going to the system is taken from the top of the accumulator and passed through a modulating steam flow control valve. The amount of steam injected into the recirculating air system to maintain a prescribed temperature is controlled by the steam control valve.

A temperature sensing element is placed near the entrance transition to monitor the temperature of the aerated steam entering the treatment chamber. The sensing element temperature is indicated by a dial thermometer on the control valve. The prescribed temperature is set by manually adjusting the spring pressure on the pilot of the steam control valve. Steam passing through the valve is distributed into the air stream through a nozzle constructed of galvanized pipe with 1/16 inch holes spaced 1 inch apart. The nozzle should be positioned horizontally across the air duct between the fan and the entrance transition with the steam emission holes facing opposite to the direction of air flow.Turbulence within the system will thoroughly mix the air and steam to provide a humid environment at the prescribed temperature for treating the seed.

7.2.a. Effect of aerated steam treatments

Aerated steam treatment at 70°C for five minutes was effective against *E. coli* and *Salmonella enterica* in alfalfa and mung bean seeds used for table purposes (sprouts) .Sprouts contaminated with human pathogens are able to cause food-borne diseases due to the favourable growth conditions for bacteria during germination and because of minimal processing steps prior to consumption. A treatment of E. coli contaminated alfalfa seeds for 90 s and longer time reduced the initial population below 1.40 log CFU/g, the detection limit of experiment. For mung bean seeds, treatment for 300 s reduced the *E. coli* population to below detection limit and an aerated steam treatment for 180 s reduced the *S. enterica* population below detection level in alfalfa seeds whereas, treatments for 90 s and longer reduced the *S. enterica* population in mung bean (Studer *et al*., 2013).

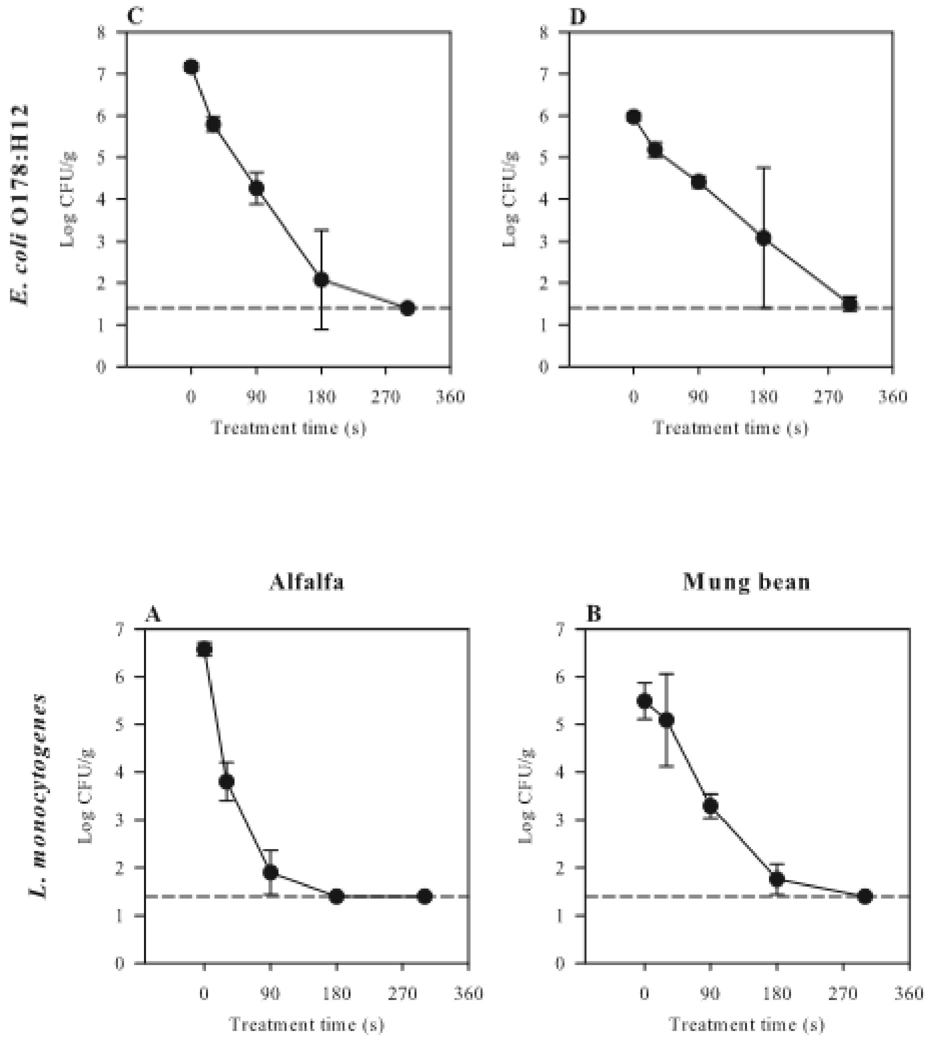


Figure 2: Effect of aerated steam treatment on population levels of E.coli O157:H7 and *S.enterica* on alfalfa and mungbean seed

7.2.b. Effect of aerated steam treatments

A study which was conducted in India explained the effect of aerated steam therapy on the development of grassy shoot disease symptoms in sugarcane. Aerated steam therapy (AST) treatment of seed cane for a period of 1 h at 50^0C is given to eliminate grassy shoot disease (GSD) incidence in sugarcane. Enhanced treatment duration from 1 h to 3 h at 50^0C and increased temperature regimes from 50 to 52 ^{0}C for 1 h were evaluated for sugarcane sett germination and GSD development in plant crop.

Table 5: Effect of aerated steam treatment on sugarcane sett germination

Genotype	Healthy setts untreated (%)	Diseased setts untreated (%)	Diseased setts treated (%)
Co 740	55.6	57.5	62.5
Co 8014	52.8	45.8	54.2
M84-119	50.0	54.2	59.7
CoC 671	55.6	47.2	56.9
Col 64	62.5	50.0	72.2

Effect of grassy shoot phytoplasma infection on sett germination revealed that AST at 50 ^{0}C for 1 h recorded higher germination of setts as compared to the untreated setts. Increased treatment time from 1 h to 3 h at 50^0C also resulted in reduced germination of setts. When treatment temperature was increased from 50 to 51 and 52 ^{0}C for 1 h or treatment at 50 ^{0}C for 2 or 3 h significant reduction in GSD build up was noticed in the field. By 12th month these treatments recorded either no disease or very restricted development of GSD as compared to untreated controls and AST treatment for 1 h at 50 ^{0}C.

Table 6: Effect of aerated steam treatment on grassy shoot disease incidence in sugarcane

Genotype and treatment	Disease incidence (%)				
	4^{th} month	6^{th} month	8^{th} month	10^{th} month	12^{th} month
Co 740					
Diseased	14.95	16.65	11.33	7.47	35.5
1 h	0.00	7.36	6.67	7.94	35.5
2 h	0.00	0.00	0.00	0.00	9.21
3 h	0.00	0.00	0.00	0.00	2.22
CoC 671					
Diseased	14.95	17.48	1.36	7.55	23.15
1 h	0.00	21.52	7.02	8.18	9.64
2 h	0.00	0.00	0.00	0.00	4.69
3 h	0.00	0.00	0.00	0.0	0.0
IST 152					
Diseased	35.77	52.31	32.9	48.88	56.66
1 h	5.56	0.00	4.86	5.13	9.29
2 h	0.00	0.00	0.00	0.00	0.00
3 h	0.00	0.00	0.00	0.00	0.00

8. ThermoSeed

Most of the research findings in the labs across the world are not commercializd. But here we can say the effect of physical treatment has been commercialized and patented as thermoseed. ThermoSeed is a new concept for control of seed-borne pathogens by use of minutely controlled, hot, humid air seed treatment. The method was developed in collaboration between the inventor, Acanova AB, and the Swedish University of Agricultural Sciences, SLU. Extensive evaluation during many years in field trials in seven European countries and on ordinary farms in Sweden have given very good results, both concerning the pathogen control and effect on crop yield. The method is now acknowledged by SUK, the Swedish seed certification authority, as an equally efficient alternative to chemical seed dressing of cereal seed.

8.1 History

It was in 1993, ThermoSeed technology was initiated and developed by research projects at the Swedish University of Agricultural Science in Uppsala. In 1998 a company was founded in Uppsala and first patent for thermoseed was filed. Up to 2004, a prototype ThermoSeed treatment system, operating at 3.5 tons/hour capacity, has been used in a commercial seed processing plant in Uppsala, Sweden. It has processed approximately 200 tons of infected cereal seed that has been tested and certified as healthy seed by the SUK to conventional farmers. During 2005, the first full-scale treatment system will be installed at one of the seed processing plants sufficiently powerful to replace a chemical treatment processing line with 30 tons/hour capacity. Evaluations done during many years at the University of Torino, Italy, have shown that the ThermoSeed system designed for cereals is also competitive for treatment of rice seed. At present, the patent rights for this technology is with the Thermoseed global company. This technology was awarded the best innovation award in 2017 by Swedish University of Agricultural Sciences.

8.2 Characteristics of thermoseed

ThermoSeed was developed on the basis of new ideas, fruitful research and advanced process technology. Through its outstanding precision, ThermoSeed maximizes the disinfection rate and all the disadvantages of hot water treatment are avoided. Development of the ThermoSeed method was enabled by a combination of great competence in areas such as modern process engineering, seed biology and seed processing technology.They are having very high precision and are as effective as chemical treatment. It shows high throughput process with low cost. Thermoseed competes with chemical seed treatment. Chemical seed treatment is not permitted in organic farming, and, to date, access to practical, useful and effective alternatives has been limited. Organic farming has a great need for effective methods of seed-borne pathogen control.

Extensive evaluations conducted across the European countries have given very good results for pathogen control, seed longevity and crop yield. Thermoseed was first published as a technology in a sympossium of ISTA in 2005. A team of researchers did research in several crops to find the effect of thermoseed. Foresberg and his co workers reported that in rice thermoseeds showed high disinfection compared to untreated seeds. The incidence of bakane and false smut diseases was high in untreated seeds.

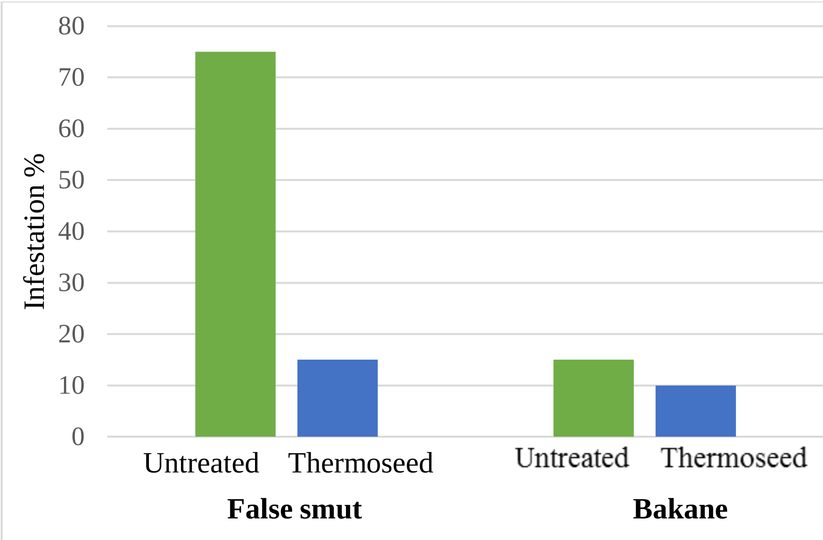
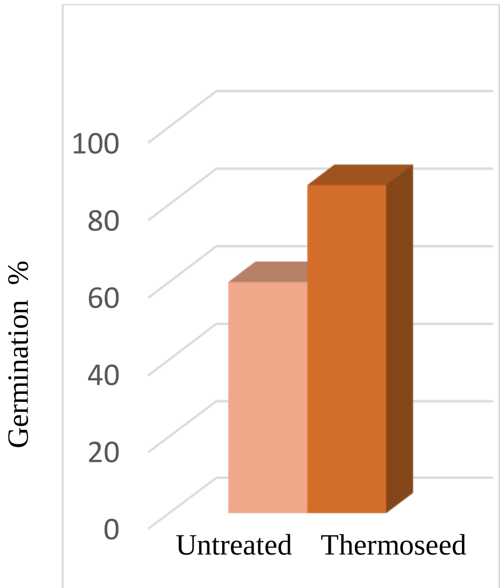


Figure 3: Effect of Thermoseed technology (TST) on disinfection efficiency in rice

In case of germination per cent of thermoseeds of rice are with 70% germination while untreated seeds showed only 60% and thermoseeds showed more yield compared to untreated seeds



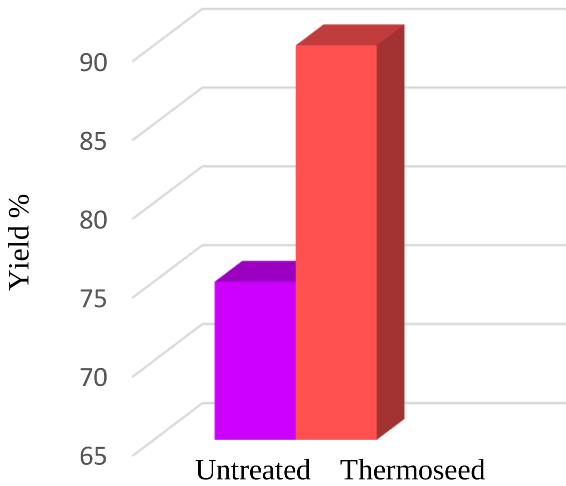


Figure 4: Effect of TST on germination and yield in rice

For vegetables also thermoseeds showed similar results, untreated seeds showed 70% seed infection and it was much less in thermoseeds.

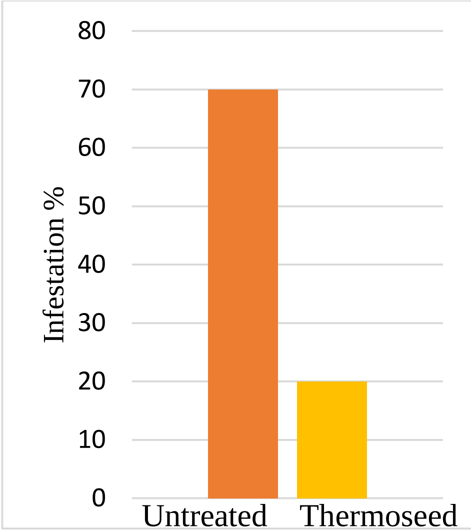


Figure 5: Effect of TST against *Botrytis alli* infection in onion

Storage studies conducted in carrot seeds exposed to thermoseed treatment revealed that the treated seeds retained a germination per cent above 75 even after one year of storage while germination of untreated seeds didn't show 60% which was the required minimum germination for carrot seed according to ISTA. (Forsberg *et al.,* 2005).

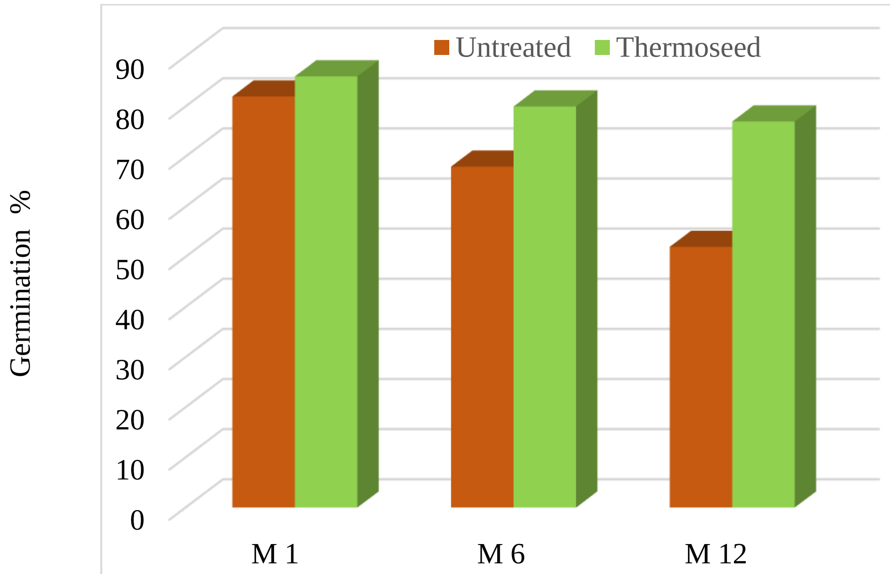
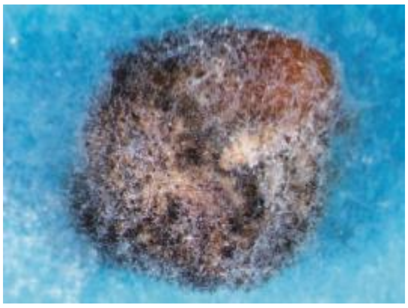


Figure 6: Effect of TST on seed longevity in carrot seeds

Thermoseeds of several crops are available commercially like rice, wheat, maize, barley, oats, onion, carrot, spinach, corn. Extensive evaluation during many years in field trials in several European countries have given very good results, both concerning the pathogen control and effect on crop yield. ThermoSeed is competitive with chemical seed treatment with regard to both treatment effectiveness and cost. It is therefore attractive for both conventional and organic farming. The method has now been acknowledged by SUK (the Swedish Seed Testing and Certification Institute), and approved as an effective commercial equivalent to chemical seed dressing of cereal seed.



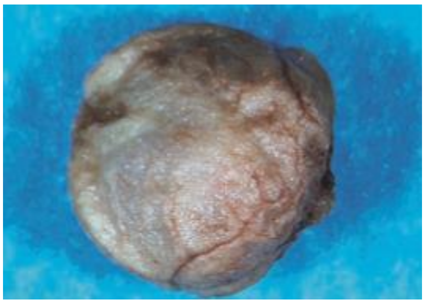


PLATE 2: Effect of TST on disinfection efficiency on untreated and thermoseeds in spinach

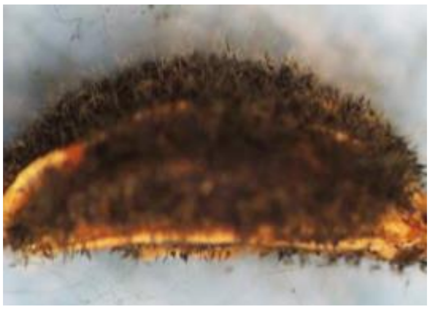


PLATE 3: Effect of TST on disinfection efficiency on untreated and thermoseeds of in carrot

8.3 Advantages

- The main advantage is the broad spectrum of action.
- It is an attractve alternative to chemical seed dressing in conventional cropping as well as an efficient way for control of seed- borne pathogens in organic farming.
- The main reason why most of the seed producers do not go for chemical seed treatment is because when treated seed fall below the prescribed seed standards it can no longer be used for consumption and the left over seeds has to be discarded due to hazardous chemicals .By using this technology we can convert seeds to grain which can be used as food or animal feed
- By avoiding chemicals the working environment is improved for farmers and for labour at seed processing plants.
- Usually when seeds are chemically treated, runoff may occur and will contaminate ground water, by using this technology we can avoid such problems.

- This technology is also cost effective. By looking into large equipments we feel as costlier technique which farmer cant afford. While working out cost of this treatment , cost will increase only by Rs.1 /kg of seed.

9. Conclusion

The concept presents an attractive alternative to chemical seed dressing in conventional cropping, as well as an efficient way for control of seed-borne pathogens in organic farming. This is possible thanks to a high pathogen control efficiency, combined with a high treatment capacity and low treatment costs. Since no products are added to the seed, leftover seed has an alternative value as food or feed. By avoiding chemicals, the working environment is improved for farmers and for labour at seed processing plants. The risk for children or animals that accidentally touch or eat seeds and the risks for ground water and the ecosystem, associated with chemical seed dressing, are eliminated. Thermoseed is a clean and safe technology which have the potential to replace seed health treatments in the future.

10. Discussion

1. How the contamination of alfalfa and mung beans occur?

   The contamination spreads through contaminated irrigation water, insufficiently composted manure used as fertilizer, dust,fecal contamination transmitted through animals and inadequate hygiene of workers and equipment during production, harvest,storage and processing .

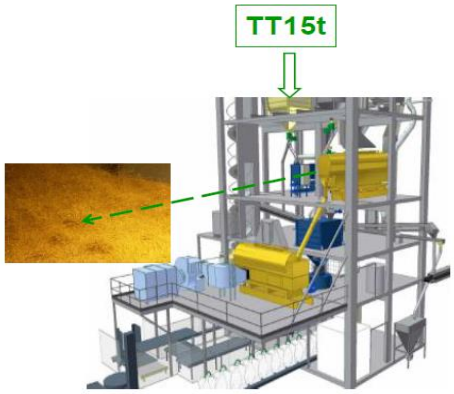
2. What are seed standards?

   For each crop there are specific seed standards. It is given by International seed testing association (ISTA). It varies from crop to crop. Seed standards like pure seed per cent, germination, moisture content, number of weed seeds other crop seeds etc. will be specified and those seeds which meet these standards can only certified .

3. Whether any studies were conducted to find the effects of Thermoseed on storage life of seeds?

   In one the studies done in cereals it was shown that germinability of seeds where increased after several months of storage. Thermoseed treatments are effective for storage also.

PLATE 4



Thermoseed equipments for cereals

Thermoseed equipments for vegetables

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KERALA AGRICULTURAL UNIVERSITY

COLLEGE OF HORTICULTURE, VELLANIKKARA

Department of Seed Science and Technology

SST 591: Master's Seminar

Name	: Riya Mary Mathew	Venue	: Seminar hall
Admission no.	: 2018-11-154	Date	: 21-12-2019
Major Advisor	: Dr. Dijee Bastian	Time	: 10.00 am

Can thermoseed replace seed health treatments?

Abstract

Seed is the most important input on which the efficacy of other agriculture inputs is dependent. It is estimated that quality seed accounts for 20-25 per cent of the productivity. Seed quality is the degree of excellence in regard to characteristics like genetic purity, physical purity, germination, moisture content and seed health.

Seed treatment refers to the application of certain agents physical, chemical or biological to the seed, prior to sowing in order to suppress, control or repel pathogens, insects and other pests that attack seeds, seedlings or plants (Sharma *et al.*, 2015). Physical seed treatments include solar heat treatment, hot water treatment, dry heat treatment and aerated steam treatment. The last two treatments are used in thermoseed technology. Thermoseed is a pasteurization treatment using hot and humid air to treat the seeds. The basic principle is that the seed-borne pathogens are much more sensitive to the treatment than the seed itself.

In dry heat treatment, we use high temperature to kill microorganisms and bacterial spores. This treatment was reported to be effective against *Cladosporium cucumerinum, Ascochyta citrullina* and *Colletotrichum orbiculare* in cucumber seeds exposed to 70 °C for 40 minutes (Yanxia *et al*., 2016). For small quantities, the seeds may be treated using hot air ovens and convection ovens.

Aerated steam is defined as a mixture of air and steam and utilizes the efficiency and uniformity of heat transfer through a moist environment. Aerated steam treatment at 70 °C for five minutes was effective against *E. coli* and *Salmonella enterica* in alfalfa and mung bean seeds used for table purposes (sprouts) (Studer *et al*., 2013).

This treatment was developed into a commercial scale by the Swedish University of Agricultural Sciences and was successfully patented by Incotec, Sweden. At present, the patent rights for this technology is with the Thermoseed global company. This technology was awarded the best innovation award in 2017 by Swedish University of Agricultural Sciences.

Extensive evaluations conducted across the European countries have given very good results for pathogen control, seed longevity and crop yield. Storage studies conducted in carrot seeds exposed to thermoseed treatment revealed that the treated seeds retained a germination per cent above 75 even after one year of storage (Forsberg *et al.*, 2005).

Effective utilization of this technology can help to reduce the use of chemical fungicides. The advantage of using thermoseed treatment is the high pathogen control efficiency coupled with low treatment cost. By avoiding chemicals, the seeds which fall below the seed standards can be used as grain. It is a clean and safe technology which has the potential to replace seed health treatments in future.

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