Thus plant seeds are closely dependent on these natural ecological factors that help in the improvement of germination rate with further increase in the portion of the quality and quantity produce. Successful germination and seedling establishment are crucial steps for maintenance and expansion of plant populations and recovery from perturbations. (de Melo et.al., 2015). A dormant seed is usually dehydrated and contains very less content of water. However all the living cells comprises of about 80 to 90 percent of water for carrying out their metabolic activities properly. Water also activates certain hydrolytic enzyme that breaks the seed coat. The hot water treatment of seeds helps in breaking the seed dormancy faster. Water also has dissolved oxygen that is used by the growing embryo. It also increases the permiability of the seeds and converts the insoluble food into soluble form (Waterworth, et.al, 2015).

Another important factor is oxygen. Germinating seeds requires abundant oxygen as they show an active rate of respiration. Moderate temperature is also required for proper germination. Germination takes place at a wide range of temperature ranging from 5°C to 40°C.The optimum range of temperature for most of the crop plants is 25°C. The seeds of those plants that grow in colder climates require low temperature for germination. This shows the effect of temperature as a control key factor in the process of germination. Cold stratification is a process that induces the dormancy breaking prior to light emission that promotes germination (Baskin and Baskin, 2014). Light or darkness is another important factor that controls the rate of germination. Although the literature of most the research works do point out that light or darkness play almost no significant role in the germination (Sadhu, 1989). However, it is observed that the seeds of many plants show a higher rate of germination when kept in dark condition. Dark place as an essential requirement is, however, not declared in any scientific research as a factor affecting germination.

It is obvious that these factors affect germination and its rate in one way or other. This is very important in the field of agriculture and farming. Seeds are central to crop production, human nutrition, and food security. Crop yield and resource use efficiency depend on successful plant establishment in the field. A higher rate of germination and thus increase in the crop yield increases the rate of successivity in market produce to gain profit in great amounts, thus improving the economy.

For a better yield of agricultural crops and a higher rate of germination, often large amount of fertilizers is added to the seeds. These fertilizers often contain synthetic chemicals that are non biodegradable. They can cause both soil and water pollution. Over time fertilizers also make the soil acidic in nature causing soil degradation. Apart from that, they have harmful effect on human health as well. Depending on the amount of fertilizer consumed, it may cause disturbances of the kidneys, lungs and liver and even cause cancer. This is due to the toxic metals that fertilizers have. While fertilizers may be beneficial to plants but it possess a great risk to human health and environment. Also, it is not cost effective for the farmers. Therefore, the study of germination carried under normal ecological factors without the application of seed boosters becomes an important aspect. Here we take into consideration the simple treatment of water application like hot water and tap water at room temperature on germination rate. Also, the germination rate of seeds that are subjected to dark conditions and light conditions are observed and studied to determine which sets of seeds shows a better rate of germination.

However, this is to be noted that hot water and dark condition is to be given only in the germination stage of seeds. Once the plant has acquired a height, it should be transferred to a light condition and given the normal water. Dark condition and hot water only triggers the rate of germination of seeds and not the rate of growth of plants. Some gardeners believe that boiling water is beneficial to plants that are particularly sensitive to water impurities. Also, giving some hot water treatment, kill some pathogens that are able to penetrate and survive within the seed. They include many bacterial pathogens of vegetables as well as fungi, oomycetes and viruses.

This research focuses on cost effectiveness and a provision of a tool to guide the farmers in agricultural techniques. The present research was carried out on *Trigonella foenum* (Fenugreek) and *Spinacea oleracea* (Spinach) by letting the sets of seeds germinate under dark condition and the other set germinate under light exposure. The sets of seeds kept in dark as well as light condition were both provided with continuous supply of hot water as well as normal tap water without the addition of any fertilizers or manure. The leafy plants were selected for the present investigation as they are fast to grow.

Materials and Method :

The seeds of *Trigonella foenum* and *Spinacea oleracea* were bought from the local nursery and they were soaked in water for 15 min.

Twenty seeds each of *Spinacea oleracea* and *Trigonella foenum* were soaked in hot water whereas, other twenty seeds of each were soaked in normal tap water.

On a set of tray, soaked seeds were freely transferred containing a platform of blotting paper which was wet by water.

They were now prepared for study of the two parameters:-

- Germination of seeds in dark and direct sunlight using normal water
- Germination of seeds in dark and direct sunlight using hot water.

Seeds were placed in petriplate on the cotton base.

Soil was used to grow the control.

Two sets of 10 seeds each of *Spinacea oleracea* and *Trigonella foenum*, respectively, were kept in dark condition.

The other two sets each of 10 seeds of *Spinacea oleracea* and *Trigonella foenum*, respectively, were kept in light condition.

One set of seeds of both the species were given hot water treatment in light as well as in dark condition to maintain the moisture content and prevent the dessication of seeds while the other set of seeds of both the species in light as well as dark condition were given normal tap water.

Care was taken to never let the cotton pad dry on which the seeds were placed.

Also, the water was not directly given, instead it was sprayed on the cotton pad and seeds gently. Giving too much water was avoided.

The set of seeds kept in light condition were provided proper sunlight for at least 4 to 6 h daily.

The setup was maintained for about 10 days and studied for growth parameters.

The rate of successful germination and the first day of emergence of leaves were noted.

Special treatment of mechanical or any inorganic and organic matter was prohibited during complete research study.

Growth of the Selected Plants :

The growth of the selected plants were studied under the following growth parameters-:

Germination (%) : Germination percentage is an estimate of the viability of a population of seeds. The equation to calculate germination percentage is: GP = seeds germinated/total seeds x 100 . The germination rate provides a measure of the time course of seed germination. Germination rate is determined by calculating the GP at different time intervals after planting and then plotting these data (Penfield, 2017).

Plant Height: Plant Height was measured after 10 days and Mean length of seedlings was determined.

Seedling Vigour Index (SVI) : The seedling vigour index was determined by multiplying the percent germination and total seedling length. Seedling vigour index = Germination(%) * Mean length of seedling (cm).

Shoot length : The significant differences was observed for shoot length. Among the different treatments, longest shoot length and shortest shoot length were recorded.

Root length : Root length (cm) differs significantly due to the treatments. Among the treatments, the longest root length and shortest root length were recorded.

Day of emergence of first leaf : Once the seedling starts to photosynthesize, it is no longer dependent on the seed's energy reserves. The apical meristem starts growing and give rise to the root and the shoot. The "true" leaves expand and could often be distinguished from the round cotyledons through their species dependent distinct shapes. The day of emergence of first leaf was noted down.

Total number of leaves : Number of leaves indicates a plant's physiological age. The number of leaves on each plant sample was counted and recorded. Every visible leaf on the plant, including the tips of new leaves just beginning to emerge was counted on the last day of experiment.

Plant Biomass : 5 leaves of each plant samples were taken and blotted gently with soft paper towel to remove any free surface moisture. They were weighed immediately (plants have a high composition of water, so waiting to weigh them may lead to some drying and therefore, produce inaccurate data).

Plant dry weight : Five Leaves of both plants of each set were taken, blotted dry to remove any free surface moisture. They were kept in a hot air oven to low heat (100 °F) for overnight. Once the plants cooled down, they were re-weighed to determine the plants' dry weight.

Results and Discussion :

The seeds were allowed to germinate in both dark and light conditions. The moisture was maintained by fulfilling the requirement with normal water treatment and hot water treatment to concerned sets. The seeds were kept for 10 days for germination in both light and dark condition and the observations for different growth parameters were noted down. The experimental set up is shown in Figure 1-5.

Fig. 1. First day of germinating seeds in dark condition

Fig. 2. First day of germinating seeds in light condition

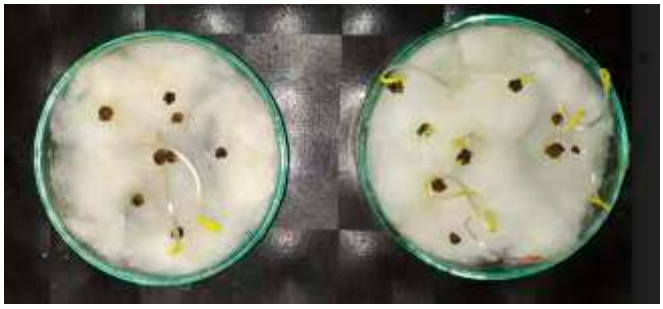

Fig. 3. Plant growth after ten days in dark condition

Fig. 4. Plant growth after ten days in light condition

Fig. 5. Control plant in the soil

Germination % : The Average % of seed germination in *Trigonella foenum* in dark condition was found to be 60.13% and 66 % when treated with normal water and hot water, respectively.

The same for *Spinacea oleracea* was 69% with normal water treatment and 62.26% with the hot water treatment, respectively when kept under dark condition. The data are presented in Figure 6.

The Average % of seed germination in *Trigonella foenum* in light condition was found to be 23.21% and 52.62% when treated with normal water and hot water, respectively.

The same for Spinacea oleracea was 68% with normal water treatment and 40% with the hot water treatment, respectively when kept under dark condition. The data are presented in Figure 7.

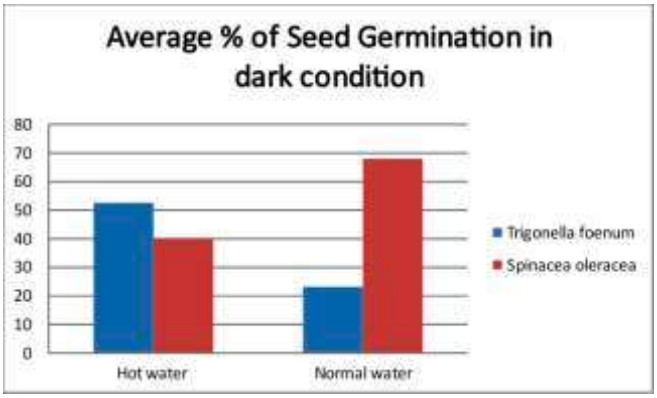

***Fig. 6. Average % of seed germination of Trigonella foenum* and *Spinacea oleracea* when treated with normal water and hot water in dark condition**

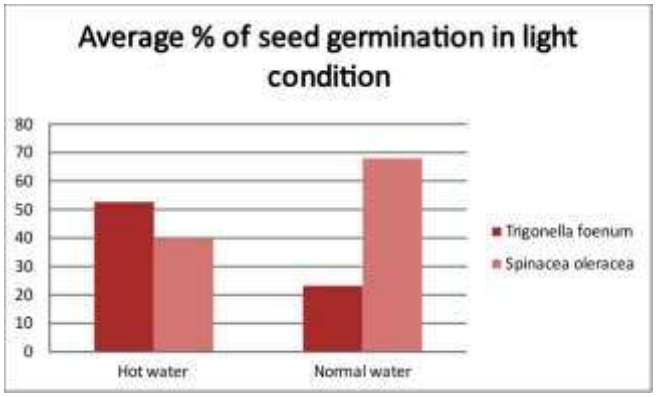

Fig. 7. Average % of seed germination of *Trigonella foenum* and *Spinacea oleracea* when treated with normal water and hot water in light condition

In above mentioned cases the specificity of results enlightens clearly that treatment of hot water seems efficient for % of seed germination in *Trigonella foenum* (66) and the normal water for *Spinacea oleracea* (69). This proves a potency of needed prior treatment before sowing the seeds in a farm based on a condition required for high rate of germination in some plants to increase the produce.

It was infered that hot water treatment and dark condition favoured growth of *Trigonella foenum* as the Average% growth was the highest (66) in this condition, whereas normal water treatment under dark condition gave highest Average% growth value (69) for Spinacea oleracea.

The Average % of seed germination in *Trigonella foenum* in light condition was found to be 23.21% when treated with normal water and 52.62% when treated with normal water and hot water, respectively.

The same for *Spinacea oleracea* in light condition was 68% when treated with hot water and 40% when treated with normal water, respectively. The data are shown in Figure 2.

The above result matched with the investigation done by Dr. Urmila Sarkar and Sensei Surendra Sawarddekar in 2019 that showed that the seed of *Trigonella foenum* germinated best when treated with hot water in dark condition. While the seeds of *Spinacea oleracea* showed the highest rate of germination under dark condition with the treatment of normal unheated water.

Plant Height : The height of *Trigonella foenum* after 10 days in dark condition was 6 cm and 8 cm when treated with normal water and hot water, respectively whereas in light condition, it was 3.5 cm and 6 cm in normal water and hot water *treatment, respectively.*

The height of *Spinacea oleracea* after 10 days in dark condition was 7 cm and 9 cm when treated with normal water and hot water, respectively whereas in light condition, it was 5 cm and 9 cm in normal water and hot water treatment, respectively.

Seedling Vigour Index (SVI): The Seedling Vigour Index of *Trigonella foenum* was 360.78 and 528 in dark condition when treated with normal water and hot water, respectively and the same was 81.235 and 315.72 in light condition when treated with normal water and hot water, respectively.

The Seedling Vigour Index of *Spinacea oleracea* was 435.82 and 621 in dark condition when treated with normal water and hot water, respectively and the same was 200 and 612 in light condition when treated with normal water and hot water, respectively.

Shoot Length: The Shoot Length of *Trigonella foenum* was 5 cm and 6.5 cm in dark condition when treated with normal water and hot water, respectively and the same was cm and 7 cm in light condition when treated with normal water and hot water, respectively.

The Shoot Length of *Spinacea oleracea* was 2.5 cm and 4.5 cm in dark condition when treated with normal water and hot water, respectively and the same was 3.8 cm and 7 cm in light condition when treated with normal water and hot water, respectively.

Root Length: The Root Length of *Trigonella foenum* was 1 cm and 2 cm in dark condition when treated with normal unheated water and hot water, respectively and the same was 1 cm and 2.5 cm in light condition when treated with normal water and hot water, respectively.

The Root Length of *Spinacea oleracea* was 1.8 cm and 2 cm in dark condition when treated with normal unheated water and hot water, respectively and the same was 1.2 cm and 2 cm in light condition when treated with normal water and hot water, respectively.

Day of emergence of first leaf: The Day of emergence of first leaf of *Trigonella foenum* was 5th day and 4th day in dark condition when treated with normal unheated water and hot water, respectively and the same was 7th day and 4th day in light condition when treated with normal water and hot water, respectively.

The Day of emergence of first leaf of *Spinacea oleracea* was 5th day and 4th day in dark condition when treated with normal unheated water and hot water, respectively and the same was 4th day and 3rd day in light condition when treated with normal water and hot water, respectively.

Total number of leaves : The Total number of leaves of *Trigonella foenum* was 6 and 8 in dark condition when treated with normal unheated water and hot water, respectively and the same was 3 and 5 in light condition when treated with normal water and hot water, respectively.

The Total number of leaves of *Spinacea oleracea* was 5 and 4 in dark condition when treated with normal unheated water and hot water, respectively and the same was 4 and 6 in light condition when treated with normal water and hot water, respectively.

Plant Biomass: The Plant biomass of *Trigonella foenum* was 192 mg and 215 mg in dark condition when treated with normal water and hot water, respectively and the same was 49 mg and 196 mg in light condition when treated with normal water and hot water, respectively.

The Plant biomass of *Spinacea oleracea* was 396 mg and 264 mg in dark condition when treated with normal water and hot water, respectively and the same was 378 mg and 150 mg in light condition when treated with normal water and hot water, respectively.

The data of all the above mentioned growth parameters of *Trigonella foenum* and *Spinacea oleracea* when treated with normal water and hot water under dark condition and under light condition are tabulated in Table 1 and Table 2, respectively.

***Table 1. Physical Parameters of Trigonella foenum* and *Spinacea oleracea* under dark condition**

S. No.	PHYSICAL PARAMETER	HOT WATER (Dark Condition) *Trigonella foenum*	NORMAL WATER (Dark Condition) *Trigonella foenum*	HOT WATER (Dark Condition) *Spinacea oleracea*	NORMAL WATER (Dark Condition) *Spinacea oleracea*
1.	% of Seed Germination	66	60.13	62.26	69
2.	Seedling Vigour	528	360.78	435.82	621
3.	Day of emergence of First leaf	4	5	5	4
4.	No. of leaves	8	6	7	8
5.	Colour of leaves	Light green	Light green	Light green	Light green
6.	Plant Height (cm)	8	6	7	9
7.	Shoot Length (cm)	6.5	5	6.2	7
8.	Root Length (cm)	2	1	1.8	2
9.	Plant Fresh Weight (mg)	896	812	960	1152
10.	Plant Dry Weight (mg)	215	192	264	396

Table 2. Physical Parameters of *Trigonella foenum* and *Spinacea oleracea* under light condition

S. No.	PHYSICAL PARAMETER	HOT WATER (Light Condition) *Trigonella foenum*	NORMAL WATER (Light Condition) *Trigonella foenum*	HOT WATER (Light Condition) *Spinacea oleracea*	NORMAL WATER (Light Condition) *Spinacea oleracea*
1.	% of Seed Germination	52.62	23.21	40	68
2.	Seedling Vigour	315.72	81.235	200	612
3.	Day of emergence of First leaf	4	7	4	3
4.	No. of leaves	5	3	4	6
5.	Colour of leaves	green	Green	Green	Green
6.	Plant Height (cm)	6	3.5	5	9
7.	Shoot Length (cm)	4.5	2.5	3.8	7
8.	Root Length (cm)	1.5	1	1.2	2
9.	Plant Fresh Weight (mg)	724	265	514	1128
10.	Plant Dry Weight (mg)	196	49	150	378

From the above investigation, data collection and considering most of the growth parameters, it can be concluded that hot water in dark condition was better for cultivation of *Trigonella foenum* and normal water in dark condition favours the cultivation of *Spinacea oleracea*.

References:

Baskin CC, Baskin JM (2014). *Variation in Seed Dormancy and Germination within and between individuals and population of a species. Seeds: Ecology, Biogeography, and, Evolution of Dormancy and Germination*. Burlington: Elsevier Science. pp. Pages 5 – 35.

De Melo RB, Franco AC, Silva CO, Piedade MTF,Ferreira CS. (2015).Seed germination and seedling development in response to submergence in tree species of the Central Amazonian floodplains.AoB Plants, 7(10):1093.

Penfield S (2017). *Seed dormancy and germination*. Current Biology.

Sadhu MK (1989). *Plant propagation*. New Age International. p.61

Sarkar U, Sensei S. (2019). Study of the Effect on seeds of *Trigonella foenum* and *Beta vulgaris;* Leafy vegetables Germination: A useful guide for Agricultural Practitioner. *International Journal of Science and Research.* 8(4):58-60.

Siegel SM, Rosen LA (1962). Effect of Reduced Oxygen Tension on Germination and Seedling Growth. *Physiologia Palntarum*.15 (3) : 437 – 444.

Waterworth WM, Bray CM, West CE (2015). The importance of safeguarding Genome integrity in germination and seed longevity. *Journal of Experimental Botany*. 66 (12) : 3549- 58.