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Abstract:

Weeds are a problem in many communities, and although weed killer may seem like the best option, there are other alternatives that are less harmful to other plants and wildlife. In this experiment, hot water was hypothesized to be as effective when compared to standard weed killer, and was tested on sunflower plants. Hot water was used to kill ten sunflower plants while standard weed killer was used on a separate group of 10 plants. Hot water killed the plants, however, the standard weed killer killed the plants more quickly than the hot water treatment. Possible sources of error in this study included the method of application of the hot water, possible inconsistency in the temperature of the water, the aggression with which the plants were handled when being moved, and the consistency of when the watering of the plants took place each day.

Introduction:

Weeds are a problem in many communities and home yards, and many people work to reduce their presence by using chemical herbicides. But is this type of weed killer the best option? Weed killer can harm wildlife, other plants, and it does not always remove the plants. In this experiment, hot water was tested as an alternative to standard chemical weed killer. Compared to standard weed killer, this study evaluated the hypothesis that hot water is equal to or even more effective at killing weeds than chemical herbicide.

Several related experiments have been performed previously examining this issue. For example, T. Astatkie et al. examined the effectiveness of hot water, infrared, and open flame thermal units as alternate approaches to weed control. In their study, the scientists found that hot water was not as effective as expected at killing weeds. However, the authors noted that perhaps this was related to the intensity at which the water was applied (Astatkie, et al. 2-3).

Another experiment evaluating different types of weed control was by Rifai et al. In this experiment, flaming, the application of hot steam, and mulching in apple orchards for weed control was compared to a chemical herbicide. Flaming is a process that produces extreme and intense heat (such as with gas-powered torch) that scorches the weed's leaves, eventually causing the cell wall to collapse and the weed to wilt. They found that flaming was the most effective for smaller plants/weeds in the seed leaf stage (Rifai, et al. 933).

Martelloni et al. conducted an experiment in which flaming, glyphosate, hot foam, and nonanoic acid were compared to see which provided better weed control. Martelloni concluded that after 29 days of treatment, hot foam as well as glyphosate and flaming, were superior to nonanoic acid in reducing weed growth (Martelloni et al, 1).

De cauwer put together an experiment studying just hot water for weed control to reduce fuel use. The independent variables in this study were water temperature, time of day, weed age, and treatment intervals. Weed control was measured and seven different species of weeds were used. The weed species with small erectophile leaves were the hardest to control and the ones with large planophile leaves were more sensitive to the hot water. This suggests that weeds with larger surface areas are more susceptible to killing by hot water. In this study, hot water of ninety-eight degrees C applied to young weeds in the afternoon in three week intervals gave the best results in weed control (De cauwer, 195).

Finally, Werner Kurfess and Siegfried Kleisinger did an experiment to see if hot water could kill the weeds in an orchard. After twenty-four hours of the treatment of hot water, the weeds became wilted and brown wherever the hot water was applied (Werner Kurfess, Siegfried Kleisinger, 14).

Many of the experiments described above were used for large-scale weed control operations. However, the use of hot water for weed control may be most practical for the home gardener. Hot water works because it distorts and then kills the plant/weed cells by the transfer of heat energy. This type of weed control is known as thermal weed control. However, one of the problems faced by this

alternate method is the risk of accidental application of the hot water to the desired plants in a home garden. Even if the hot water slightly comes into contact with a plant, that plant will most likely die. Therefore, the best use for thermal weed control is likely on weeds such as in sidewalk cracks and along driveways where there are not other plants intended for growth, that could be harmed.

In this study, hot water and standard weed killer were applied to *Helianthus annuus* (Sunflower). Sunflower is a rapidly growing, broad-leafed plant ideal for such a study due to its rapid growth and the manner in which thermal weed control works as noted above. The hypothesis of this experiment was that hot water would kill sunflower plants as effectively as chemical weed killer.

Materials and Methods:

Ten planting cups were labeled for each treatment group as follows: 1A-10A; 1B-10B ; 1C-10C. Soil was placed in all cups for each treatment group, to the level of 5 cm from the cup's top. Three small holes were dug 1 cm from the soil's surface in each cup. One sunflower seed was planted in each hole. Each cup was watered with 30 mL of water directly over where the seeds were planted.
Cups were watered daily with 30 mL of water for ten days. As the sunflowers sprouted and grew, the amount of water applied to every cup was increased to 60 mL. This occurred on day eight of the study.

After the sunflower plants had grown to a height of between 8 cm and 18 cm, the weed treatment methods were applied to the cups. Over the plants in cups 1A-10A, 30 ml of water boiled to 100 C was applied to the base of each plant. Two complete sprays of standard weed killer containing the active ingredient, glyphosate, was sprayed over cups 1B-10B. Cups 1C-10C served as the control for this experiment and received no treatment other than watering. Data was recorded by how fast the plants wilted and/or died in each group. Time to death of plant was recorded in minutes. Death was if the plant wilted or collapsed.

Results:

Subjective observations of plant status were taken at intervals following the treatment applications. The plants were rated according to the following scale and assigned a number:

5: green in color, stiff in stem turgor, smooth in leaf texture

4: green in color, slightly flexible in stem turgor, smooth in leaf texture

3: brownish green in color, weak in stem turgor, withered in leaf texture

2: more brown than green in color, soft and weak in stem turgor, brittle in leaf texture

1: brown in color, withered in stem turgor, decayed and/or crunchy in leaf texture

One hour after hot water treatment, cups 1A-10A were pale green in color, stiff in stem turgor and smooth in leaf texture (5). One hour after standard weed killer treatment, cups 1B-10B were pale green in color, stiff in stem turgor and smooth in leaf texture (5). One hour after no treatment, cups 1C-10C were pale green in color, stiff in stem turgor and smooth in leaf texture (5).

Five hours after hot water treatment, cups 1A-10A were pale green in color, stiff in stem turgor and smooth in leaf texture (5). Five hours after standard weed killer treatment, cups 1B-10B were pale green in color, stiff in stem turgor and smooth in leaf texture (5). Five hours after no treatment, cups 1C-10C were pale green in color, stiff in stem turgor and smooth in leaf texture (5).

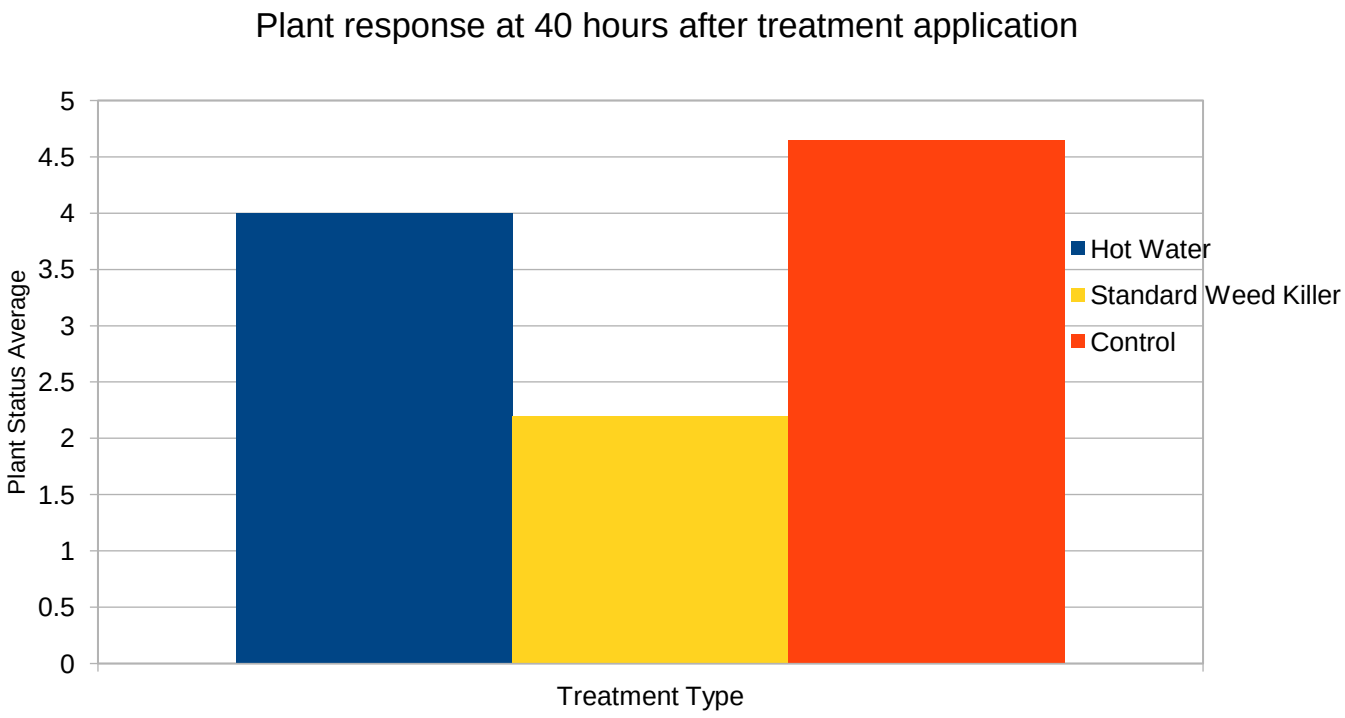
Fifteen hours after hot water treatment, cups 1A-10A were pale green in color, stiff in stem turgor and smooth in leaf texture (5). Fifteen hours after standard weed killer treatment, cups 1B-10B were pale green in color, stiff in stem turgor and smooth in leaf texture (5). Fifteen hours after no treatment, cups 1C-10C were pale green in color, stiff in stem turgor and smooth in leaf texture (5).

Twenty-hours after hot water treatment, cups 1A-10A were pale green in color, stiff in stem turgor, and smooth in leaf texture (5). Twenty-hours after standard weed killer treatment, cups 1B-10B were green in color, slightly flexible in stem turgor and smooth in leaf texture (4). Twenty-hours after no treatment, cups 1C-10C were pale green in color, stiff in stem turgor and smooth in leaf texture (5).

Twenty-five hours after hot water treatment, cups 1A-10A were pale green in color, stiff in stem turgor, and smooth in leaf texture (5). Twenty-five hours after standard weed killer treatment, cups 1B-3B, 5B-7B and 9B-10B were brownish green in color, weak in stem turgor, and brittle in leaf texture (2.5). However, cups 4B and 8B were pale green in color, stiff in stem turgor and smooth in leaf texture

(5). Twenty-five hours after no treatment, cups 1C, 2C, 3C, 6C, 8C, and 9C were pale green in color, stiff in stem turgor, and smooth in leaf texture (5). However, cups 4C, 5C, 7C and 10C had a withered leaf texture (4).

Forty hours after hot water treatment, cups 1A-10A were pale green in color, weak in stem turgor and smooth in leaf texture (4). Forty hours after standard weed killer treatment, cups 1B, 2B, 3B, 5B, 6B, 7B, 9B and 10B were brownish green in color, shriveled in stem turgor, and brittle in leaf texture (2). Cup 4B was brownish green in color, stiff in stem turgor, and brittle in leaf texture (3). Cup 8B pale green in color, shriveled in stem turgor, and brittle in leaf texture (3). Forty hours after no treatment, cups 1C-3C were pale green in color, stiff in stem turgor, and tough in leaf texture (4.5). Cups 4C-7C were pale green in color, stiff in stem turgor, and withered in leaf texture (4.5). Cups 8C-10C pale green in color, stiff in stem turgor, and smooth in leaf texture (5).



Discussion:

The purpose of this experiment was to see if hot water could be used as an effective substitute for weed killer. Weed killer can harm desirable plants and is sometimes ineffective in eliminating weeds. The major findings were that the hot water application did kill the weeds (sunflowers in this experiment), though less effectively than did the standard weed killer. The weeds killed by the herbicide were more shriveled than the ones killed by hot water. The time to plant death was also longer for the group treated with hot water as compared to the group which received the herbicide. The control group which received only tap water for irrigation and no herbicide or hot water, remained healthy as expected, demonstrating normal growth. This supports the idea that it was the herbicide that led to the death of plants in Group A and the hot water application that led to the death of plants in Group B.

T. Astatkie et al. found that hot water wasn't as effective as expected in a study done using apple orchards, noting that perhaps this was because of the method of water application (Astatkie, et al. 2-3). Rifai et al. completed an experiment that examined different types of weed control and although hot water worked, flaming, a process of using extreme heat to kill the plants, was much more effective, especially on younger plants (Rifai, et al. 933). Martelloni et al. found similar results to the Rifai Study (Martelloni et al, 1). Werner Kurfess and Siegfried Kleisinger conducted an experiment extremely similar to my own (only using hot water and weed killer as the substances) and found the hot water was very effective in killing weeds. After twenty-four hours of their hot water treatment, their plants were dead (Werner Kurfess, Siegfried Kleisinger, 14).

There were several sources of possible error in this study, that could have contributed to incorrect results. There may have been some error in the hot water and weed killer application, with slightly more weed killer or hot water applied to one plant than another. The hot water should also have been reheated each time to the same degree after pouring over each plant , as the water may have cooled down very slightly from plant to plant. The plants were watered all at the same time of day,

though the time of watering varied from day to day. There may also have been some variance in the manner in which each pot was moved or adjusted during the study. This movement, though slight, could have affected plant growth and susceptibility to the weed killing procedures. Finally, there may have been some variance in the depth of planting of each of the seeds.

There are several areas for future research related to this topic. Evaluating different types of hot water application such as spraying the hot water instead of pouring it, could provide better efficacy in weed killing. Research evaluating the most vulnerable part of the plant with regard to herbicide or hot water application would also be of interest. Adjusting the area of the plant (such as over the leaves or stem instead of at the roots) targeted with the weed killer or hot water might result in more effective weed killing. Lastly, evaluating greater volumes of herbicide and hot water application would be another experiment for future investigation.

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