MDARD Horticulture Fund

Grant# 210000001065

Fiscal Year 2021 Final Report

Proposal Title: Developing Alternative Weed Control Strategies for Landscape and Christmas Tree Production

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Summary of Project: Weeds can compete with landscape and Christmas tree growth at any stage of production for water, nutrients, space, and light. However, effective weed control is required during the initial years after transplanting in the field to maintain tree quality and vigorous growth. The main objectives of this proposal are to help Michigan landscape and Christmas tree growers to increase their success with weed management during the establishment phase of the trees and to develop alternative control strategies for common ragweed species that has reportedly become herbicide resistant. On-farm trials are being conducted on 2 to 3-year-old Fraser fir, Scotch pine, blue spruce, and White pine trees. Twelve different weed control treatments of postemergence herbicides and organic mulch were applied. Data collection includes visual weed control ratings, tree growth indices, and visual estimation of phytotoxicity of trees. Another separate greenhouse experiment is being conducted at HTRC, MSU, where alternative strategies are being tested upon clopyralid (Stinger) herbicide-resistant common ragweed species. Currently, data collection is going on. Best integrated strategies to control weeds successfully during establishment stage of landscape and Christmas trees and the alternative techniques to manage herbicide-resistant common ragweed will be identified and recommended to the growers at the end.

Background: Weeds can interfere with landscape and Christmas tree growth at any stage of production as they compete with the trees for water, nutrients, space, and light. However, effective weed control is required during the first three years after transplanting in the field to maintain tree quality and vigorous growth. It is important to maintain a balance between reducing weed competition with trees and protecting soil and water. During the year of establishment, weed competition may suppress the tree growth and can even kill young trees (Pic. 1). The rate of growth in the second and third years is directly related to the amount of weed competition. On sandy loams, weeds may utilize the available moisture, and the young trees may succumb to drought stress. Young trees that grow with minimal weed competition can develop healthy root systems, which allow them to withstand drought and other adverse conditions later in the crop rotation. Weeds can also interfere with production practices such as spraying and pruning. It is very difficult to prune trees and apply pesticides in the fields that are infested with horseweed, ragweed, pokeweed, sumac and other large or poisonous weeds. Broadleaf weeds such as giant ragweed, hoary alyssum, field bindweed, etc. can grow into the tree branches and it can be extremely difficult to remove them. Hence, a good weed management plan is essential to produce high quality and marketable landscape and Christmas trees.

Pic 1. Weeds competing with Christmas trees in production system during establishment stage.

Pic 2. Clopyralid (Stinger) herbicide resistant common ragweed species

An effective weed management program includes different strategies and practices to keep weed populations in control. Using the same herbicide can select for weeds that are no longer affected by that herbicide. An integrated approach of combining chemical and cultural/mechanical control practices along with proper identification of dominant weed species can help to prevent weed shifts and herbicide resistance from developing.

Application of herbicides during the establishment phase of tree plantations is crucial as there are chances of phytotoxic effects and tree injuries. Michigan Christmas tree growers rely largely on application of postemergence (POST) herbicides to control weeds. However, repeated applications of the same herbicides have resulted in herbicide-resistance among some of the weed species in Michigan. Common ragweed is one of the major problematic weed species in Christmas tree production fields. To control this weed species, growers have applied herbicides with same modes of action repeatedly over the years. As a result, there are recent reports on common ragweed resistance to clopyralid (Stinger), a synthetic auxin herbicide (Pic. 2), by some Michigan Christmas tree growers, especially in Montcalm County, MI.

Growth of the Michigan landscape and Christmas tree sector is largely hampered by the laborious and problematic practices of weed control and the recalcitrant nature of field weeds. Improving the efficiency and profitability of this green industry through improved weed control can further increase the economic stimulus supplied by this specialty crop sector and its job creation potential.

Specific Objectives:

Objective 1: Develop integrated strategies to address emerging weed management challenges in Christmas tree production.

> **Activity 1.** Evaluate the weed control efficacy of different types of POST herbicide combinations and compare with organic mulch weed control efficacy.
>
> **Activity 2.** Evaluate the phytotoxic effects of POST herbicide combinations and organic mulching on four different types of Christmas trees during establishment.

Hypothesis: Combinations of POST herbicides and organic mulch materials will provide a synergistic effect with improved weed control efficacy and less phytotoxic injury to the Christmas trees during establishment stage.

Objective 2- Develop alternative strategies to control clopyralid herbicide-resistant common ragweed in landscape and Christmas tree production.

> **Activity 1.** Investigate the impacts of POST herbicide combinations and organic mulch on common ragweed control efficacy.

Hypothesis: Combination of organic mulch along with POST herbicides with different modes of action than clopyralid will provide improved common ragweed control.

Materials and Methods:

Field Experiments: To achieve objectives 1 and 2, field experiments were conducted in summer and fall 2021 at four different Christmas tree farms located in Michigan which includes Korson Tree farm, Wahmhoff tree farm, Badger tree and nursery, and Gwinn tree farm (Fig 1). Four different varieties of Christmas trees were studied in this experiment were Fraser fir [*Abies fraseri*(Pursh) Poir], blue spruce (*Picea pungens* Engelm.), white pine (*Pinus strobus* L.) , and Scotch pine (*Pinus sylvestris* L.). Twelve weed control treatments (Table 1) were applied in each field, with 4 replications each of the five fields, and they were in completely randomized block design. The treatments were cypress bark organic mulch and herbicides (clopyralid, oxyfluorfen, and glyphosate) which were either applied alone or in combinations with each other or in combinations with the organic mulch as well as control without herbicides or mulch. The mulch was applied at a depth of 5cm and diameter of 30cm. Liquid formulations of oxyfluorfen, glyphosate, and clopyralid were applied at their highest labeled rates of 4.6 LHa^{-1}, 1.9 L Ha^{-1}, 0.58 L Ha^{-1}, respectively. All herbicides were applied uniformly with a CO_2 backpack sprayer calibrated at 252.55 LHa^{-1} output at 206.843 kpa pressure (Fig 2). Initial and final growth indices of the trees were taken and the dominant weed species in each field were recorded prior to treatments.

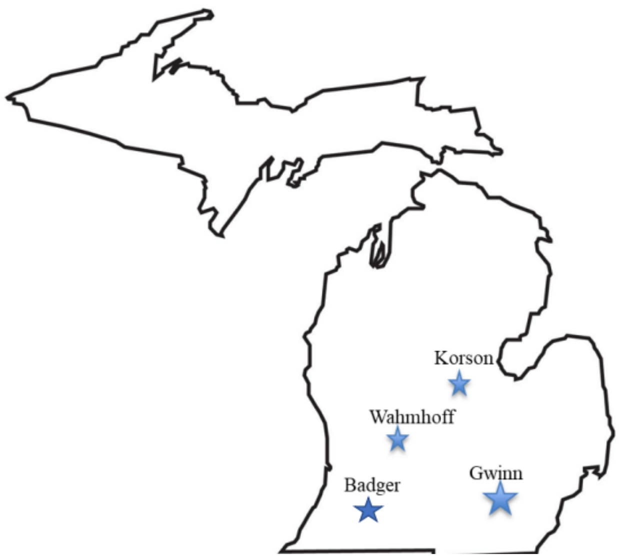

Figure 1. Locations of four cooperating Christmas tree farms in Michigan where field trials were conducted in summer and early fall 2021.

Figure 2. Weed control treatment application at Korson's Tree Farm by Dr. Debalina Saha, MSU Dept. of Horticulture and assisted by grad student, Greta Gallina, MSU Dept. of Horticulture.

Data collection included visual estimations of weed control and phytotoxicity to the trees at 30, 60, and 90 days after treatment (DAT) using a scale of 0% (no control/not phytotoxic) to 100% (complete control/tree death). Also, initial and final growth indices of each tree were calculated by taking average of 2 widths and 1 height of each tree. All data were analyzed in SAS 9.4 by using ANOVA and Tukey's HSD test was used to separate out the means.

Table 1. List of twelve weed control treatments that were applied to each field

Treatments	**Rate of application (highest labeled rate)**
Clopyralid	0.58 L Ha^{-1}
Glyphosate	1.9 L Ha^{-1}
Oxyfluorfen	4.6 LHa^{-1}
Oxyfluorfen + Glyphosate	4.6 LHa^{-1} + 1.9 L Ha-1
Clopyralid + Oxyfluorfen	0.58 L Ha-1 + 4.6 LHa^{-1}
Clopyralid + Glyphosate	0.58 L Ha-1 + 1.9 L Ha-1
Mulch only	5cm depth 0.3m diameter
Mulch + Oxyfluorfen + Glyphosate	5cm depth 0.3m diameter + 4.6 LHa^{-1} +1.9 L Ha-1
Mulch + Clopyralid + Oxyfluorfen	5cm depth 0.3m diameter + 0.58 L Ha-1 + 4.6 LHa^{-1}
Mulch + Clopyralid + Glyphosate	5cm depth 0.3m diameter + 0.58 L Ha-1 + 1.9 L Ha-1
Clopyralid + Oxyfluorfen + Glyphosate	0.58 L Ha-1 + 4.6 LHa^{-1} + 1.9 L Ha-1
Control (no herbicides, no mulch)	

Greenhouse Experiment: To achieve objective 3, a greenhouse experiment was conducted at the Horticulture Teaching and Research Center, Michigan State University in summer 2021 and summer 2022. In this trial, 1 pt. square nursery plastic containers were filled with substrate

(Suremix: 70% peatmoss, 21% perlite, 9% vermiculite) amended with osmocote controlled release fertilizer. Then they were subjected to 0.5 inches of irrigation inside the greenhouse. After one day, 20 seeds of clopyralid resistant common ragweed were sown in each container and grown for two different stages (stage 1: 6-9 leaves and stage 2: 10-14 leaves) (Fig 3). The clopyralid resistant common ragweed seeds were obtained from MSU Plant and Pest Diagnostic Center. All twelve weed control treatments (listed in table 1) were applied to each stage. There were 4 replications per treatment in each stage. All pots were arranged in a complete randomize design in the greenhouse. All herbicides and their combinations were applied uniformly with a CO_2 backpack sprayer calibrated at 27 gallons/acre output. The organic mulch used was the shredded cypress mulch.

Data collection included visual estimation of clopyralid resistant common ragweed at 2, 4, 6, weeks after treatment (WAT) at a scale rating 0% (no control) to 100% (complete control, total death). At 6 WAT the fresh weights of the clopyralid resistant common ragweed were recorded. The whole experiment was conducted in summer 2021 and was again repeated in summer 2022. Data collected from both the rounds were combined and then analyzed. Data were analyzed in SAS 9.4 by using ANOVA and Tukey's HSD test were used to separate out the means.

Figure 3. Clopyralid resistant common ragweed growing in the greenhouse before the treatments were applied. Photo credits: Debalina Saha, MSU Horticulture.

Results

Field Experiments:

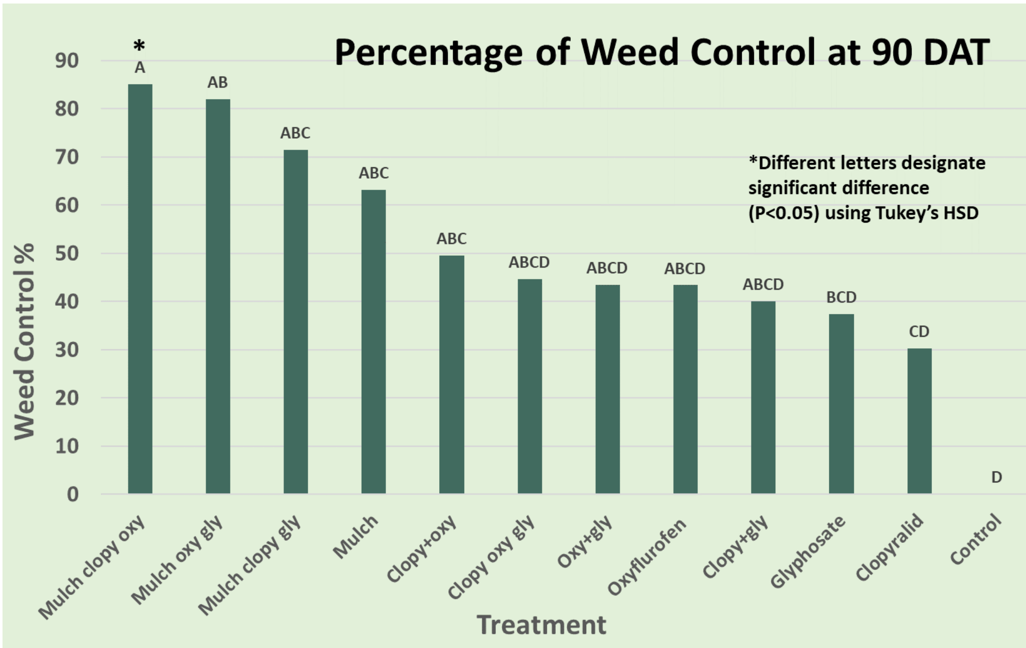

Figure 4: Graphical presentation of weed control percentages at 90 days after treatment for all the Christmas tree farms.

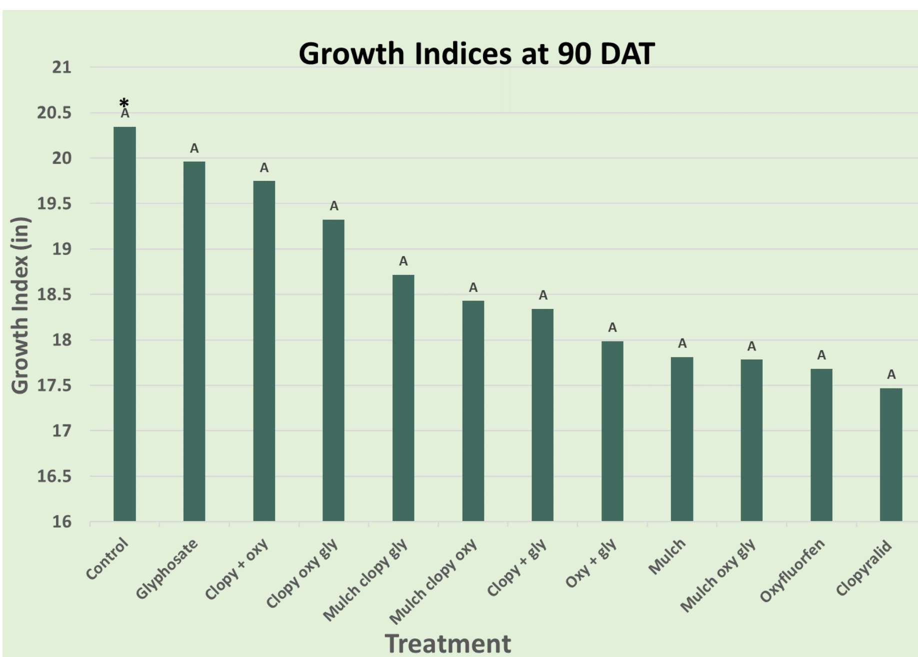

Figure 5: Graphical presentation of growth indices at 90 days after treatment for all the Christmas tree farms.

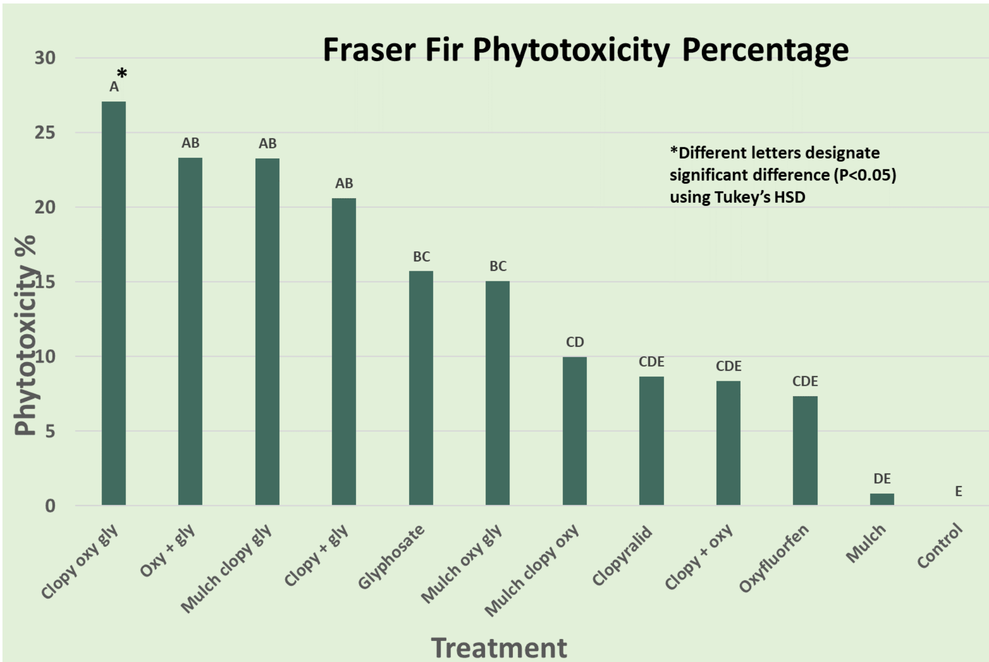

Figure 6: Graphical presentation of phytotoxicity percentage on Fraser fir.

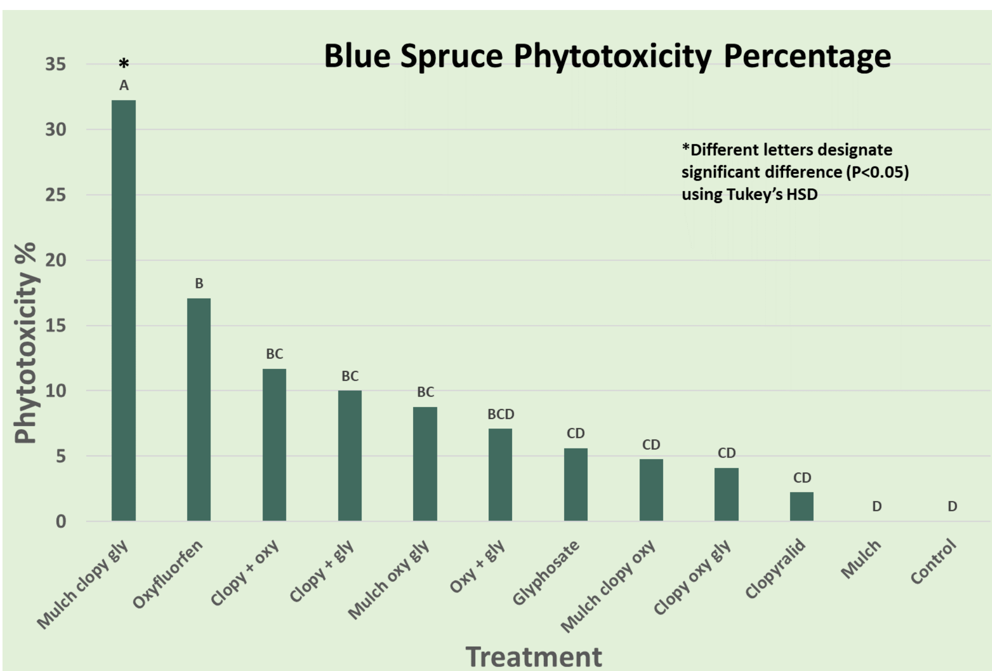

Figure 7: Graphical presentation of phytotoxicity percentage on Blue Spruce.

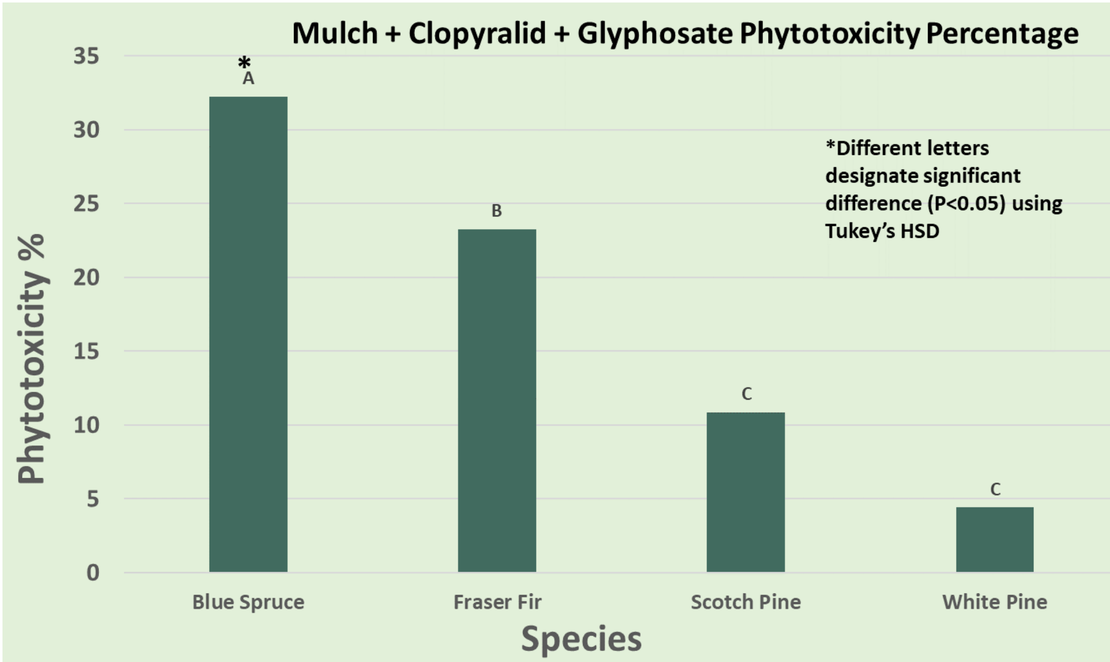

Figure 8: Graphical presentation of phytotoxicity percentage on four different Christmas tree species for the treatment of mulch + clopyralid + glyphosate.

Weed Control: At 90 DAT, when mulch was used either alone or in combination with herbicides, it provided significant weed control ranging from 65% to 85% (Fig 4). Whereas herbicides alone or in combination were able to provide weed control ranging from 30% to 50% (Fig 4).

Growth indices: The data analysis of growth indices showed no significant differences (Fig 5).

Phytotoxicity: Fraser fir had many significantly different levels of phytotoxicity but the most phytotoxic was clopyralid+ oxyfluorfen + glyphosate (Fig 6). All treatments containing glyphosate were more phytotoxic to Fraser fir than those without glyphosate. Blue spruce experienced the most significant phytotoxic effects from mulch + clopyralid + glyphosate and followed by oxyfluorfen (Fig 7).

Among all the twelve weed control treatments, mulch + clopyralid + glyphosate showed the highest phytotoxicity to blue spruce, followed by Fraser fir, scotch pine, and white pine (Fig 8).

Overall, the pines experienced significantly less phytotoxic effects.

Results

Greenhouse Experiment:

Common ragweed stage 1 (6-9 leaves)

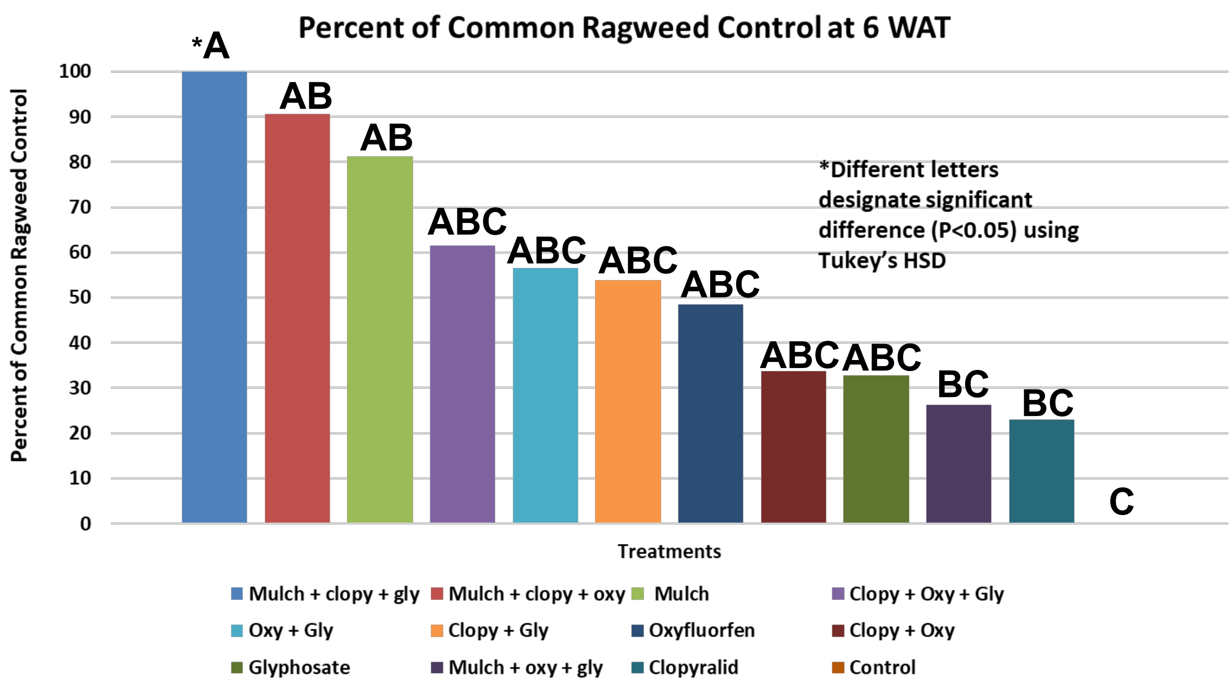

Figure 9: Graphical presentation of greenhouse experiment results for common ragweed stage 1 (6-9 leaves) control.

The data analysis showed that for stage 1 of clopyralid resistant common ragweed, mulch + clopyralid + glyphosate provided maximum control (99.9%) (Fig 9) and mulch + clopyralid + oxyfluorfen and mulch only provided significant and acceptable control (80%-90%) of common ragweed which has become clopyralid resistant.

Common ragweed stage 2 (14-16 leaves)

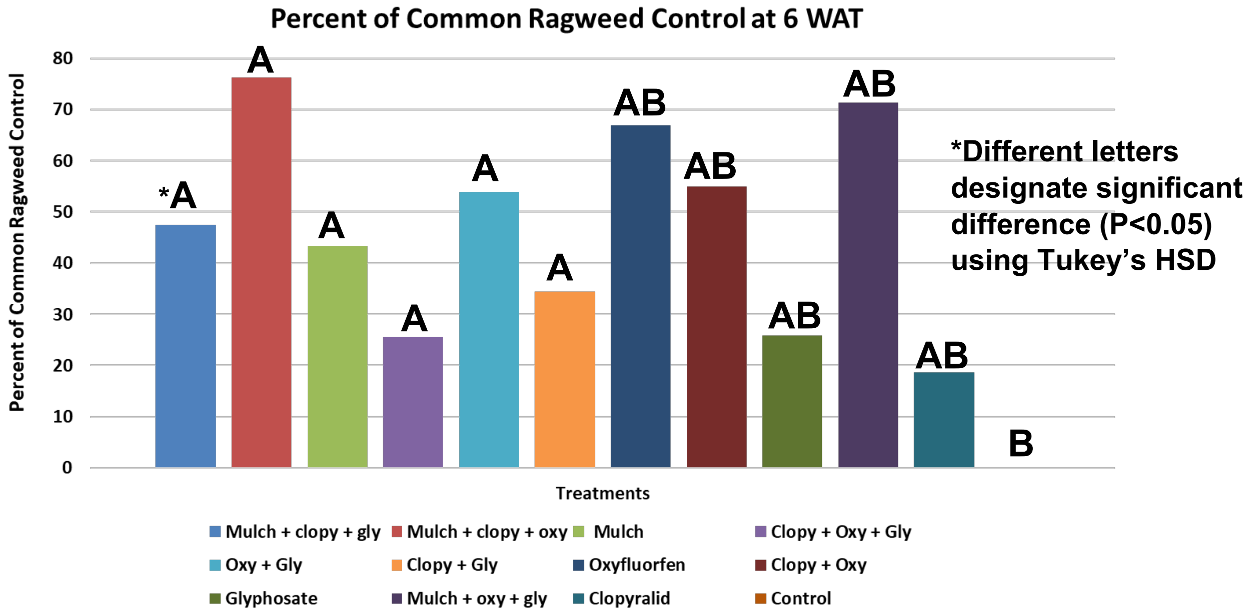

Figure 10: Graphical presentation of greenhouse experiment results for common ragweed stage 2 (14-16 leaves) control.

From the data analysis it was found that mulch + clopyralid + oxyfluorfen combination provided maximum control (76%) followed by mulch + oxyfluorfen + glyphosate (70%) of the 14-16 leaves growth stage of the clopyralid- resistant common ragweed. Mulch alone did not provide an effective control (only 42%).

Conclusions:

Field Experiments: When organic mulch was combined with herbicide combinations, 65%-100% weed control was achieved in all the cases. Whereas herbicides alone or in combination with each other showed only 30%-50% weed control. Combination of mulch + clopyralid + glyphosate was the most phytotoxic to blue spruce and scotch pine. Fraser fir experience the most phytotoxic effects with glyphosate and its combinations. Hence, it is recommendable to combine the organic mulch material with the herbicide combinations for an effective weed control in Christmas tree production. However, the growers need to read the label of the herbicides carefully to make sure it does not cause injury to their Christmas tree varieties.

Greenhouse Experiment: Overall, combination of mulch + clopyralid + oxyfluorfen showed maximum amount of control for both the stages (6-9 leaves stage and 14-16 leaves stage) of common ragweed. So, it can be recommended to the growers to use the combination of mulch + clopyralid + oxyfluorfen to control the clopyralid-resistant common ragweed as alternative strategy.

Based on the results of this project, future research can be focused on studying the phytotoxic effects of different combinations of herbicides on additional species of Christmas trees; herbicidal residual effects on weed control; subsequent year studies for long term effects of organic mulch on weed control and soil characters.

Financial Summary:

Following is the financial summary of the project compared to the budget submitted.

Items	**Actual expenses**	**Expenses mentioned in the budget**
Hourly basis temporary worker	$ 4,939.49	$9,645
Material & supplies	$5,267.41	$6,400
Publication	$1,806	$3,900
Total	$12,012.98	$19,945

Acknowledgement:

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