# TURMERIC EFFECTS ON JACK PINE GROWTH AND ITS SURVIVAL

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NRMT 4010 THESIS

Faculty of Natural Resources Management

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# ABSTRACT

Keywords: Jack pine, Container seedling, Turmeric, Growth, Height, Root Collar Diameter

Efficient forest restoration requires the planting of superior seedlings with optimum development potential. Jack pine is an important species because it helps to maintain the structure and function of ecosystems and provides a habitat for a wide diversity of different types of animals. It has good growth and yield characteristics and is a profitable species for commercial forestry operations. Curcuma longa (turmeric), a member of the Zingiberaceae family, is a perennial plant that originates from Southeast Asia. It has gained widespread popularity and is used in traditional medicinal practices. The application of turmeric extract has been seen to have a positive impact on the development of wheat seedlings. This research aspires to find values of turmeric in the forestry field and hopes to satisfy the question of the impact of turmeric in the growth and survival of jack pine. Jack pine seedlings were grown with 5% of turmeric by weight mixed in with soil, 10% turmeric by weight mixed in the soil, spraying turmeric with 10% concentration mixed in water, 30% turmeric concentration in water sprayed. I hypothesized that when turmeric is added to soil or sprayed with water dilution, it will promote height and diameter growth of jack pine. This hypothesis was rejected because increases in turmeric concentration resulted in lower height and root collar diameter of the seedlings. Possibly, the component curcumin, which is an active ingredient in turmeric, can inhibit the growth of certain plants.

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# ACKNOWLEDGEMENTS

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In conclusion, I would like to express my gratitude to Lakehead University, which gave me the chance to go much further into the subject matter, so increasing the breadth and depth of my knowledge, as well as the ability to apply this information to my understanding of horticulture and forestry.

# 1 INTRODUCTION

Jack pine (*Pinus banksiana*) is common merchantable and ecologically important species in the boreal forest that frequently regenerates after fire disturbance (Rudolph et al. 1990). Jack pine is a commercially significant species of timber often used to produce pulpwood and timber (Zhou et al. 2013), as a result impacts on the availability of reforested jack pine timber may lead to reduced harvest levels and increased costs for forest managers (Ferris et al. 2013). Pulpwood, used in producing paper goods, is one of the essential applications for jack pine (Zhou et al. 2013). Wood is also used in the building industry as timber, which is used for framing, flooring, and panelling, among other things.

In addition, Jack pine is very important to the process of forest regeneration in regions that have been damaged, because of its adaptation to fire disturbance and rapid growth, it is often one of the first trees to establish itself in places that have been logged, burnt, or otherwise disturbed (Venier et al. 2013). This helps to stabilize the soil and provides shelter for other plant and animal species (Venier et al. 2013). Due to its vast range and relatively rapid development, it is an appealing plant for commercial and ecological uses throughout Canada and the northern United states (Ferris et al. 2013). Jack pine forests provide essential habitat for a wide range of wildlife species (Nantel and Gagnon. 1999). Many animals, such as birds, small mammals, and insects, depend on the tree for nesting, foraging, and shelter, for example, the endangered Kirtland's warbler relies heavily on young jack pine stands for nesting habitat (Nantel and Gagnon. 1999). The serotinous cones of jack pine, which require heat from wildfires to release their seeds, also create a unique habitat for certain specialized species adapted to fire-dependent ecosystems (Nantel and Gagnon. 1999).

Jack pine seedlings are frequently container grown in nurseries and then planted in the field once they have reached a suitable size (Kremsater et al. 1999). Production involves sowing seeds in a mix of peat moss, perlite, and vermiculite (Kremsater et al. 1999). The containers are then placed in a greenhouse or other protected environment to ensure adequate moisture and warmth for germination (Kremsater et al. 1999). By producing jack pine seedlings in nurseries, foresters can ensure that the seedlings are healthy and have a greater chance of survival once they are planted in the field (Kremsater et al. 1999). Nursery production also allows foresters to control the growth conditions of the seedlings, which can lead to faster growth rates and more uniform seedling sizes (Kremsater et al. 1999). Improving growth rates may allow for larger seedlings and therefore higher survival rates, faster-growing seedlings have a competitive advantage in acquiring essential resources such as sunlight, water, and nutrients, they can outcompete neighbouring plants and establish a stronger root system, enabling them to access more resources from the environment, this increased resource acquisition enhances their overall health and RCD, contributing to higher survival rates (Coomes et al. 2007).

One option for improving growth of container stock is application of *Curcuma longa* (turmeric), a member of the Zingiberaceae family, is a perennial plant that originates from Southeast Asia and the Indian subcontinent (Soni et al. 2020). Turmeric has gained widespread popularity and has been used in traditional medicinal practices in India and China for centuries (Soni et al. 2020). Curcumin, a constituent of turmeric, is accountable for the spice's vivid yellow hue and its advantageous properties for human health (Lopresti et al. 2021). Curcumin exhibits antioxidative and anti-inflammatory characteristics and has demonstrated potential advantages for diverse health ailments like arthritis, diabetes, and cardiovascular disease (Lopresti et al. 2021).

This research intends to evaluate the potential for turmeric in the forestry field and hopes to satisfy the question: How does application of turmeric impact the height and diameter growth of container jack pine seedlings?

$H_0$- When turmeric is added to soil or sprayed with water dilution, there is no effect on height and diameter growth of container grown jack pine seedlings.

$H_1$- When turmeric is added to soil or sprayed as a water dilution, it will promote height and diameter growth of jack pine seedlings.

$H_2$- When turmeric is added to soil or sprayed with water dilution, it can decrease height and diameter growth of jack pine seedlings

# 2 LITERATURE REVIEW

Efficient forest restoration that uses seedlings requires the planting of superior seedlings with optimum development potential. Planting in container stock is a way to grow plants in containers like plastic pots or compartments before moving them to their final location. Container stock plants are grown in soil or a soilless mix that allows the roots of the seedling grow in a controlled environment and makes it easy to move them to the planting spot (Harris et al. 1993). Nurseries must therefore grow seedlings with plant characteristics that enhance their chances of establishing well in the field. Since the middle of the twentieth century, research foresters have analysed plant characteristics that promote enhanced seedling development under diverse restoration site circumstances (Grossnickle and Macdonald. 2018). Plants that are grown in containers have well-developed root systems, a well-developed root system plays a crucial role in supporting the above-ground growth of seedlings, the roots anchor the plant and provide structural stability, allowing the stem to elongate and the seedling to grow taller, a larger root collar diameter indicates a more substantial root system, which is capable of providing greater support, stability, and nutrient uptake that help them get established quickly in the ground, this can lead to faster and stronger growth than direct seeding (Young and Richard. 2000). Nurseries use a high-quality growing medium and fertilizer regime that provides seedlings with the nutrients and water they need for ideal growth (Harris et al. 1993).

## 2.1 GROWTH

Different growth aspects can result in better seedlings, a seedling's field performance depends on the morphological features because morphological characteristics are maintained for lengthy durations after seedlings have been out-planted (Puttonen 1997). The height and root collar diameter of a seedling have significant implications for its field performance, taller seedlings with larger biomass and more extensive root systems possess a competitive advantage, allowing them to shade out weeds and withstand competition from neighbouring plants (Haase. 2000). Increased height indicates robust growth and RCD, while their extensive root systems enable efficient nutrient uptake and anchorage in the soil, such seedlings tend to exhibit higher survival rates and establish themselves more quickly upon transplantation (Haase. 2000). These plants outcompete surrounding vegetation for light, water, and nutrients, leading to better field performance. Seedlings with a larger root collar diameter have improved drought resistance, as their well-developed root systems can explore a larger soil volume and extract moisture from deeper soil layers, thereby enhancing their resilience to water stress (Haase. 2000). Furthermore, their enhanced root system enables more efficient absorption of nutrients from the soil, resulting in improved growth rates and overall performance in terms of biomass accumulation and quality (Haase. 2000). Therefore, they are regarded as valid indices of seedling quality (Puttonen 1997).

### 2.1.1 HEIGHT

In conifers, seedlings with a more significant initial height have the potential to have a more considerable shoot-system growth in the future. This is because they have a more significant number of branches, buds, and leaves (Campo et al. 2010). As a result, these seedlings have a larger photosynthetically active surface area (Luis et al. 2009). Therefore, the height of the seedlings may be used as a method to determine the health of the seedlings and their capacity to thrive in an environment that is full of competition.

### 2.1.2 DIAMETER

Diameter correlates with seedling weight and the development of the root system, initial stem diameter is often regarded as the most accurate morphological trait for predicting future development. In particular, stem diameter has been shown to correlate positively with seedling weight, which may be considered the total seedling size after nursery growth (Rawat and Singh. 2000). According to one conceptual model, the seedling size was regarded as an essential quality because it considers nutritional reserves, absorption capacity, and competitive ability in connection to field performance (Villar-Salvador et al. 2012). Although competition for light between planted seedlings and other plants is the primary factor restricting development, the size of the shoot system may be crucial in locations where soil water and nutrients are not limiting (Grossnickle 2000). Finally, the diameter of the seedling's stem indicates its robustness and, as a result, helps protect it from the damaging effects of extreme temperatures and drought (Grossnickle 2012).

## 2.2 JACKPINE

The jack pine is an important species because it helps to maintain the structure and function of ecosystems and provides a habitat for a wide diversity of different types of animals (Snyder et al. 2015). The open and irregular crown structure of mature jack pines creates suitable locations for birds like the red-breasted nuthatch, pine warbler, and evening grosbeak to build their nests and find shelter (Corace et al. 2000). Red squirrels, chipmunks, and mice feed on the seeds within the cones, contributing to the dispersal of jack pine seeds throughout the forest, these small mammals also cache cones for later consumption, inadvertently promoting seed dispersal and aiding in forest regeneration (Ahlgren. 1966). The total value of jack pine wood products in Canada is approximately $400 million per year, with sawn wood products accounting for the majority of this value (Hudak et al. 2012). Jack pine is an ecologically important species in fire-prone ecosystems and has significant economic value in the forestry industry (Snyder et al. 2015).

## 2.2.1 JACKPINE ECOLOGICAL VALUE

Jack pine plays an important role in preserving the ecological balance of the boreal forest in the northern part of the United States and Canada by providing a rich habitat for a diverse range of plant and animal species, promoting biodiversity and supporting the interconnectedness of ecosystems (Boulanger et al. 2019). It initiates the process of forest succession, as one of the first tree species to colonize disturbed or open areas, it stabilizes the ecosystem and paves the way for the establishment of other tree species over time, the needles and cones shed by the trees contribute organic matter to the forest floor, which decomposes and releases nutrients back into the soil which increases soil nutrient availability (Orangeville et al. 2013).

The litter produced by jack pine trees, including needles, twigs, and cones, accumulates on the forest floor and microorganisms, such as bacteria and fungi, actively decompose this organic material through enzymatic processes, leading to the release of nitrogen as a by-product (LeDuc et al. 2007). This process, known as litter decomposition, contributes to nitrogen mineralization and the availability of inorganic nitrogen forms (e.g., ammonium and nitrate) in the soil (LeDuc et al. 2007). Through root exudation, jack pine releases organic compounds, including simple sugars, organic acids, and other carbon-based compounds, into the surrounding soil which serve as a food source for soil microorganisms and stimulate microbial activity as microorganisms utilize the exudates and contribute to the decomposition of organic matter and the subsequent release of dissolved organic carbon into the soil (St-Laurent et al. 2017; Zeng et al. 2003). The carbon stored in both aboveground biomass and soil organic matter is more than other tree species as they have a relatively fast growth rate which allows it to accumulate biomass more rapidly, the dense foliage and extensive branching structure of jack pine contribute to its biomass accumulation potential, having a relatively shallow and extensive root system that can cover a large area contributes to the input of carbon into the soil through root exudation which highlights the importance of jack pine in forest carbon cycling (Barr et al. 2014; Zeng et al. 2003).

Bird species, including the endangered Kirtland's Warbler relies on jack pine stands for breeding, because it has specific requirements for nesting and breeding , the dense lower branches of young jack pines between the ages of 5 to 20 years old offer suitable nesting sites and protection from predators, the warbler's breeding habitat also consists of a ground layer of grasses and shrubs that provide cover and support the insect prey they feed on (Peach et al. 2018).

The snags are also used by a wide range of wildlife species, particularly insectivorous species as various insects and arthropods inhabit the decaying wood and once the woodpeckers have completed their nesting cycle, other bird species, such as owls, chickadees, nuthatches, and cavity-nesting ducks, make use of these abandoned cavities for nesting and forage on the insects found within the snag's bark and wood, the availability of insects in snags provide important habitat features and therefore it plays a crucial role in jack pine’s ecological value (Hannon et al. 2007).

### 2.2.2 JACK PINE'S ECONOMIC VALUE

Jack pine has good growth and yield characteristics and is a profitable species for commercial forestry operations (Khasa et al. 2008). It also has good strength properties which makes jack pine a suitable species for structural applications (Jin et al. 2012). Demand for jack pine lumber has also increased in recent years, driven by a growing market for sustainable building materials and increased use in construction applications (Finnie et al., 2019). jack pine has high potential as a source of woody biomass for energy production, and could be an economically viable alternative to traditional fossil fuels (Alonso et al. 2010). use of jack pine residues for bioenergy production could be economically feasible, and could provide an alternative income source for forest owners (El-Lakany et al. 2012). Its bark has potential as a source of tannins which is used in producing vegan leather, and could be a valuable resource for the leather industry (Bertrand et al. 2016).

## 2.3 TURMERIC

A study on tomato plants evaluated the plant growth response to a foliar spray of varying concentrations of turmeric extract (Giri and Mukherjee. 2013). According to the study, tomato plants with a higher concentration of turmeric extract showed the most growth and nutrient absorption (Giri and Mukherjee. 2013). This suggests that turmeric extract could be a beneficial natural supplement for enhancing plant health and growth (Giri and Mukherjee. 2013).

Similarly, (Gill et al. 1999) investigated turmeric's impact on wheat seedlings development, when turmeric extract was mixed into the soil, at different concentrations: 0.1 percent, 0.5 percent, and 1 percent, had a discernible impact on the development, the seedlings that had been given turmeric extract had significantly increased shoot and root length, as well as increased fresh and dry weight and chlorophyll content (Gill et al. 1999). The impact of turmeric extract on seedling development was shown to be concentration-dependent in the research, with the highest concentration (1%) exhibiting the most considerable influence on seedling growth (Gill et al. 1999).

A similar study was conducted by (Singh et al. 2019) evaluating the role of turmeric in modifying wheat response to salination. Seedlings were given varying doses of turmeric extract and stress was induced with salt, characteristics associated with the development of the plant, including photosynthesis and antioxidant defence mechanisms was assessed and the study demonstrated that turmeric treatment considerably boosted wheat plants growth, photosynthesis, and antioxidant defence systems subjected to salt stress (Singh et al. 2019).

The presence of antioxidant compounds in turmeric, particularly curcuminoids, can play a significant role in protecting plants from oxidative stress and enhancing their overall growth and resilience, oxidative stress occurs when there is an imbalance between the production of reactive oxygen species and the plant's ability to detoxify them (El-Bahr. 2013). Environmental factors such as high light intensity, extreme temperature, drought, and pollutants can increase reactive oxygen species production, leading to cellular damage and hindered growth (El-Bahr. 2013). Turmeric's antioxidant compounds scavenge and neutralize reactive oxygen species, preventing the harmful effects of reactive oxygen species on plant membranes, proteins, and DNA by mitigating oxidative stress, when plants are exposed to adverse conditions, such as drought or high temperatures, the production of reactive oxygen species increases, turmeric compounds help mitigate the negative impact of stress, allowing plants to better withstand challenging environmental conditions (El-Bahr. 2013). This enhanced resilience can result in improved growth, survival, and productivity (El-Bahr. 2013; Singh et al. 2019).  Curcuminoids and essential oils are examples of bioactive substances that are found in turmeric and these molecules have been shown to have anti-inflammatory and stress-relieving characteristics, which may be partly responsible for observed growth benefits (Singh et al. 2019).

# 3 MATERIALS AND METHODS

## 3.1 LOCATION

A study was carried out in the greenhouse at Lakehead University under the direction of Keri Pidgen-Welyki, who holds the position of Greenhouse Manager at 48.4211° North and 89.2607° West on October 2022.

## 3.2 MATERIALS AND METHODS

In order to carry out the study, several items, such as organic turmeric *(Curcuma longa)*, seedling trays with six units, jack pine seeds *(Pinus banksiana)*, a measuring tape for determining height, a diameter calliper for determining RCD and soil media.

There were six seedling trays utilized, and each one had 10 portions. The planting was divided into five treatments: the first treatment was control growth of the jack pine seedling the second treatment was soil with 5% of turmeric by weight mixed in it which is 5 gm turmeric in 100 gm of soil, the third treatment was soil with 10% turmeric by weight mixed in the soil, the fourth treatment was spraying turmeric with 10% concentration mixed in water which is 10 gm in 100 ml, the fifth treatment was turmeric of 30% concentration in water sprayed. Organic turmeric was used in all these treatments. After that, seeds of jack pine *(Pinus banksiana)* were sown. In order to eliminate the possibility of biased results, the portions of the plantation were chosen at random to reflect a random plantation. The figure 1 below shows the random plantation in the tray when the experiment was carried out.

| | | | | | |
|---|---|---|---|---|---|
| B | C | C | B | B | A |
| D | D | B | A | D | E |
| B | E | D | C | A | C |
| A | C | A | E | B | E |
| E | A | D | E | C | D |

| | | | | | |
|---|---|---|---|---|---|
| E | B | C | D | A | C |
| B | C | B | C | B | D |
| D | D | D | E | D | E |
| C | A | A | B | C | E |
| E | A | E | A | B | A |

| | | |
|---|---|---|
| A - control | B- 5% in soil | D- 10% in water |
| | C- 10% in soil | E- 30 % in water |

Figure 1- Experimental layout through a randomized plot design. A represents the control, B- 5% in soil, C – 10% in soil, D- 10% in water, E- 30% in water.

Seedling height and RCD were measured at the end of the experiment on the 10th week. The information on the evolution of height and RCD growth data in various media were analysed with ANOVA. In addition, a normality test and a post hoc Tukey test was also carried out, which is used to evaluate whether or not a specific data set has a significant difference, this helped to understand the variation in different treatments.

# 4 RESULTS

## 4.1 GROWTH

The growth of seedlings was examined based on height and RCD. The results indicated that the growth of the control treatment was higher than the turmeric-induced treatments. Turmeric with a 30% concentration in water showed the lowest mean height. On the other hand, 5% turmeric in soil and 10% turmeric in water showed similar results, both outperforming the 10 % turmeric in soil. The RCD was highest in the control treatment but lowest in the 30% in water treatment; the RCD was seen to have proportional results to the height of the seedlings.

### 4.1.1 HEIGHT

The height of seedlings in each medium was measured, and a graph was constructed to compare the average height in each medium. As seen in the following graph, the cumulative height of the control medium was the highest. In contrast, reduction in height can be seen in 5% turmeric in soil and 10% turmeric in soil,  the lowest height recorded was in 30% concentration in water sprayed. However, the average height in that medium was between 2.5 and 3 centimetres (Figure 2).

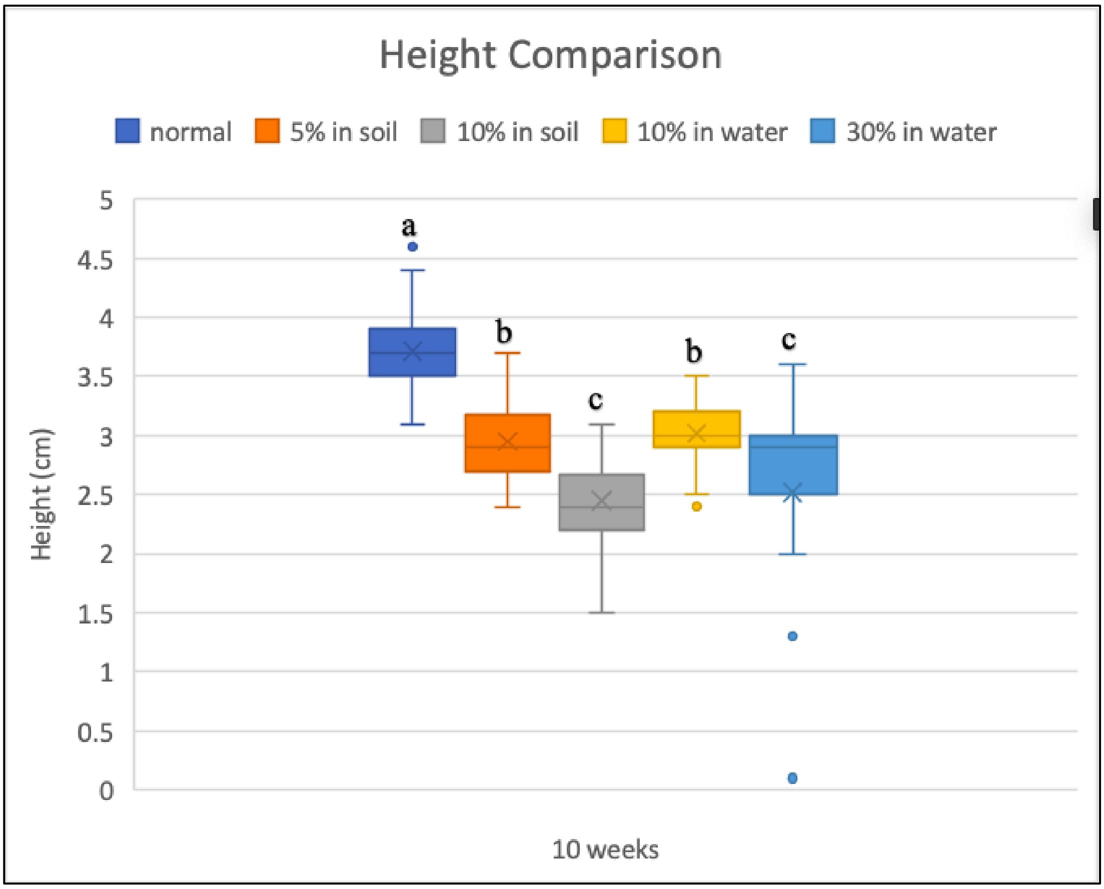


Figure 2- The height growth in the turmeric treatments on the tenth week of the experiment. Significance is indicated by lowercase letters. Like letters indicate statistical insignificance, while different letters indicate statistically significant results.

### 4.1.2 RCD

The root collar diameter was recorded at the end of the tenth week to compare growth at varying levels of turmeric. Figure 3 shows that growth of the seedlings in the control treatment was greater compared to other treatments ($p<0.05$). The 5% soil and 10% concentration in water showed similar results. The 30 % in water showed diebacks and had an average diameter of no more than 0.18 mm.

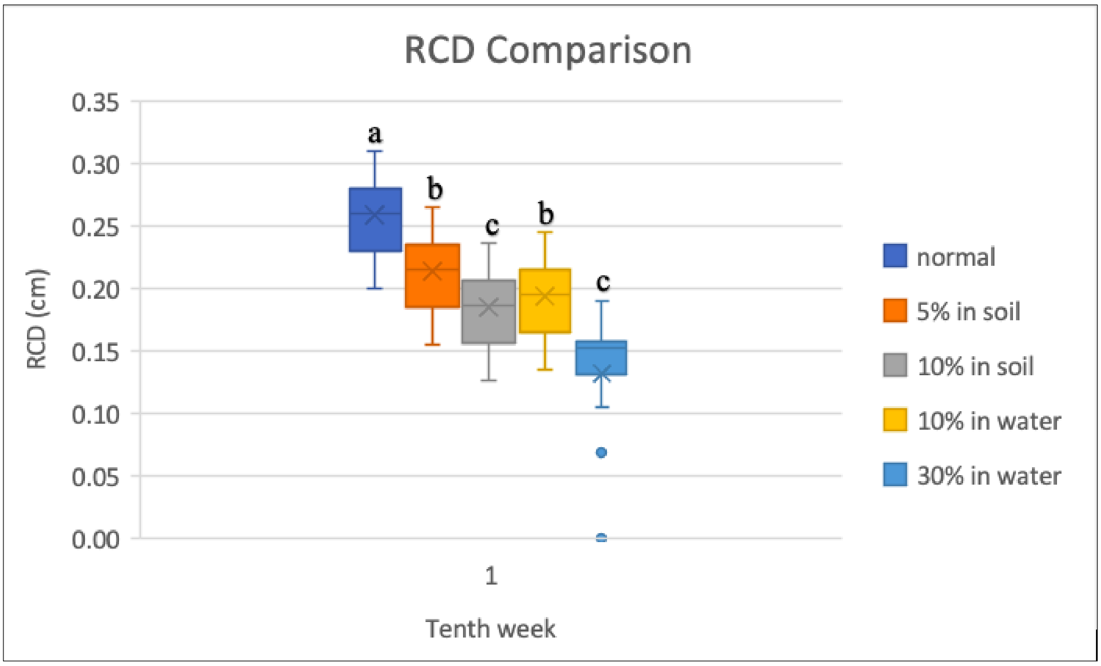


Figure 3- The RCD in the turmeric treatments on the tenth week of the experiment. Significance is indicated by lowercase letters. Like letters indicate statistical insignificance, while different letters indicate statistically significant results.

## 4.2 SURVIVAL

The survival of the seedling was observed in all the treatments, 10 % in soil had stunned growth and presence of fungal growth can be observed. 30% in water treatment had die backs with low growth rate and reduced height and RCD.

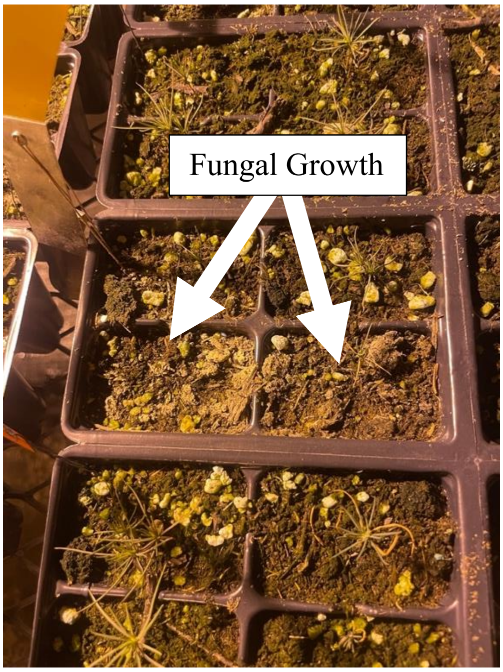


Figure 4- Fungal growth in 10 % turmeric in soil treatment.

Figure 5- The above figure shows dying seedling in 30 % turmeric concentration treatment plot.

## 4.3 STATISTICAL ANALYSES

| | SUMMARY | | | | | |
|---|---|---|---|---|---|---|
| | Groups | Count | Sum | Average | Variance | |
| | control | 48 | 178.3 | 3.71458333 | 0.10552748 | |
| | 5% in soil | 48 | 141.7 | 2.95208333 | 0.10467642 | |
| | 10% in soil | 48 | 144.8 | 3.01666667 | 0.05716312 | |
| | 10% in water | 48 | 144.8 | 3.01666667 | 0.05716312 | |
| | 30% in water | 48 | 120.2 | 2.50416667 | 0.87785461 | |
| | | | | | | |
| | | | ANOVA for height | | | |
| Source of Variation | SS | df | MS | F | P-value | F crit |
| Between Groups | 36.04775 | 4 | 9.0119375 | 37.4752652 | 3.1034E-24 | 2.41005781 |
| Within Groups | 56.5120833 | 235 | 0.24047695 | | | |
| | | | | | | |
| Total | 92.5598333 | 239 | | | | |

Figure 6- ANOVA test for height of all the treatments shows the p value is more than 0.05, stating no effect was observed and means of the groups has no significant difference.

**Multiple Comparisons**

Dependent Variable: height
Tukey HSD

| (I) treatment | (J) treatment | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval Lower Bound | Upper Bound |
|---|---|---|---|---|---|---|
| 1 | 2 | .76250* | .10211 | <.001 | .4818 | 1.0432 |
| | 3 | 1.26667* | .10211 | <.001 | .9860 | 1.5474 |
| | 4 | .69792* | .10211 | <.001 | .4172 | .9786 |
| | 5 | 1.21042* | .10211 | <.001 | .9297 | 1.4911 |
| 2 | 1 | -.76250* | .10211 | <.001 | -1.0432 | -.4818 |
| | 3 | .50417* | .10211 | <.001 | .2235 | .7849 |
| | 4 | -.06458 | .10211 | .970 | -.3453 | .2161 |
| | 5 | .44792* | .10211 | <.001 | .1672 | .7286 |
| 3 | 1 | -1.26667* | .10211 | <.001 | -1.5474 | -.9860 |
| | 2 | -.50417* | .10211 | <.001 | -.7849 | -.2235 |
| | 4 | -.56875* | .10211 | <.001 | -.8495 | -.2880 |
| | 5 | -.05625 | .10211 | .982 | -.3370 | .2245 |
| 4 | 1 | -.69792* | .10211 | <.001 | -.9786 | -.4172 |
| | 2 | .06458 | .10211 | .970 | -.2161 | .3453 |
| | 3 | .56875* | .10211 | <.001 | .2880 | .8495 |
| | 5 | .51250* | .10211 | <.001 | .2318 | .7932 |
| 5 | 1 | -1.21042* | .10211 | <.001 | -1.4911 | -.9297 |
| | 2 | -.44792* | .10211 | <.001 | -.7286 | -.1672 |
| | 3 | .05625 | .10211 | .982 | -.2245 | .3370 |
| | 4 | -.51250* | .10211 | <.001 | -.7932 | -.2318 |

*. The mean difference is significant at the 0.05 level.

Figure 7- Tukey test to compare the variance in height in different treatments and the control treatment. 1 is the control treatment, 2- 5% in soil, 3- 10% in soil, 4-10% in water and 5- 30% in water. There is a no significant difference in treatment 2 and 4, no significant difference was found in 3 and 5 as well. This means 5% in soil and 10% in water had no significant difference and 10% in soil and 30% in water had no significant difference.

| | SUMMARY | | | | | |
|---|---|---|---|---|---|---|
| | Groups | Count | Sum | Average | Variance | |
| | normal | 48 | 12.420378 | 0.25875788 | 0.00051207 | |
| | 5% in soil | 48 | 9.870822 | 0.20564213 | 0.00050794 | |
| | 10% in soil | 48 | 8.18505 | 0.17052188 | 0.00051414 | |
| | 10% in water | 48 | 10.086768 | 0.210141 | 0.00027738 | |
| | 30% in water | 48 | 8.373132 | 0.17444025 | 0.0042598 | |

| ANOVA for RCD | | | | | | |
|---|---|---|---|---|---|---|
| Source of Variation | SS | df | MS | F | P-value | F crit |
| Between Groups | 0.24160069 | 4 | 0.06040017 | 49.7420066 | 2.745E-30 | 2.41005781 |
| Within Groups | 0.28535319 | 235 | 0.00121427 | | | |
| | | | | | | |
| Total | 0.52695388 | 239 | | | | |

Figure 8- ANOVA test for RCD of all the treatments shows the p value is less than 0.05, stating a significant effect was observed among the treatment groups.

# 5 DISCUSSION

We reject the hypothesis $H_0$ that when turmeric is added to soil or sprayed with water dilution, it can promote growth and RCD of jack pine. We accept the hypothesis $H_2$ stating when turmeric is added to soil or sprayed with water dilution, it can decrease growth and RCD of jack pine seedlings.

Increase in turmeric concentration resulted in lower height of the seedlings, this may have been because, curcumin which is an active ingredient in turmeric, can inhibit the growth of certain plants (Raiz et al. 2019). This inhibition can occur through a variety of mechanisms, such as the disruption of the plant's photosynthetic system or the inhibition of certain enzymes involved in plant growth (Raiz et al. 2019). The negative effects of high turmeric concentrations on plant growth can also depend on the specific plant species and the concentration and duration of turmeric exposure (Kaur et al. 2019). Some plants may be more sensitive to turmeric than others, and exposure to high concentrations of turmeric over a longer period of time may have a greater negative impact on plant growth (Kaur et al. 2019).

The results of RCD were similar to the height, this may be indicator of balanced growth, in young jack pine trees, RCD and height are generally positively correlated, meaning that as the height of the tree increases, so does the RCD, this is because in young trees, growth is more rapid and the development of the root system and the shoot system are closely linked (Lapointe and Bradley 2017). As the research was not too long it is difficult to understand the relationship between RCD and height in different turmeric concentration treatments.

Growth of mold can be observed in 10 % in soil treatment which may have been because, even though turmeric has been shown to have antifungal properties against a number of fungal pathogens but it is important to note that while turmeric may have some antifungal effects, it is not a broad-spectrum fungicide and may not be effective against all types of fungi (Chang and  Huang 2019). Studies have found that turmeric may promote the growth of pathogenic fungi under certain conditions. For example, the application of turmeric extract to soil increased the incidence of Fusarium wilt disease in tomato plants (Nakkeeran et al. 2006).

This research differs from other studies on turmeric as in this research turmeric was added by weight in order to understand the function of turmeric when different methods are used to induce turmeric, this research was carried out with conifer which helps to understand the effects of turmeric on growth and RCD of jack pine, adding turmeric by weight to soil can be an effective way to improve for plant growth, but the amount of turmeric to be added will depend on several factors and should be determined based on the specific needs of the soil and plants (Islam et al. 2013).

Wheat and jack pine have different growth habits and specific needs to grow, for wheat it is essential to provide the crop with conditions such as full sun, well-drained soils, and consistent moisture throughout the growing season (Slafer and Rawson 1995). Jack pine is a tree that grows slowly when compared with wheat and lives for many years. It can survive in areas with limited sunlight, poor soil quality, and little water (Tremblay et al. 2003). Wheat is an annual crop that proliferates, so it is essential to ensure it has the necessary resources to thrive (Slafer and Rawson 1995). It is important to note that wheat usually matures within a single growing season (Slafer and Rawson 1995). In contrast, jack pine may take several years to reach maturity and can live for many decades or centuries (Tremblay et al. 2003). Wheat and jack pine have unique growth requirements from their distinct ecological niches. These requirements are a reflection of their specific adaptations to their respective environments (Slafer and Rawson 1995; Tremblay et al. 2003).

More research is needed to fully understand the effects of turmeric on plant growth, as we understand from this research that inducing turmeric at different concentration can impact the growth and yield greatly, As some research shows, turmeric extract can improve the survival and growth of wheat; this can be further examined in conifers to understand the effects of turmeric extract in different species and analyse if turmeric extract can act as a natural fertilizer. In this research, turmeric was used by weight, A low-concentration treatment can be done for further research, and water-holding capacity and root growth can also be examined.

# 6 CONCLUSION

Jack pine is an ecologically and economically essential species; this research showed the negative effects of turmeric on the growth and survival of jack pine. The research was done to understand turmeric effects on jack pine but as the research progressed it was understood that higher concentration can lead to negative effects in jack pine growth. Even though the results did not have a positive outcome, there is still a need for further research to fully understand the effects of turmeric on plant growth and soil health. Most of the research in this area has focused on the use of turmeric extracts or turmeric powder, and there is a need for more studies that investigate the effects of turmeric on different plant species, in different soil types, and under different environmental conditions.

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