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Effects of Soil Types on the Growth and Development of *Amaranthus* var. Durga (IC35407) (Ramdana)

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Abstract: The study examined the impact of soil types on *Amaranthus* var. Durga (IC35407) germination and growth in a laboratory experiment across seven soil types: barren land, cultivated land, pine, quercus, deodar, mixed forest, and populus. The fastest germination occurred on the first day was in populus soil, while no significant differences were found on days 2, 3, and 4. Mean daily germination, seedling lengths, and fresh and dry weights were highest in mixed Forest and populus soil, while lowest in deodar soil. Shoot length was greatest in quercus and mixed forest soil, while the longest root length was observed in mixed forest soil. Cultivated land soil had the highest seed vigor index-I and index-II, while mixed forest and populus soil had the lowest values. Deodar soil had the highest mortality rate, while mixed forest soil had the lowest. These findings provide valuable insights into the cultivation and management practices of *Amaranthus* var. Durga, enhancing the understanding of the crop's growth and cultivation practices.

Keywords: Germination, Soil types, Plant growth, Variability, Vigour Index

Amaranthus var. Durga (IC35407), commonly known as Ramdana, is a highly nutritious and versatile plant that belongs to the Amaranthaceae family. It is an annual herbaceous crop that has gained significant attention in recent years due to its potential as a sustainable food source and its adaptability to different environmental conditions (Das 2016, Kavinila et al 2020). Ramdana is known for its high protein content, essential amino acids, vitamins, and minerals, making it an important crop for addressing nutritional deficiencies and food security challenges (Ruth et al 2021, Alegbejo 2013). The growth and development of any plant species are influenced by various factors, and soil type plays a crucial role in determining the success and productivity of crops (Fageria et al 2008, Tanzin 2018). Soil type refers to the physical and chemical properties of the soil, including texture, structure, fertility, and nutrient composition. Different soil types have distinct characteristics that directly impact plant growth, nutrient availability, water-holding capacity, and root development (Begum 2003, Esmaeilzadeh and Ahangar 2014).

Understanding the effects of soil types on the growth and development of *Amaranthus* var. Durga is vital for optimizing cultivation practices, improving yield, and enhancing overall crop performance. By examining the influence of various soil types on Ramdana, farmers, and researchers can identify the most suitable soil conditions for maximizing production and implementing sustainable agricultural practices (Singh 2009, Zhong et al.2020). The composition and structure of the soil affects plant growth in several ways. The texture of the soil determines its water-holding capacity and drainage characteristics. Sandy soils, for instance, tend to have large particles and drain water rapidly, which can lead to poor water retention and lower nutrient availability for the plants (Bhadha et al 2017). Conversely, clay soils, composed of fine particles, have higher water-holding capacity but may suffer from poor drainage and aeration, potentially causing root rot or other adverse effects on plant growth. Soil fertility is another critical factor influencing plant growth. Fertile soils contain an adequate supply of essential nutrients required for plant development (Jones 2012, Ohshiro et al 2016, Kumar 2018). Nitrogen, phosphorus, and potassium are primary macronutrients that plants require in relatively large quantities. Additionally, micronutrients like iron, zinc, and manganese are crucial for various physiological processes (Maathuis 2009). The availability of these nutrients in the soil greatly affects the growth, yield, and nutritional quality of *Amaranthus* var. Durga.

Furthermore, the pH level of the soil affects the availability of nutrients to the plant. Each plant species has an optimal pH range for growth, and deviations from this range can negatively impact nutrient uptake and utilization. *Amaranthus* var. Durga generally thrives in slightly acidic to neutral soils with pH levels ranging from 6.0 to 7.5. Acidic or alkaline soils can hinder nutrient availability, disrupt root development, and ultimately limit the growth potential of Ramdana. Soil structure, including its aggregation and porosity, influences root penetration, oxygen availability, and the movement of water through the soil profile. Well-structured soils with good aggregation allow roots to penetrate easily, facilitating nutrient and water uptake. The compacted or poorly structured soils can impede root growth, limiting access to nutrients and leading to stunted plant development. The objective of this study is to examine the effects of different soil types on the germination and growth of *Amaranthus* var. Durga (IC35407) (Ramdana).

MATERIAL AND METHODS

Study area: The study was conducted from January to July at University of Horticulture and Forestry, Ranicahuri campus, located in Tehri Garhwal, Uttarakhand. The experimental site is situated approximately 10 km away from Chambaat, at an altitude of about 2100 m above mean sea level. The study area falls within the mid-hill zone of Uttarakhand, positioned between 30°17' N latitude and 78°30' East longitude. During the study period, various abiotic factors influenced the growth and development of *Amaranthus* var. Durga (IC35407) (Ramdana). Temperature played a crucial role, with average temperatures ranging from 7.5°C to 22.5°C [lowest in January and Highest in June]. Precipitation patterns also affected the plants, with an average rainfall of average rainfall during the study period is approximately 76.33 (mm) whereas, with the highest rainfall in the month of July] during the experimental period. Additionally, factors such as sunlight intensity, humidity levels, and soil moisture content contributed to the overall environmental conditions experienced by the plants. These abiotic factors collectively shaped the growth, germination, and physiological responses of *Amaranthus* var. Durga (IC35407) (Ramdana) throughout the study.

Soil collection: In February to March 2021, soil samples were collected from the temperate region. Seven different soils, namely pine soil, deodar soil, cultivated soil, quercus soil, populus soil, barren land soil, and mixed forest soil, were obtained from a depth of 15 to 30 cm below the soil surface. A "V-shaped" cut was made using a spade or similar tool to reach the desired depth at each sampling spot. At least 4-5 samples were collected from each designated sample unit and placed on a newspaper. The collected samples were then thoroughly mixed to ensure homogeneity, and any foreign materials such as roots, stones, pebbles, and gravel were removed. The bulk volume of the samples was reduced using the quartering method. This involved dividing the thoroughly mixed sample into four equal parts, discarding two opposite quarters, and re-mixing the remaining two quarters. This process was repeated until the desired sample size was obtained. The collected soil samples were carefully placed in poly bags for further analysis.

Germination and growth: For the germination experiment, 10 seeds of *Amaranthus* were sown in each Petri plate, with three replications. The soil from each sample was evenly distributed in the Petri dishes, ensuring consistent seed placement. For the speed germination analysis, the number of seedlings emerging from the seeds in the petri dish was counted daily from the day of planting until germination was complete. The germination percentage was calculated using the formula: GP = (seeds germinated/total seeds) x 100. The germination rate was determined by calculating GP at different time intervals after planting and plotting the data. Mean daily germination was calculated by dividing the final germination by the number of days from sowing to the end of the test period. The speed of germination was determined by identifying the peak value, which represents the maximum mean germination reached during the test period. The seedling length was measured by randomly selecting five seedlings from each replication and recording their lengths in centimeters. The average length of these seedlings was calculated. The seedling's fresh weight was determined by selecting five seedlings, the same ones used for measuring the seedling length and recording their fresh weights in milligrams. For seedling dry weight measurement, the selected seedlings were dried in a hot air oven at 60°C for 24 hours, cooled in desiccators, and then weighed on an electronic balance. The average weight of dried seedlings from each replication was calculated as the dry weight of the seedlings in milligrams. Moisture percentage was calculated using the formula: Moisture percentage = (fresh weight of the seedling – dry weight of seedling) / fresh weight of the seedling × 100. The seed vigor index was assessed by multiplying the standard germination percentage by the average seedling length for Seed Vigor Index I, and by multiplying the standard germination percentage by the average seedling dry weight for Seed Vigor Index II. The mortality rate was determined by subtracting the initial germination from the final germination and dividing it by the initial germination.

Statistical analysis: The statistical analysis of the data was performed using STPR-3 Software. This software package offers a comprehensive range of statistical tools and techniques to analyze and interpret experimental results. The collected data on various parameters such as speed germination, germination percentage, mean daily germination, seedling length, seedling fresh weight, seedling dry weight, moisture percentage, seed vigor index, and mortality rate were input into the STPR-3 Software for further analysis.

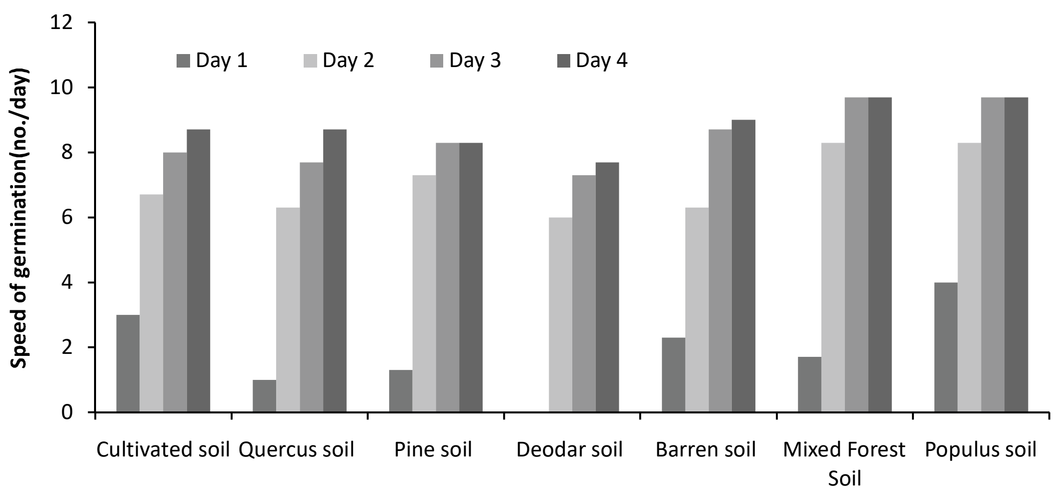
RESULTS AND DISCUSSION

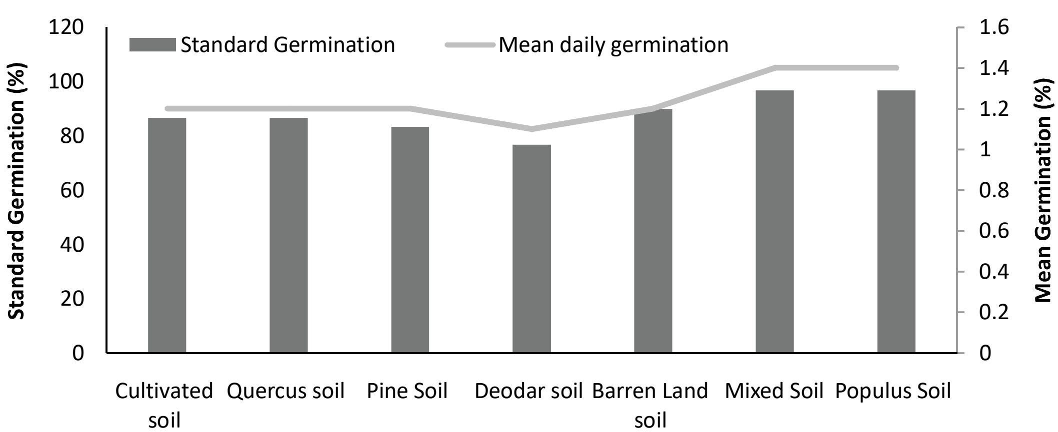
Speed of germination: There were significant differences among the different treatments on the first day, with the highest speed of germination observed in populus soil, which was comparable to barren land soil. From the second to the fourth day, there were no significant differences among the treatments, and the highest speed of germination was observed in mixed forest soil and populus soil, while the lowest was in deodar soil. There was a highly significant interaction between seed depth and soil type, and plant growth was higher in the lighter soils.

Mean daily germination and standard germination: The standard germination of Amaranth showed no significant difference among the treatments, with the highest germination observed in mixed forest soil and populus soil, and the lowest in deodar soil. The mean daily germination also showed no significant difference among the treatments, with the highest mean daily germination observed in mixed forest soil and populus soil, and the lowest in deodar soil (T_4). Kavinila et al (2020) also reported maximum germination of 83% and a minimum of 72% in *Amaranthus*.

Shoot, root, and seedling length: Shoot length showed a significant difference among the treatments, with the highest shoot length observed in quercus soil and mixed forest soil, which was comparable to pine soil. Root length showed no significant difference among the treatments, but the highest root length was observed in mixed forest soil, while the lowest was in barren land soil and cultivated soil. Seedling length showed a significant difference among the treatments, with the highest seedling length observed in mixed forest soil, which was comparable to deodar soil, and the lowest in cultivated soil. Similar results were reported by Kavinila et al. (2020) in *Amaranthus.*

Seed vigour index-I, seed vigour index-II, moisture content, mortality rate, fresh and dry weight: Fresh weight and dry weight showed a significant difference among the treatments, with the highest values observed in populus soil and mixed forest soil, and the lowest in cultivated soil.





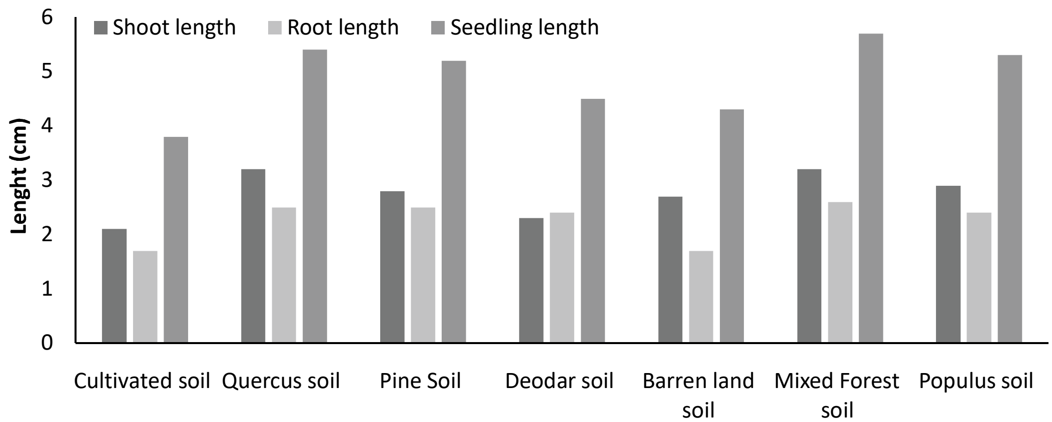


Table 1. Effect of different soil types on daily germination, shoot length, root length, and seedling length

Treatments	Day 1 (cm)	Day 2 (cm)	Day 3 (cm)	Day 4 (cm)	Standard Germination (%)	Mean daily germination (%)	Shoot length (cm)	Root length (cm)	Seedling length (cm)
Cultivated soil	3	6.7	8	8.7	86.7	1.2	2.1	1.7	3.8
Quercus soil	1	6.3	7.7	8.7	86.7	1.2	3.2	2.5	5.4
Pine soil	1.3	7.3	8.3	8.3	83.3	1.2	2.8	2.5	5.2
Deodar soil	0	6	7.3	7.7	76.7	1.1	2.3	2.4	4.5
Barren soil	2.3	6.3	8.7	9	90	1.2	2.7	1.7	4.3
Mixed forest soil	1.7	8.3	9.7	9.7	96.7	1.4	3.2	2.6	5.7
Populus soil	4	8.3	9.7	9.7	96.7	1.4	2.9	2.4	5.3
CD (p=0.05)	1.1381	0.8224	0.8039	0.6189	6.1394	0.0971	0.3594	0.3311	0.5921
CV	0.6477	0.1265	0.1024	0.0758	0.0753	0.0845	0.1417	0.1586	0.1310

Table 2. Effect of different soil types on fresh weight, dry weight, moisture content, seed vigour index and mortality rate

Treatments	Fresh weight (gm)	Dry weight (gm)	Moisture content (%)	SVI I	SVI II	Mortality rate (%)
Cultivated soil	31.7	2.3	91.6	328.7	205.3	3.1
Quercus soil	48.9	3	93.9	456.7	171.3	0.7
Pine soil	65.8	8.9	87.8	444.7	816.7	1.8
Deodar soil	58.4	6.1	90.2	349.3	521.3	0
Barren land soil	61.2	7.7	87.1	384.3	707.3	4
Mixed forest soil	66.1	80	88.2	554.7	769	6.4
Populus soil	94.1	13.4	85.8	512.3	1307.3	1.5
CD (p=0.05)	16.23	23.87	2.42	71.69	335.36	1.88
CV	0.29	1.49	0.03	0.18	0.56	0.81

The moisture content of seedlings showed no significant difference among the treatments, but the highest moisture content was observed in quercus soil, while the lowest was in populus soil. Seed vigour index-I showed no significant difference among the treatments, with the highest index observed in mixed forest soil and the lowest in cultivated soil. Seed vigour index-II showed a significant difference among the treatments, with the highest index observed in populus soil and the lowest in quercus soil. The mortality rate showed a significant difference among the treatments, with the highest rate observed in mixed forest soil, comparable to barren land soil, and the lowest in deodar soil. Aufhammer et al (1994) reported that Amaranth emergence was highest in loamy clay soil with 12% moisture while decreasing soil moisture to 5% inhibited emergence. The nature of the soil surface, such as soil crusting, also had a strong impact on Amaranth's emergence.

CONCLUSION

Mixed forest soil and populus soil performed well across various germination and growth parameters, while deodar soil and cultivated soil exhibited lower rates. These findings provide valuable insights for optimizing agricultural practices and selecting suitable soil types to enhance the productivity of *Amaranthus* crops. Further research is needed to explore additional factors influencing growth and development, such as nutrient availability, pH levels, and environmental conditions. Understanding these factors can contribute to the development of targeted cultivation strategies and improve the overall success of *Amaranthus* cultivation.

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