The Effect of the Amount of Water on Seed Germination

Planting Science – Group #3

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[1]Valley Stream North High School

Introduction

Seed germination is the initiation of the first phase of development in the lifecycle of plants and is followed by the after germinative growth of the seedling. It is a complex process during which the mature seed continues to grow and shifts from the phase of maturation to the phase of germination development then followed by seedling growth (Wolny, Betekhtin and Rojek). The process of seed germination is related with many metabolic, cellular, and molecular events, coordinated by a complex regulatory network (Hernández, Diaz-Vivancos and Barba-Espín). It is the beginning stage of a plant's life and is a three-phase process. The first phase is inhibition in which the seeds absorb water, and the hydrolysis process takes place (Haj Sghaier, Tarnawa and Khaeim). Seed inhibition is a result from the interactions between proteins, carbohydrates, and lipids, and variations in their quantities can affect the process (Haj Sghaier, Tarnawa and Khaeim). The second phase is the regulation of germination, indicated by the activation of ATP synthesis in glycolysis, the Krebs cycle, the respiratory chain, and the translation of stored mRNA (Haj Sghaier, Tarnawa and Khaeim). The third phase illustrates the completion of germination, when the radicle protrudes from the seed coat and forms a root, and the plumules form a shoot system capable of using inorganic matter, water, and light energy for healthy growth (Haj Sghaier, Tarnawa and Khaeim). Abiotic factors such as drought, light, salinity, seed burial depth, soil pH, and temperature as well as disturbance events such as a fire, flooding or tillage has a significant role in initiating or discouraging seed germination (Humphries, Chauhan and Florentine). Water is considered the primary germination regulator because for germination to take place sufficient moisture must be present. A lack of water availability is the primary limitation affecting seed germination, for it is necessary for enzymatic reactions and the mobilization of the seed storage reserves, including lipids, carbohydrates, and proteins, which is why the consumption of the soil water content influences seed inhibition (Haj Sghaier, Tarnawa and Khaeim). Temperature is also a critical environmental factor in seed germination because the pace and rate of germination which controls water absorption can be affected by the temperature below or above optimal range. Research studies showed that the number of germinated seeds increases linearly as the temperature rises to an optimal level and then decreases linearly as the temperature exceeds the limit, and showed that low temperatures reduce the activity of enzymes and slow down food mobilization, limiting the metabolic processes necessary for germination and development (Haj Sghaier, Tarnawa and Khaeim). Water and temperature stresses are the primary constraints on successful crop establishment and the subsequent crop performance therefore understanding how the amount of water can affect the process of seed germination is important.

Methodology

This research study was done using pea seeds in petri dishes with varying amounts of water. It was conducted by 4 High School students in grade 10 taking the Authentic Science Research course and lasted approximately 15 days, from day 0-14, with no data for the weekends (Saturday and Sunday). Prior to the research study, all 16 pea seeds that were used were grouped into 1 petri dish and completely soaked in water for approximately 12 hours, serving as a pre-soak. At the start of the research study, the 16 pea seeds were split into 4 different groups, the fully saturated group, the half-saturated group, the droplets group, and the unsaturated group, and were placed by a window with access to sunlight. Each pea seed in each group was labeled a specific letter once growth was shown, A-D, to keep track of each seed in each group. The pea seeds were studied 5 days a week excluding the weekends, and all measurements were put into an Excel file throughout the study correlating to the correct day, group, seed, and if it was the length of the radical or sprout.

Figure 1: All 16 pea seeds grouped together in a 12-hour pre-soak prior to the study.

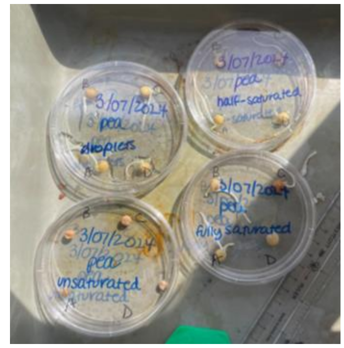

Figure 2: Labeled pea seeds on day 3.

Day	Treatment Type	Seed	Radical Growth Length (mm)	Sprout Growth Length (mm)
0	Full Saturated	A	0	0
0	Full Saturated	B	0	0
0	Full Saturated	C	0	0
0	Full Saturated	D	0	0
0	Half-Saturated	A	0	0
0	Half-Saturated	B	0	0
0	Half-Saturated	C	0	0
0	Half-Saturated	D	0	0
0	Droplets	A	0	0
0	Droplets	B	0	0
0	Droplets	C	0	0
0	Droplets	D	0	0
0	None	A	0	0
0	None	B	0	0
0	None	C	0	0
0	None	D	0	0

Table 1: The Excel file on day 0.

The 4 groups of pea seeds had constant amounts of water added throughout the study and had different amounts of water in each group, with the water being measured using a graduated cylinder in milliliters. The fully saturated group was watered with 20ml of water, the half-saturated group was watered with 10ml of water, the droplets group was watered with 2ml of water, and the unsaturated group was watered with 0ml of water. Each group was watered each day the study was conducted (5 days a week) from the start to the finish of the entire study (day 0-14) with normal tap water at room temperature.

Figure 3: Watered pea seeds on day 0

All 16 pea seeds were measured based on their radical length and their sprout length, using a clear ruler measured in millimeters. The radical length measurements started on day 0, whilst the sprout length measurements started on day 5. When the seeds started showing measurements greater than 0, each seed in the petri dish was labeled and all measurements were put in the Excel file. Once day 7 arrived, and at least one out of the 16 seeds reached a length in which it was pushing the lid of the petri dish up, the lids were removed and only the base of the petri dish remained, to give space for the growth of the radicals and sprouts.

Figure 4: Measuring a pea seed.

Results

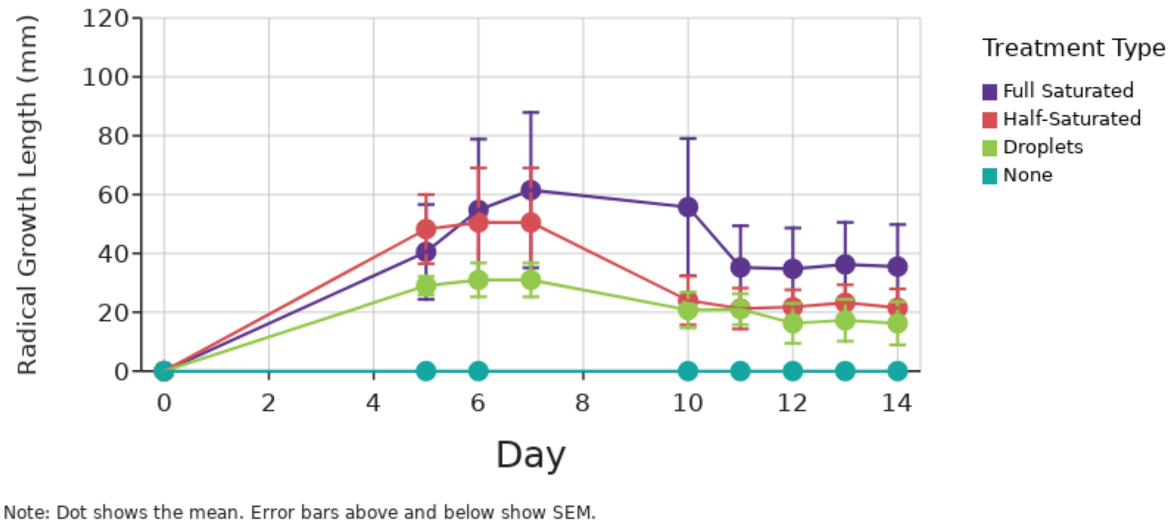

Figure 5: Radical Growth over Time for Each Treatment Type

	r^2	Degrees of Freedom (df)	Slope	Std. Error (SE)	T-Score (Slope / SE)	P-value	Interpretation of P
Day	0.00263	138	0.32	0.531	0.6	0.55	A P-value of **0.55** means **no evidence** that there is a relationship.

Table 2: P-value Analysis

The purpose of the experiment was to identify how varying amounts of water affect sprout and radical growth. It was found that the seeds with no water in the petri dish did not grow at all. Except for Day 5 when the half-saturated seeds had more radical growth, the fully saturated seed radicals were consistently of greater length compared to the rest, reaching their greatest length at 60mm (millimeters) on Day 7. The half-saturated seeds reached a length of 45mm and the droplets reached 26mm. The fully saturated seeds were steadily growing from Day 0 to Day 7, while the half-saturated and the seeds with droplets leveled out at Day 6. After these days the seed growth began to decline and then steadied on Days 12 through 14.

Discussion

The results of this experiment were generally unexpected. The authors predicted that either the half-saturated or fully saturated seeds would be most successful yet were surprised to find that the half-saturated did not beat out the fully saturated. It was predicted that the half-saturated seeds would thrive because the fully saturated seeds would have been overwatered and ultimately drowned in the water. Yet, this was not the case as the fully saturated seed radicals were continuously longer than of the half-saturated ones. Thus, it is evident that seeds that are just slightly submerged under water (fully saturated) grow most successfully. During the latter half of the experiment, the authors noticed a decline in growth. This growth decrease is a possible outcome of the removal of the dish lids. Since the radicals were pushing the lid up, it was removed to allow the radicals more freedom. When the lidless petri dish was placed near the windows, the seeds were exposed to new levels of direct sunlight, possibly drying them out.

The p-value analyzed for this data was 0.55. When the p-value is below 0.05 there is a clear relationship between the variables studied. However, the p-value analyzed for this data was 0.55, so there is no evidence that a relationship between water levels and radical growth is present. There are several other limitations to the study which include a small sample size of 16 seeds, the lack of data collection on Saturdays and Sundays, and the short experimentation period. Still, the water was replaced each day at the same time (about 12 p.m.), proving consistency throughout the experiment. In future studies, the authors recommend experimenting with a larger sample size such as 16 seeds per water level. This could potentially correct the high p-value, validating the relationship between water levels and radical growth. Additionally, subsequent studies can replace the Petri dishes with cups of soil to provide nutrients for the seeds and store the water. This would prevent the seeds from drying out when placed in direct sunlight. To understand how this study can be applied to farmers, placing the seeds in the soil would also allow for better emulation of farmland.

Conclusion

In conclusion, this study conducted on the saturated seeds showed that contrary to expectations, the fully saturated seeds outperformed the half-saturated seeds. Thus, indicating that seeds slightly submerged in water were most successful. The analysis yielded a p-value of 0.55, indicating no significant relationship between water levels and radical growth, likely due to limitations such as the small sample size, lack of weekend data collection, and short experimentation period. We suggest that seeds should be fully saturated when watered for optimal radical and sprout growth. This study helps the community as it shows the results of different saturated seeds which correlate to drought levels. It shows how drought can affect plant growth in nearby communities. Finally, future studies could benefit from a larger sample size and using cups of soil to provide nutrients, so that the community may be better prepared for the effects of drought and water levels on seed germination.

Bibliography

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