

## Prize Winner

# Scientific Inquiry

# Year 7-8

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Department of Defence







# The Effect of Climate Change on Seed Germination and Plant Growth

How does pH and water affect seed germination and plant growth in the context of climate change?

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0445-012



#### **Scientific Report**

#### <u>Title</u>

The Effects of Climate Change on Seed Germination and Plant Growth

#### **Research Question**

How does pH and water affect seed germination and plant growth in the context of climate change?

#### **Background information**

Seed germination is the fundamental embryonic phase of the plant life cycle that influences plant yield and quality (Science Facts, 2019; Tuan, 2014). Under optimal extrinsic and intrinsic conditions, a complex interplay of metabolic and cellular activities allows mature seeds to break dormancy and germinate through the development of the embryo axis into a seedling, as evidenced by the protrusion of the plumule and radicle (Tuan, 2014). Being genetically, physically, and chemically divergent, different seeds prefer different germination conditions (Tuan, 2014).

Once sufficient imbibition of water by the embryo is achieved, germination of fully developed seeds commences, allowing the activation of enzymes and metabolic processes including mobilisation of food reserves, respiration, and protein synthesis (Ali and Elozeiri, 2017). Seed germination is greatly affected by phytohormones, including gibberellins, which stimulate the enzymatic activities in the seeds and further facilitate metabolic activities such as cell divisions, which are catalysed by enzymatic reactions and expedited by water (Heslop-Harrison, 2022; Tuan, 2014). In the early growth of a plant, seeds typically initiate with the protrusion of the primary root, known as the radicle, or in some species, including coconut, the rudimentary stem, called the plumule, develops first (Figure 1) (Heslop-Harrison, 2022). During the post-germination phases, as the radicles and plumules continue to elongate and cotyledons develop, photosynthesis and energy metabolism promote final seedling establishment (Stivers and Dupont, 2019). When seeds are in conditions that exceed their stress tolerance limit, they remain dormant to maintain their ability to germinate (Tuan, 2014). However, in severe and extreme conditions, cell death may occur, resulting in a disruption in germination and growth.

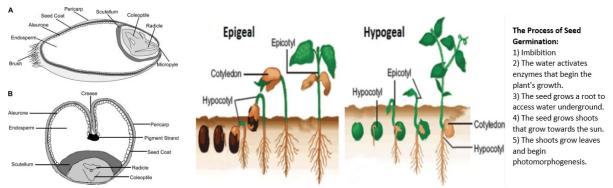


Figure 1a. Structure of a wheat seed (Sethi, 202)

Figure 1b. The process of seed germination (Rathjen and Strounina, 2009)

Climate change is defined as the prolonged changes in temperature and weather patterns on Earth, predominantly caused by the emissions of greenhouse gases. The growth of plants is primarily influenced by extrinsic and intrinsic factors, which are eminently caused by climate change, resulting in greater stress and lower productivity (Hatfield & Prueger 2015). These factors include precipitation, soil pH, temperature, light, nutrients, humidity, UV radiation, and ozone. Climate change inflicts nutrient imbalances through the spread of invasive plants, vulnerability to pests, saltwater intrusion, and altered ecosystem structure (NPS, 2021). Therefore, climate change has been a detrimental stressor and disruption to plant resilience, forest structure, and ecosystems (NPS, 2021). While imposing more frequent and severe extreme weather conditions, including turbulent droughts, hurricanes, and thunderstorms, the rising temperatures have eminently affected soil erosion, organic carbon, nutrients, and alkalinity, therefore influencing plant production and growth or even leading to plant death (Hatfield & Prueger, 2015; Climate change impacts on our soils, 2023).

In this investigation, wheat, lettuce, grass, mung bean, red bean, and chia seeds were selected to investigate the effect of pH and water on seed germination and plant growth in the context of climate change. In experiment 1, seven pH groups were examined against seed germination and plant growth in hydroponics and soil environments. In experiment 2, five water conditions were used. PH formulation can be made using lemon juice, lye water, baking soda, sulphur, and garden lime. Additionally, qualitative and quantitative analyses were conducted to observe the effect of pH and moisture on the plants.

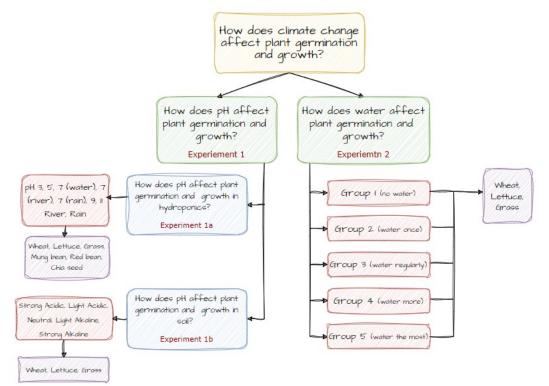
#### <u>Aim</u>

Climate change will affect the pH level and moisture of the soil. This experiment investigates the effect of extrinsic pH levels and water conditions on seed germination and plant growth by measuring the average length and number of germinated seeds of the chosen plants. This investigation also reflects on the impact of climate change on plant germination and growth as well as food production for our society.

#### **Hypotheses**

Hypothesis 1:	If the pH level of the solution is near neutral (pH 7 $\pm$ 10%), the germination of seeds will occur and the average height in plants will be the greatest.
Hypothesis 2:	If the amount of water given to the soil is below or above the optimum
	amount of water, the germination of the plant will be negatively impacted,
	and its growth rate will decrease.

#### **Experiment flowchart**



#### **Variables**

#### **Independent and Dependent Variables**

Independent Variables	Experiment 1: pH levels of solutions and soil
	Experiment 2: Water conditions
Dependent Variables	Plant germination and plant growth measured by number and average
	height of germinated seeds

#### **Controlled Variables**

Controlled variables are to ensure that this experiment is a 'fair test'.

Controlled variables	Method of Control	Reason			
Weight of soil	The same amount of soil is placed in each plastic cup and measured with weighing scale. (50g for experiment 1 and 60g for experiment 2.)	across all samples. Different volume of soil may have varied nutrient supply and affect plant			
Number of seeds in each sample	Each cup is placed with 10 seeds using a tweezer.	Different number of seeds may influence degree of nutrient, solution and oxygen uptake. The number of seeds is controlled to ensure fair test.			

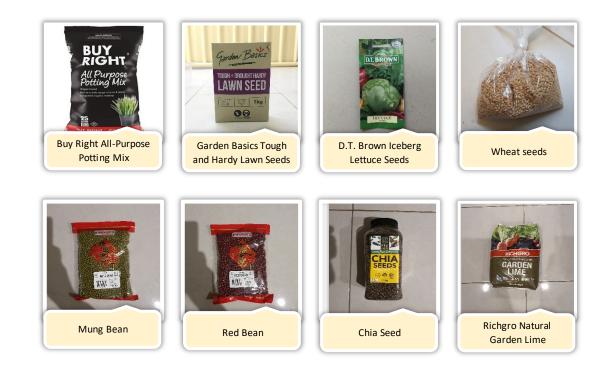
Volume and size of plastic cups Measurement/observation time Environment Weighing scale, ruler, PH test	The plastic cups of the same volume, size and of the same brand are used. The data is collected at the specific time intervals. All the experiments are conducted in the same environment. The temperature range is 8°C to 20°C. The same equipment is	Plastic cups must be of the same size to ensure the same height of soil or solution for fair test. The data must be collected at the same time for fair test. Different environment, such as temperature and humidity, affects plant growth, e.g., Plant enzymes requiring an optimal temperature to function. This is to minimise systematic
strips	used for measurement.	errors and hence improve the accuracy of the data collected.
Number and volume of cotton balls	All cups were placed with only 3 cotton balls. The cotton balls were volumized in the same state.	Different number and volume of cotton balls may affect the rate of plant growth.
Source of plant seeds	The seeds of each type of plants were sourced from the same brand and packet.	Different source of plant seeds has different viability which will affect the rate and quality of seed germination and seedling growth.
Volume of pH solution (for Experiment 1a)	Each cup was measured and placed with 50ml of pH solution using a 10ml syringe.	Water is a factor that results in different plant germination and growth rates. Therefore, volume of pH solution must be controlled for fair test.

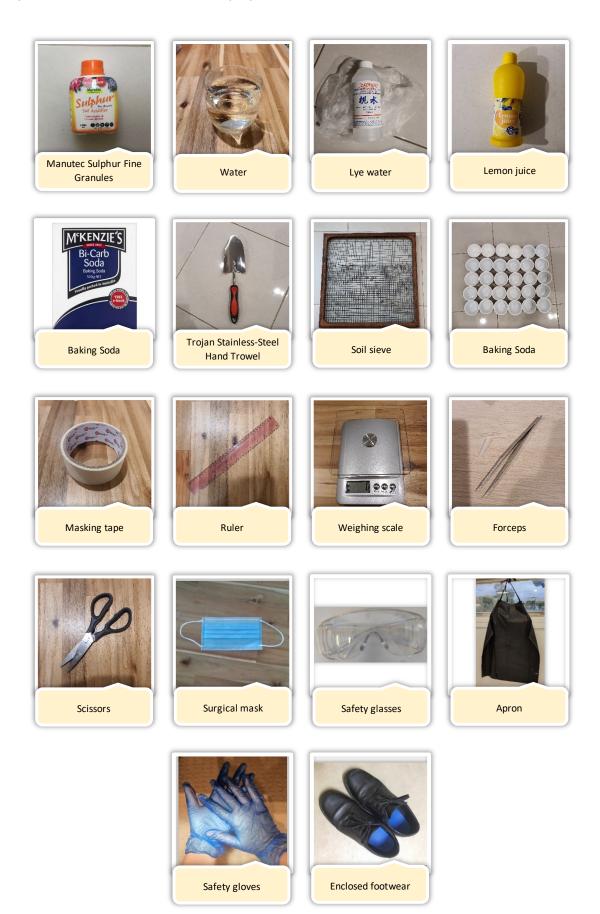
#### **Uncontrolled Variables**

Uncontrolled variables	Reason why it cannot be controlled and its effect on data				
The time lapse between measuring and observation time for each plant for both experiments, and the timing for watering each plant in Experiment 2	The time lapse for measuring and observation for each plant, and watering for each plant is different for merely few minutes since time is consumed when measuring. Its effect on data is insignificant since there is no rapid change in growth rate and number of germinated seeds in that short amount of time.				
The quality of plant seeds	The quality of seeds can be genetically, physically, and chemically distinct from each other. Owing to varying ages, sizes and storage methods of each seed, seeds will have varied viability, manifesting intrinsic errors that affect the reliability of the data.				

#### **Equipment and Materials**

Equipment and Materials (in all experiments)										
Materials		Equipment	Ρ	ersonal Protective Equipment						
540g Buy Right All- Purpose Potting Mix 70 + 50 + 50 Wheat seeds (kernel) 70 + 50 + 50 D.T. Brown Iceberg Lettuce Seeds 70 + 50 + 50 Garden Basics Tough and Hardy Lawn Seeds 70 Mung beans 70 Red beans 70 Red beans 70 Chia seeds Water Manutec Sulphur Fine Granules Richgro Natural Garden Lime Baking soda Lye water 4.78 mol Lemon juice		EquipmentTrojan Stainless-SteelHand TrowelSoil sievePlastic cupsPlastic bagsPlastic traysWeighing scaleRulerScissorsForcepsTraysSyringesPH test tripsGlasses for mixingand storing PHsolutionsBarium sulphateWatch glassUniversal Indicator		Apron Safety glasses Safety gloves Surgical mask Enclosed footwear						





#### **Risk Assessment**

#### **Safety Precautions**

Prudent laboratory safety practices were followed. Chemical contact was avoided by putting on personal protective equipment including an apron, safety glasses, safety gloves, enclosed footwear, and a surgical mask for preventing inhalation of chemicals. Hair was tied back so that hair did not contact with any chemicals. The experiment was handled with care as soil contains living microorganisms including bacteria, fungi and protozoa and can cause irritation in nose, throat and lungs, and illnesses from hay fever, asthma to pneumonia-like illnesses if inhaled (bioaerosols). During observation, personal protective equipment was used to reduce the risk of contamination and biohazards including mould growth. When cutting plastic bags and cardboard, scissors and cutter knives were carefully handled to prevent cuts. The equipment and apparatus used in this experiment were carefully handled to prevent any incidents.

#### **Environmental Consideration**

The experiment was conducted in compliance with the control measures for preparation, usage of laboratory materials and disposal of chemical wastes. There were no significant environmental considerations as the equipment and actions used in this experiment presented no hazard or danger to the environment.

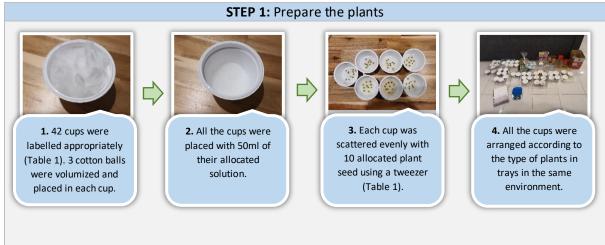
#### **Ethical Consideration**

There were no significant ethical considerations as the equipment and actions used in this experiment presented no harm to society or any individual.

#### Experiment 1: pH

#### **Procedure**

#### **Experiment 1a. Hydroponics**



ble 1a. The cups were labelled. The pH value was obtained by mixing the specific solution wit water using dilution method and measure with PH test strips.									
Experiment 1a.	Amount of solution	Solution							
рН 3	50 ml	1.67% lemon water							
рН 5	50 ml	0.67% lemon water							
рН 7	50 ml	Tap water							
рН 9	50 ml	0.03125% 4.78M lye water							
pH 11	50 ml	2% 4.78M lye water							
Rainwater PH 7	50 ml	Rainwater (from precipitation)							
River water PH 7	50 ml	Surface river water (from Morialta Conservation Park)							

STEP 2: Measure and record data and observations daily

1. The weight of each plant was measured using a weighing scale.



2. The height of each plant was measured using a ruler.



3. The number of germinated seeds of each plant was recorded.

#### **Experiment 1b. Soil**

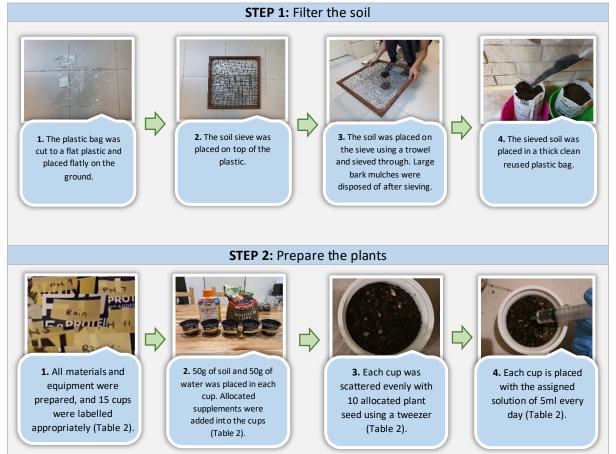


	Table 1b.	The cups were labelled.							
Label	Supplement (Day 0)	Solution (Day 1 to 10)	Solution (Day 11 to 14)						
Strong Acidic	20g sulphur	5ml (10% lemon juice)	5ml (33% lemon juice)						
Light Acidic	nt Acidic 10g sulphur 2ml (10% lemon juice) + 3ml water		2ml (33% lemon juice) + 3ml water						
Neutral	None	5ml water	5ml water						
Light Alkaline	10g garden lime	2ml (4% baking soda water) + 3ml water	2ml (10% baking soda water) + 3ml water						
Strong Alkaline	20g garden lime	5ml (4% baking soda water)	5ml (10% baking soda water)						
 S	TEP 3: Measure and r	ecord data and observat	ions daily						
STEP 3: Measure and record data and observations daily         1. The weight of each plant was measured using a weighing scale.         Image: Constraint of the sector of									

Table 1c. pH values for simulated soil samples impacted by climate change for 3 types of plant seeds were measured on Day 15.

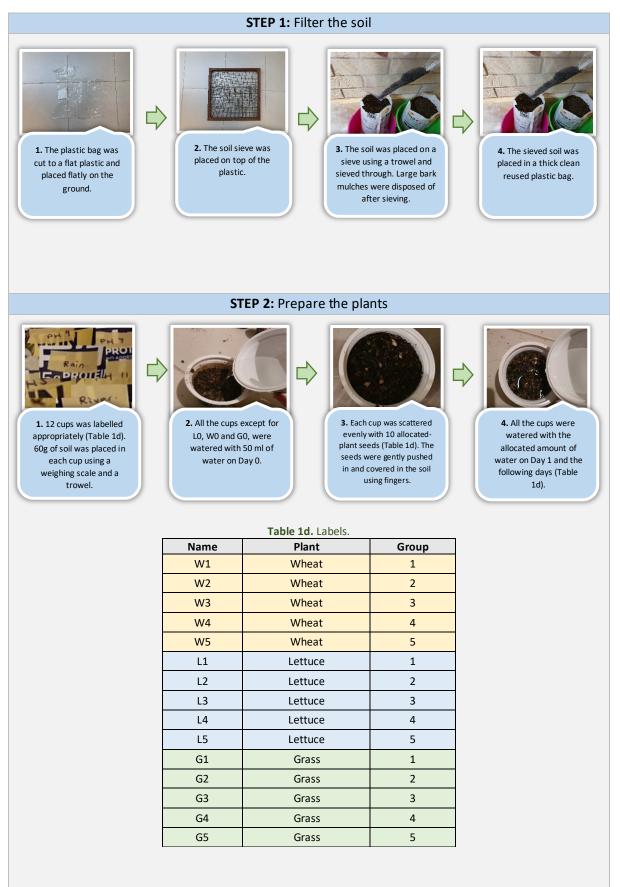
Simulated soil sample	Soil pH for wheat	Soil pH for lettuce	Soil pH for grass
Strong Acidic	6	5.5	6
Light Acidic	6.5	6	6.5
Neutral	7	7	7
Light Alkaline	8	7.5	7.5
Strong Alkaline	8.5	8	8

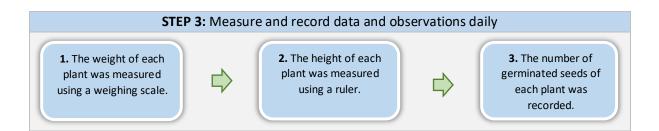
#### **Experiment 2: Water**

#### **Groups and Labels:**

Groups	Water amount	Days of water intake	Total water intake (ml)
Group 1	No water at all.	-	0
Group 2	Water once.	Day 0: 50ml	50
Group 3	Water regularly.	Day 0: 50ml, Day 1, 2 & 7: 15ml	95
Group 4	Water more.	Day 0: 50ml, Day 1, 2 & 7: 30ml	140
Group 5	Water the most.	Day 0 & 1: 100ml	200

#### **Procedure**





#### **Processing and Analysing Data and Information:**

#### Experiment 1a: Wheat (on Day 14)





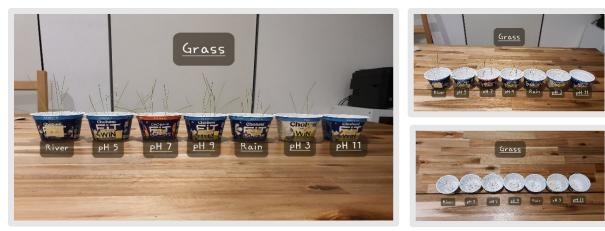






#### Experiment 1a: Lettuce (on Day 14)





#### Experiment 1a: Grass (on Day 14)

Experiment 1a: Mung bean (on Day 14)





Experiment 1a: Red bean (on Day 14)





# <image>

Experiment 1b: Wheat (on Day 14)







Experiment 1b: Lettuce (on Day 14)







#### Experiment 1a: Chia seed (on Day 14)



#### Experiment 1b: Grass (on Day 14)

Figure 2. The plants for observation Experiments 1a and 1b.

#### **Experiment 1**

**Table 2.** Number and average growth rate of 6 types of plant seeds in Experiment 1a during the period of 14 days. Table 2 comprises of Tables 2a to 2f.

**Table 2a.** Number and average length of germinated wheat seeds in Experiment 1a during the period of 14 days.

D		Wheat Growth Rate												
D A	рН 3		pH !	рН 5		water)	pH 7 (rain	water)	pH 7 (river water)		рН 9		pH 11	
у	Avg. Length (mm)	No.												
0	0	<sup>0</sup> / <sub>10</sub>												
1	0	<sup>0</sup> / <sub>10</sub>												
2	2.22	<sup>9</sup> / <sub>10</sub>	4.50	<sup>10</sup> / <sub>10</sub>	2.00	<sup>9</sup> / <sub>10</sub>	3.50	<sup>10</sup> / <sub>10</sub>	4.00	<sup>10</sup> / <sub>10</sub>	2.60	<sup>10</sup> / <sub>10</sub>	2.00	7/10
3	4.89	<sup>9</sup> / <sub>10</sub>	15.00	<sup>10</sup> / <sub>10</sub>	10.40	<sup>10</sup> / <sub>10</sub>	12.90	<sup>10</sup> / <sub>10</sub>	12.50	<sup>10</sup> / <sub>10</sub>	7.10	<sup>10</sup> / <sub>10</sub>	5.10	<sup>10</sup> / <sub>10</sub>
4	5.80	<sup>10</sup> / <sub>10</sub>	9.00	<sup>10</sup> / <sub>10</sub>	11.70	<sup>10</sup> / <sub>10</sub>	12.00	<sup>10</sup> / <sub>10</sub>	14.60	<sup>10</sup> / <sub>10</sub>	12.00	<sup>10</sup> / <sub>10</sub>	4.00	<sup>10</sup> / <sub>10</sub>
5	6.90	<sup>10</sup> / <sub>10</sub>	23.00	<sup>10</sup> / <sub>10</sub>	23.10	<sup>10</sup> / <sub>10</sub>	23.20	<sup>10</sup> / <sub>10</sub>	27.50	<sup>10</sup> / <sub>10</sub>	24.40	<sup>10</sup> / <sub>10</sub>	4.50	<sup>10</sup> / <sub>10</sub>
6	13.00	<sup>10</sup> / <sub>10</sub>	49.50	<sup>10</sup> / <sub>10</sub>	51.50	<sup>10</sup> / <sub>10</sub>	45.50	<sup>10</sup> / <sub>10</sub>	52.00	<sup>10</sup> / <sub>10</sub>	50.20	<sup>10</sup> / <sub>10</sub>	5.90	<sup>10</sup> / <sub>10</sub>
7	18.00	<sup>10</sup> / <sub>10</sub>	74.50	<sup>10</sup> / <sub>10</sub>	76.00	<sup>10</sup> / <sub>10</sub>	71.50	<sup>10</sup> / <sub>10</sub>	77.00	<sup>10</sup> / <sub>10</sub>	77.50	<sup>9</sup> / <sub>10</sub>	8.00	<sup>10</sup> / <sub>10</sub>
8	21.50	<sup>10</sup> / <sub>10</sub>	94.50	<sup>10</sup> / <sub>10</sub>	98.00	<sup>10</sup> / <sub>10</sub>	86.00	<sup>10</sup> / <sub>10</sub>	97.00	<sup>10</sup> / <sub>10</sub>	101.40	<sup>9</sup> / <sub>10</sub>	20.40	7/10
9	26.40	<sup>10</sup> / <sub>10</sub>	112.50	<sup>10</sup> / <sub>10</sub>	109.90	<sup>10</sup> / <sub>10</sub>	100.00	<sup>10</sup> / <sub>10</sub>	112.20	<sup>10</sup> / <sub>10</sub>	126.60	<sup>9</sup> / <sub>10</sub>	20.40	7/10
10	42.30	<sup>10</sup> / <sub>10</sub>	128.00	<sup>10</sup> / <sub>10</sub>	122.50	<sup>10</sup> / <sub>10</sub>	109.80	<sup>10</sup> / <sub>10</sub>	125.70	<sup>10</sup> / <sub>10</sub>	142.00	<sup>9</sup> / <sub>10</sub>	25.60	<sup>7</sup> / <sub>10</sub>
11	52.30	<sup>10</sup> / <sub>10</sub>	134.00	<sup>10</sup> / <sub>10</sub>	128.40	<sup>10</sup> / <sub>10</sub>	111.80	<sup>10</sup> / <sub>10</sub>	130.40	<sup>10</sup> / <sub>10</sub>	150.60	<sup>9</sup> / <sub>10</sub>	25.60	7/10
12	66.00	<sup>10</sup> / <sub>10</sub>	143.00	<sup>10</sup> / <sub>10</sub>	136.40	<sup>10</sup> / <sub>10</sub>	113.00	<sup>10</sup> / <sub>10</sub>	136.50	<sup>10</sup> / <sub>10</sub>	163.90	<sup>9</sup> / <sub>10</sub>	26.30	7/10
13	72.70	<sup>10</sup> / <sub>10</sub>	148.00	<sup>10</sup> / <sub>10</sub>	144.50	<sup>10</sup> / <sub>10</sub>	119.00	<sup>10</sup> / <sub>10</sub>	139.50	<sup>10</sup> / <sub>10</sub>	166.10	<sup>9</sup> / <sub>10</sub>	27.00	7/10
14	72.70	<sup>10</sup> / <sub>10</sub>	148.00	<sup>10</sup> / <sub>10</sub>	151.36	<sup>10</sup> / <sub>10</sub>	112.50	<sup>10</sup> / <sub>10</sub>	145.50	<sup>10</sup> / <sub>10</sub>	171.44	<sup>9</sup> / <sub>10</sub>	29.00	7/10

D		Lettuce Growth Rate												
A	рН 3		рН 5		pH 7 (tap water)		pH 7 (rainwater)		pH 7 (river water)		pH 9		pH 11	
у	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.
0	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
1	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
2	3.00	<sup>10</sup> / <sub>10</sub>	5.00	<sup>10</sup> / <sub>10</sub>	6.00	<sup>10</sup> / <sub>10</sub>	6.00	<sup>8</sup> / <sub>10</sub>	6.00	<sup>10</sup> / <sub>10</sub>	6.00	<sup>10</sup> / <sub>10</sub>	2.00	<sup>4</sup> / <sub>10</sub>
3	7.00	<sup>10</sup> / <sub>10</sub>	8.22	<sup>9</sup> / <sub>10</sub>	10.00	<sup>9</sup> / <sub>10</sub>	10.00	<sup>9</sup> / <sub>10</sub>	10.00	<sup>9</sup> / <sub>10</sub>	10.00	<sup>10</sup> / <sub>10</sub>	2.50	<sup>8</sup> / <sub>10</sub>
4	4.7	<sup>10</sup> / <sub>10</sub>	6.90	<sup>10</sup> / <sub>10</sub>	14.67	<sup>9</sup> / <sub>10</sub>	11.44	<sup>8</sup> / <sub>10</sub>	18.67	<sup>9</sup> / <sub>10</sub>	15.20	<sup>10</sup> / <sub>10</sub>	1.875	<sup>8</sup> / <sub>10</sub>
5	6.00	<sup>10</sup> / <sub>10</sub>	10.80	<sup>10</sup> / <sub>10</sub>	20.00	<sup>9</sup> / <sub>10</sub>	22.75	<sup>8</sup> / <sub>10</sub>	28.11	<sup>9</sup> / <sub>10</sub>	23.33	<sup>10</sup> / <sub>10</sub>	5.00	<sup>8</sup> / <sub>10</sub>
6	6.00	<sup>10</sup> / <sub>10</sub>	22.78	<sup>9</sup> / <sub>10</sub>	41.67	<sup>9</sup> / <sub>10</sub>	36.25	<sup>8</sup> / <sub>10</sub>	41.50	<sup>10</sup> / <sub>10</sub>	37.00	<sup>10</sup> / <sub>10</sub>	5.00	<sup>8</sup> / <sub>10</sub>
7	6.00	<sup>10</sup> / <sub>10</sub>	30.70	<sup>10</sup> / <sub>10</sub>	44.44	<sup>9</sup> / <sub>10</sub>	40.63	<sup>8</sup> / <sub>10</sub>	46.00	<sup>10</sup> / <sub>10</sub>	41.00	<sup>10</sup> / <sub>10</sub>	5.00	<sup>8</sup> / <sub>10</sub>
8	6.00	<sup>10</sup> / <sub>10</sub>	31.20	<sup>10</sup> / <sub>10</sub>	46.67	<sup>9</sup> / <sub>10</sub>	40.63	<sup>8</sup> / <sub>10</sub>	46.00	<sup>10</sup> / <sub>10</sub>	41.00	<sup>10</sup> / <sub>10</sub>	5.00	<sup>8</sup> / <sub>10</sub>
9	5.00	<sup>10</sup> / <sub>10</sub>	34.50	<sup>10</sup> / <sub>10</sub>	47.22	<sup>9</sup> / <sub>10</sub>	40.63	<sup>8</sup> / <sub>10</sub>	46.00	<sup>10</sup> / <sub>10</sub>	41.00	<sup>10</sup> / <sub>10</sub>	5.00	<sup>8</sup> / <sub>10</sub>
10	5.00	<sup>10</sup> / <sub>10</sub>	37.00	<sup>10</sup> / <sub>10</sub>	47.22	<sup>9</sup> / <sub>10</sub>	40.63	<sup>8</sup> / <sub>10</sub>	46.00	<sup>10</sup> / <sub>10</sub>	41.00	<sup>10</sup> / <sub>10</sub>	5.00	<sup>8</sup> / <sub>10</sub>
11	5.00	<sup>10</sup> / <sub>10</sub>	42.50	<sup>10</sup> / <sub>10</sub>	47.22	<sup>9</sup> / <sub>10</sub>	40.63	<sup>8</sup> / <sub>10</sub>	46.00	<sup>10</sup> / <sub>10</sub>	41.00	<sup>10</sup> / <sub>10</sub>	5.00	<sup>8</sup> / <sub>10</sub>
12	5.00	<sup>10</sup> / <sub>10</sub>	42.50	<sup>10</sup> / <sub>10</sub>	47.22	<sup>9</sup> / <sub>10</sub>	40.63	<sup>8</sup> / <sub>10</sub>	46.00	<sup>10</sup> / <sub>10</sub>	41.00	<sup>10</sup> / <sub>10</sub>	5.00	<sup>8</sup> / <sub>10</sub>
13	5.00	<sup>10</sup> / <sub>10</sub>	42.50	<sup>10</sup> / <sub>10</sub>	47.22	<sup>9</sup> / <sub>10</sub>	40.63	<sup>8</sup> / <sub>10</sub>	46.00	<sup>10</sup> / <sub>10</sub>	41.00	<sup>10</sup> / <sub>10</sub>	5.00	<sup>8</sup> / <sub>10</sub>
14	5.00	<sup>10</sup> / <sub>10</sub>	46.50	<sup>10</sup> / <sub>10</sub>	47.22	<sup>9</sup> / <sub>10</sub>	40.63	<sup>8</sup> / <sub>10</sub>	46.00	<sup>10</sup> / <sub>10</sub>	41.00	<sup>10</sup> / <sub>10</sub>	5.00	<sup>8</sup> / <sub>10</sub>

**Table 2b.** Number and average length of germinated lettuce seeds in Experiment 1a during the period of 14 days.

**Table 2c.** Number and average length of germinated grass seeds in Experiment 1a during the periodof 14 day.

D							Grass Grov	wth Rate						
A	pH :	3	pH	5	pH 7 (tap	water)	pH 7 (rair	water)	pH 7 (rive	r water)	pH	9	pH 1	1
у	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.
0	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
1	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
2	0	<sup>0</sup> / <sub>10</sub>	1.00	<sup>2</sup> / <sub>10</sub>	1.00	<sup>5</sup> / <sub>10</sub>	1.00	7/10	1.00	7/10	1.00	<sup>4</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
3	2.00	<sup>3</sup> / <sub>10</sub>	1.00	<sup>10</sup> / <sub>10</sub>	1.70	<sup>10</sup> / <sub>10</sub>	1.86	7/10	1.25	<sup>8</sup> / <sub>10</sub>	1.00	<sup>6</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
4	3.33	<sup>3</sup> / <sub>10</sub>	5.40	<sup>10</sup> / <sub>10</sub>	5.10	<sup>10</sup> / <sub>10</sub>	5.50	<sup>8</sup> / <sub>10</sub>	6.13	<sup>8</sup> / <sub>10</sub>	4.29	<sup>7</sup> / <sub>10</sub>	1.00	<sup>2</sup> / <sub>10</sub>
5	5.80	<sup>5</sup> / <sub>10</sub>	9.90	<sup>10</sup> / <sub>10</sub>	15.90	<sup>10</sup> / <sub>10</sub>	11.80	<sup>10</sup> / <sub>10</sub>	14.11	<sup>9</sup> / <sub>10</sub>	14.10	<sup>10</sup> / <sub>10</sub>	1.00	<sup>2</sup> / <sub>10</sub>
6	13.00	<sup>8</sup> / <sub>10</sub>	28.60	<sup>10</sup> / <sub>10</sub>	39.50	<sup>10</sup> / <sub>10</sub>	33.00	<sup>10</sup> / <sub>10</sub>	28.67	<sup>9</sup> / <sub>10</sub>	38.00	<sup>10</sup> / <sub>10</sub>	1.00	<sup>2</sup> / <sub>10</sub>
7	23.65	<sup>8</sup> / <sub>10</sub>	51.10	<sup>10</sup> / <sub>10</sub>	58.00	<sup>10</sup> / <sub>10</sub>	50.70	<sup>10</sup> / <sub>10</sub>	70.56	<sup>9</sup> / <sub>10</sub>	57.50	<sup>10</sup> / <sub>10</sub>	1.00	<sup>2</sup> / <sub>10</sub>
8	35.13	<sup>8</sup> / <sub>10</sub>	66.30	<sup>10</sup> / <sub>10</sub>	69.00	<sup>10</sup> / <sub>10</sub>	58.20	<sup>10</sup> / <sub>10</sub>	80.22	<sup>9</sup> / <sub>10</sub>	75.30	<sup>10</sup> / <sub>10</sub>	2.80	<sup>5</sup> / <sub>10</sub>
9	49.75	<sup>8</sup> / <sub>10</sub>	82.00	<sup>10</sup> / <sub>10</sub>	89.70	<sup>10</sup> / <sub>10</sub>	70.50	<sup>10</sup> / <sub>10</sub>	100.89	<sup>9</sup> / <sub>10</sub>	90.00	<sup>10</sup> / <sub>10</sub>	2.50	<sup>6</sup> / <sub>10</sub>
10	42.89	<sup>9</sup> / <sub>10</sub>	102.50	<sup>10</sup> / <sub>10</sub>	93.00	<sup>10</sup> / <sub>10</sub>	80.00	<sup>10</sup> / <sub>10</sub>	109.22	<sup>9</sup> / <sub>10</sub>	100.80	<sup>10</sup> / <sub>10</sub>	5.17	<sup>6</sup> / <sub>10</sub>
11	55.78	<sup>9</sup> / <sub>10</sub>	111.40	<sup>10</sup> / <sub>10</sub>	104.00	<sup>10</sup> / <sub>10</sub>	83.00	<sup>10</sup> / <sub>10</sub>	122.78	<sup>9</sup> / <sub>10</sub>	106.50	<sup>10</sup> / <sub>10</sub>	7.00	<sup>6</sup> / <sub>10</sub>
12	59.78	<sup>9</sup> / <sub>10</sub>	121.50	<sup>10</sup> / <sub>10</sub>	115.00	<sup>10</sup> / <sub>10</sub>	91.00	<sup>10</sup> / <sub>10</sub>	126.56	<sup>9</sup> / <sub>10</sub>	113.50	<sup>10</sup> / <sub>10</sub>	8.00	<sup>6</sup> / <sub>10</sub>
13	63.78	<sup>9</sup> / <sub>10</sub>	130.00	<sup>10</sup> / <sub>10</sub>	119.00	<sup>10</sup> / <sub>10</sub>	92.30	<sup>10</sup> / <sub>10</sub>	135.00	<sup>9</sup> / <sub>10</sub>	120.00	<sup>10</sup> / <sub>10</sub>	8.00	<sup>6</sup> / <sub>10</sub>
14	69.44	<sup>9</sup> / <sub>10</sub>	137.00	<sup>10</sup> / <sub>10</sub>	124.00	<sup>10</sup> / <sub>10</sub>	98.50	<sup>10</sup> / <sub>10</sub>	152.22	<sup>9</sup> / <sub>10</sub>	122.50	<sup>10</sup> / <sub>10</sub>	8.00	<sup>6</sup> / <sub>10</sub>

	4 uays.													
D						N	1ung Bean G	rowth Rat	te					
Α	pH∶	3	pH	5	pH 7 (tap	water)	pH 7 (rair	water)	pH 7 (river	water)	pH 9	9	pH 1	1
у	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.
0	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
1	1.00	<sup>1</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
2	4.13	<sup>8</sup> / <sub>10</sub>	6.78	<sup>9</sup> / <sub>10</sub>	6.71	<sup>7</sup> / <sub>10</sub>	5.00	<sup>9</sup> / <sub>10</sub>	5.86	<sup>7</sup> / <sub>10</sub>	6.375	<sup>8</sup> / <sub>10</sub>	2.67	<sup>3</sup> / <sub>10</sub>
3	9.11	<sup>9</sup> / <sub>10</sub>	13.78	<sup>9</sup> / <sub>10</sub>	11.67	<sup>9</sup> / <sub>10</sub>	6.57	<sup>9</sup> / <sub>10</sub>	13.4	<sup>9</sup> / <sub>10</sub>	11.25	<sup>8</sup> / <sub>10</sub>	4.8	<sup>5</sup> / <sub>10</sub>
4	10.56	<sup>9</sup> / <sub>10</sub>	16.44	<sup>9</sup> / <sub>10</sub>	13.60	<sup>10</sup> / <sub>10</sub>	15.00	<sup>9</sup> / <sub>10</sub>	13.44	<sup>9</sup> / <sub>10</sub>	14.00	<sup>8</sup> / <sub>10</sub>	2.14	7/10
5	10.78	<sup>9</sup> / <sub>10</sub>	16.44	<sup>9</sup> / <sub>10</sub>	15.50	<sup>10</sup> / <sub>10</sub>	15.67	<sup>9</sup> / <sub>10</sub>	14.11	<sup>9</sup> / <sub>10</sub>	17.5	<sup>8</sup> / <sub>10</sub>	2.29	<sup>7</sup> / <sub>10</sub>
6	10.11	<sup>9</sup> / <sub>10</sub>	20.00	<sup>9</sup> / <sub>10</sub>	19.40	<sup>10</sup> / <sub>10</sub>	19.90	<sup>9</sup> / <sub>10</sub>	15.89	<sup>9</sup> / <sub>10</sub>	20.67	<sup>8</sup> / <sub>10</sub>	1.83	<sup>6</sup> / <sub>10</sub>
7	13.83	<sup>6</sup> / <sub>10</sub>	22.78	<sup>9</sup> / <sub>10</sub>	28.70	<sup>10</sup> / <sub>10</sub>	24.40	<sup>9</sup> / <sub>10</sub>	25.78	<sup>9</sup> / <sub>10</sub>	28.125	<sup>8</sup> / <sub>10</sub>	1.83	<sup>6</sup> / <sub>10</sub>
8	13.83	<sup>6</sup> / <sub>10</sub>	22.78	<sup>9</sup> / <sub>10</sub>	28.70	<sup>10</sup> / <sub>10</sub>	24.40	<sup>9</sup> / <sub>10</sub>	25.78	<sup>9</sup> / <sub>10</sub>	28.125	<sup>8</sup> / <sub>10</sub>	1.83	<sup>6</sup> / <sub>10</sub>
9	13.83	<sup>6</sup> / <sub>10</sub>	22.78	<sup>9</sup> / <sub>10</sub>	28.70	<sup>10</sup> / <sub>10</sub>	26.67	<sup>9</sup> / <sub>10</sub>	25.78	<sup>9</sup> / <sub>10</sub>	23.75	<sup>8</sup> / <sub>10</sub>	1.83	<sup>6</sup> / <sub>10</sub>
10	13.83	<sup>6</sup> / <sub>10</sub>	25.11	<sup>9</sup> / <sub>10</sub>	31.80	<sup>10</sup> / <sub>10</sub>	28.33	<sup>9</sup> / <sub>10</sub>	38.00	<sup>9</sup> / <sub>10</sub>	26.25	<sup>8</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
11	13.83	<sup>6</sup> / <sub>10</sub>	26.78	<sup>9</sup> / <sub>10</sub>	36.70	<sup>10</sup> / <sub>10</sub>	29.40	<sup>9</sup> / <sub>10</sub>	49.67	<sup>9</sup> / <sub>10</sub>	28.75	<sup>8</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
12	20.00	<sup>2</sup> / <sub>10</sub>	27.89	<sup>9</sup> / <sub>10</sub>	41.00	<sup>10</sup> / <sub>10</sub>	29.40	<sup>9</sup> / <sub>10</sub>	47.70	<sup>9</sup> / <sub>10</sub>	31.875	<sup>8</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
13	20.00	<sup>2</sup> / <sub>10</sub>	29.56	<sup>9</sup> / <sub>10</sub>	44.00	<sup>10</sup> / <sub>10</sub>	32.22	<sup>9</sup> / <sub>10</sub>	52.56	<sup>9</sup> / <sub>10</sub>	35.00	<sup>8</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
14	20.00	<sup>2</sup> / <sub>10</sub>	30.89	<sup>9</sup> / <sub>10</sub>	45.30	<sup>10</sup> / <sub>10</sub>	33.11	<sup>9</sup> / <sub>10</sub>	55.44	<sup>9</sup> / <sub>10</sub>	35.63	<sup>8</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>

**Table 2d.** Number and average length of germinated mung beans in Experiment 1a during the period of 14 days.

**Table 2e.** Number and average length of germinated red beans in Experiment 1a during the period of 14 days.

D						I	Red Bean Gr	owth Rate	e					
A	pH :	3	pH	5	pH 7 (tap	water)	pH 7 (rair	water)	pH 7 (rive	r water)	pH s	9	pH 1	1
у	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.
0	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
1	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
2	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
3	1.00	<sup>3</sup> / <sub>10</sub>	3.25	<sup>4</sup> / <sub>10</sub>	2.00	<sup>3</sup> / <sub>10</sub>	1.00	<sup>1</sup> / <sub>10</sub>	3.67	<sup>3</sup> / <sub>10</sub>	3.00	<sup>1</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
4	1.25	<sup>8</sup> / <sub>10</sub>	5.33	<sup>6</sup> / <sub>10</sub>	5.50	<sup>4</sup> / <sub>10</sub>	1.67	<sup>3</sup> / <sub>10</sub>	5.00	<sup>6</sup> / <sub>10</sub>	2.50	<sup>4</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
5	3.75	<sup>8</sup> / <sub>10</sub>	5.375	<sup>8</sup> / <sub>10</sub>	5.83	<sup>6</sup> / <sub>10</sub>	1.80	<sup>5</sup> / <sub>10</sub>	5.75	<sup>8</sup> / <sub>10</sub>	3.57	<sup>7</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
6	4.78	<sup>9</sup> / <sub>10</sub>	7.00	<sup>10</sup> / <sub>10</sub>	5.25	<sup>8</sup> / <sub>10</sub>	3.20	<sup>5</sup> / <sub>10</sub>	6.89	<sup>9</sup> / <sub>10</sub>	5.43	<sup>7</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
7	5.33	<sup>9</sup> / <sub>10</sub>	8.10	<sup>10</sup> / <sub>10</sub>	8.13	<sup>8</sup> / <sub>10</sub>	3.17	<sup>6</sup> / <sub>10</sub>	11.11	<sup>9</sup> / <sub>10</sub>	5.44	<sup>9</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
8	5.33	<sup>9</sup> / <sub>10</sub>	8.10	<sup>10</sup> / <sub>10</sub>	8.13	<sup>8</sup> / <sub>10</sub>	3.17	<sup>6</sup> / <sub>10</sub>	11.11	<sup>9</sup> / <sub>10</sub>	5.44	<sup>9</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
9	6.56	<sup>9</sup> / <sub>10</sub>	11.90	<sup>10</sup> / <sub>10</sub>	9.00	<sup>8</sup> / <sub>10</sub>	3.17	<sup>6</sup> / <sub>10</sub>	10.11	<sup>9</sup> / <sub>10</sub>	6.22	<sup>9</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
10	9.90	<sup>10</sup> / <sub>10</sub>	11.90	<sup>10</sup> / <sub>10</sub>	10.25	<sup>8</sup> / <sub>10</sub>	3.17	<sup>6</sup> / <sub>10</sub>	11.78	<sup>9</sup> / <sub>10</sub>	6.22	<sup>9</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
11	10.40	<sup>10</sup> / <sub>10</sub>	11.90	<sup>10</sup> / <sub>10</sub>	10.25	<sup>8</sup> / <sub>10</sub>	3.17	<sup>6</sup> / <sub>10</sub>	12.33	<sup>9</sup> / <sub>10</sub>	6.22	<sup>9</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
12	10.40	<sup>10</sup> / <sub>10</sub>	11.90	<sup>10</sup> / <sub>10</sub>	10.25	<sup>8</sup> / <sub>10</sub>	3.17	<sup>6</sup> / <sub>10</sub>	14.00	<sup>9</sup> / <sub>10</sub>	6.22	<sup>9</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
13	12.70	<sup>10</sup> / <sub>10</sub>	11.90	<sup>10</sup> / <sub>10</sub>	10.25	<sup>8</sup> / <sub>10</sub>	3.17	<sup>6</sup> / <sub>10</sub>	18.44	<sup>9</sup> / <sub>10</sub>	6.22	<sup>9</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
14	13.70	<sup>10</sup> / <sub>10</sub>	11.90	<sup>10</sup> / <sub>10</sub>	10.25	<sup>8</sup> / <sub>10</sub>	3.17	<sup>6</sup> / <sub>10</sub>	19.78	<sup>9</sup> / <sub>10</sub>	6.22	<sup>9</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>

						(	Chia Seed Gr	owth Rate	e					
D A	рН	3	pH !	5	pH 7 (tap	water)	pH 7 (rain	water)	pH 7 (rive	r water)	pH	9	pH 1	1
у	Avg. Length (mm)	No.	Avg. Length (mm)	No.										
0	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
1	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
2	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
3	0	<sup>0</sup> / <sub>10</sub>	3.00	<sup>5</sup> / <sub>10</sub>	4.00	<sup>5</sup> / <sub>10</sub>	3.67	<sup>3</sup> / <sub>10</sub>	3.17	<sup>6</sup> / <sub>10</sub>	3.00	<sup>1</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
4	2.00	<sup>1</sup> / <sub>10</sub>	9.20	<sup>5</sup> / <sub>10</sub>	6.57	<sup>7</sup> / <sub>10</sub>	8.40	<sup>5</sup> / <sub>10</sub>	7.00	<sup>6</sup> / <sub>10</sub>	4.00	<sup>3</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
5	2.00	<sup>1</sup> / <sub>10</sub>	5.13	<sup>5</sup> / <sub>10</sub>	9.14	<sup>7</sup> / <sub>10</sub>	8.70	<sup>5</sup> / <sub>10</sub>	7.67	<sup>6</sup> / <sub>10</sub>	4.00	<sup>8</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
6	2.00	<sup>1</sup> / <sub>10</sub>	6.20	<sup>5</sup> / <sub>10</sub>	11.71	<sup>7</sup> / <sub>10</sub>	9.00	<sup>5</sup> / <sub>10</sub>	8.33	<sup>6</sup> / <sub>10</sub>	4.38	<sup>8</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
7	2.00	<sup>1</sup> / <sub>10</sub>	9.60	<sup>5</sup> / <sub>10</sub>	17.00	<sup>7</sup> / <sub>10</sub>	14.40	<sup>5</sup> / <sub>10</sub>	16.33	<sup>6</sup> / <sub>10</sub>	9.14	<sup>7</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
8	2.00	<sup>1</sup> / <sub>10</sub>	14.80	<sup>5</sup> / <sub>10</sub>	34.29	<sup>7</sup> / <sub>10</sub>	23.33	<sup>6</sup> / <sub>10</sub>	34.17	<sup>6</sup> / <sub>10</sub>	22.71	<sup>7</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
9	2.00	<sup>1</sup> / <sub>10</sub>	17.80	<sup>5</sup> / <sub>10</sub>	36.43	<sup>7</sup> / <sub>10</sub>	24.33	<sup>6</sup> / <sub>10</sub>	35.83	<sup>6</sup> / <sub>10</sub>	27.42	<sup>7</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
10	2.00	<sup>1</sup> / <sub>10</sub>	22.40	<sup>5</sup> / <sub>10</sub>	42.14	<sup>7</sup> / <sub>10</sub>	27.83	<sup>6</sup> / <sub>10</sub>	41.00	<sup>6</sup> / <sub>10</sub>	32.43	<sup>7</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
11	2.00	<sup>1</sup> / <sub>10</sub>	23.40	<sup>5</sup> / <sub>10</sub>	42.14	<sup>7</sup> / <sub>10</sub>	30.83	<sup>6</sup> / <sub>10</sub>	41.00	<sup>6</sup> / <sub>10</sub>	32.43	<sup>7</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
12	2.00	<sup>1</sup> / <sub>10</sub>	26.20	<sup>5</sup> / <sub>10</sub>	42.14	<sup>7</sup> / <sub>10</sub>	31.83	<sup>6</sup> / <sub>10</sub>	41.67	<sup>6</sup> / <sub>10</sub>	33.14	<sup>7</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
13	2.00	<sup>1</sup> / <sub>10</sub>	29.20	<sup>5</sup> / <sub>10</sub>	43.57	<sup>7</sup> / <sub>10</sub>	34.00	<sup>6</sup> / <sub>10</sub>	43.00	<sup>6</sup> / <sub>10</sub>	35.29	<sup>7</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
14	2.00	<sup>1</sup> / <sub>10</sub>	29.20	<sup>5</sup> / <sub>10</sub>	45.00	<sup>7</sup> / <sub>10</sub>	36.00	<sup>6</sup> / <sub>10</sub>	43.00	<sup>6</sup> / <sub>10</sub>	36.86	<sup>7</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>

**Table 2f.** Number and average length of germinated chia seeds in Experiment 1a during the period of 14 day.

**Table 3.** Number and average growth rate of 3 types of plant seeds in Experiment 1b during the period of 14 days. Table 3 comprises of Tables 3a to 3c.

**Table 3a.** Number and average length of germinated wheat seeds in Experiment 1b during the period of 14 days.

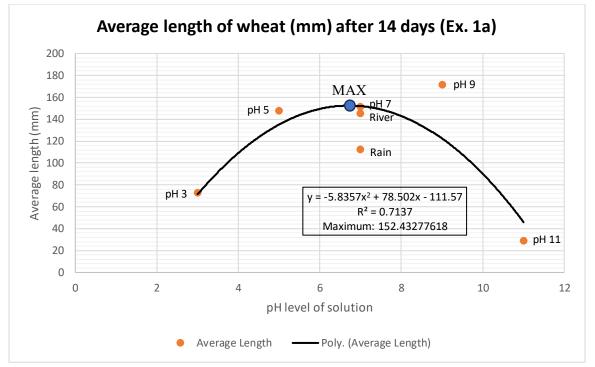
D				W	neat Growth Rate	(Experiment	1b)			
D A	Strong Ac	idic	Light Acidic		Neutra	al	Light Alka	line	Strong Alk	aline
У	Avg. Length (mm)	No.								
0	0	<sup>0</sup> / <sub>10</sub>								
1	0	<sup>0</sup> / <sub>10</sub>								
2	0	<sup>0</sup> / <sub>10</sub>								
3	5.00	<sup>5</sup> / <sub>10</sub>	4.67	<sup>5</sup> / <sub>10</sub>	5.00	<sup>3</sup> / <sub>10</sub>	5.00	<sup>2</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
4	11.57	<sup>8</sup> / <sub>10</sub>	9.25	<sup>8</sup> / <sub>10</sub>	8.86	<sup>8</sup> / <sub>10</sub>	13.00	<sup>6</sup> / <sub>10</sub>	4.00	<sup>4</sup> / <sub>10</sub>
5	21.30	<sup>10</sup> / <sub>10</sub>	23.00	<sup>10</sup> / <sub>10</sub>	18.60	<sup>10</sup> / <sub>10</sub>	17.40	<sup>10</sup> / <sub>10</sub>	12.78	<sup>9</sup> / <sub>10</sub>
6	35.80	<sup>10</sup> / <sub>10</sub>	39.09	<sup>10</sup> / <sub>10</sub>	32.00	<sup>10</sup> / <sub>10</sub>	31.00	<sup>10</sup> / <sub>10</sub>	25.00	<sup>10</sup> / <sub>10</sub>
7	51.00	<sup>10</sup> / <sub>10</sub>	55.00	<sup>10</sup> / <sub>10</sub>	50.00	<sup>10</sup> / <sub>10</sub>	50.00	<sup>10</sup> / <sub>10</sub>	38.50	<sup>10</sup> / <sub>10</sub>
8	71.30	<sup>10</sup> / <sub>10</sub>	81.36	<sup>10</sup> / <sub>10</sub>	71.50	<sup>10</sup> / <sub>10</sub>	72.10	<sup>10</sup> / <sub>10</sub>	56.60	<sup>10</sup> / <sub>10</sub>
9	93.10	<sup>10</sup> / <sub>10</sub>	108.27	<sup>10</sup> / <sub>10</sub>	97.00	<sup>10</sup> / <sub>10</sub>	91.70	<sup>10</sup> / <sub>10</sub>	79.50	<sup>10</sup> / <sub>10</sub>
10	108.80	<sup>10</sup> / <sub>10</sub>	121.82	<sup>10</sup> / <sub>10</sub>	116.80	<sup>10</sup> / <sub>10</sub>	106.00	<sup>10</sup> / <sub>10</sub>	87.00	<sup>10</sup> / <sub>10</sub>
11	122.50	<sup>10</sup> / <sub>10</sub>	142.27	<sup>10</sup> / <sub>10</sub>	137.00	<sup>10</sup> / <sub>10</sub>	122.00	<sup>10</sup> / <sub>10</sub>	100.00	<sup>10</sup> / <sub>10</sub>
12	134.50	<sup>10</sup> / <sub>10</sub>	155.00	<sup>10</sup> / <sub>10</sub>	151.50	<sup>10</sup> / <sub>10</sub>	138.5	<sup>10</sup> / <sub>10</sub>	109.50	<sup>10</sup> / <sub>10</sub>
13	137.50	<sup>10</sup> / <sub>10</sub>	163.81	<sup>10</sup> / <sub>10</sub>	164.00	<sup>10</sup> / <sub>10</sub>	141.0	<sup>10</sup> / <sub>10</sub>	110.50	<sup>10</sup> / <sub>10</sub>
14	144.9	<sup>10</sup> / <sub>10</sub>	176.81	<sup>10</sup> / <sub>10</sub>	177.30	<sup>10</sup> / <sub>10</sub>	148.5	<sup>10</sup> / <sub>10</sub>	111.00	<sup>10</sup> / <sub>10</sub>

J				Let	tuce Growth Rate	(Experiment	: 1b)			
D A	Strong Ac	idic	Light Acidic		Neutra	Neutral		line	Strong Alkaline	
у	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.
0	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
1	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
2	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	5.00	<sup>1</sup> / <sub>10</sub>	1.00	<sup>1</sup> / <sub>10</sub>	1.00	<sup>1</sup> / <sub>10</sub>
3	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	6.00	<sup>1</sup> / <sub>10</sub>	3.00	<sup>3</sup> / <sub>10</sub>	3.00	<sup>4</sup> / <sub>10</sub>
4	7.50	<sup>4</sup> / <sub>10</sub>	3.00	<sup>3</sup> / <sub>10</sub>	3.50	<sup>8</sup> / <sub>10</sub>	4.25	<sup>4</sup> / <sub>10</sub>	5.50	<sup>4</sup> / <sub>10</sub>
5	10.13	<sup>8</sup> / <sub>10</sub>	4.17	<sup>6</sup> / <sub>10</sub>	10.50	<sup>10</sup> / <sub>10</sub>	6.67	<sup>6</sup> / <sub>10</sub>	5.50	<sup>4</sup> / <sub>10</sub>
6	18.89	<sup>9</sup> / <sub>10</sub>	11.38	<sup>8</sup> / <sub>10</sub>	16.80	<sup>10</sup> / <sub>10</sub>	6.67	<sup>6</sup> / <sub>10</sub>	7.25	<sup>4</sup> / <sub>10</sub>
7	28.44	<sup>9</sup> / <sub>10</sub>	20.67	<sup>9</sup> / <sub>10</sub>	29.00	<sup>10</sup> / <sub>10</sub>	8.17	<sup>6</sup> / <sub>10</sub>	9.00	<sup>4</sup> / <sub>10</sub>
8	38.56	<sup>9</sup> / <sub>10</sub>	30.44	<sup>9</sup> / <sub>10</sub>	38.50	<sup>10</sup> / <sub>10</sub>	11.17	<sup>6</sup> / <sub>10</sub>	10.40	<sup>5</sup> / <sub>10</sub>
9	44.67	<sup>9</sup> / <sub>10</sub>	36.44	<sup>9</sup> / <sub>10</sub>	45.80	<sup>10</sup> / <sub>10</sub>	11.83	<sup>6</sup> / <sub>10</sub>	11.67	<sup>6</sup> / <sub>10</sub>
10	48.44	<sup>9</sup> / <sub>10</sub>	42.89	<sup>9</sup> / <sub>10</sub>	48.60	<sup>10</sup> / <sub>10</sub>	12.71	<sup>6</sup> / <sub>10</sub>	12.17	<sup>6</sup> / <sub>10</sub>
11	53.44	<sup>9</sup> / <sub>10</sub>	49.67	<sup>9</sup> / <sub>10</sub>	52.00	<sup>10</sup> / <sub>10</sub>	12.71	<sup>6</sup> / <sub>10</sub>	12.17	<sup>6</sup> / <sub>10</sub>
12	49.1	<sup>9</sup> / <sub>10</sub>	49.67	<sup>9</sup> / <sub>10</sub>	52.60	<sup>10</sup> / <sub>10</sub>	13.71	<sup>6</sup> / <sub>10</sub>	12.17	<sup>6</sup> / <sub>10</sub>
13	49.1	<sup>9</sup> / <sub>10</sub>	49.67	<sup>9</sup> / <sub>10</sub>	52.60	<sup>10</sup> / <sub>10</sub>	13.71	<sup>6</sup> / <sub>10</sub>	12.17	<sup>6</sup> / <sub>10</sub>
14	49.1	<sup>9</sup> / <sub>10</sub>	49.67	<sup>9</sup> / <sub>10</sub>	52.60	<sup>10</sup> / <sub>10</sub>	13.71	<sup>6</sup> / <sub>10</sub>	12.17	<sup>6</sup> / <sub>10</sub>

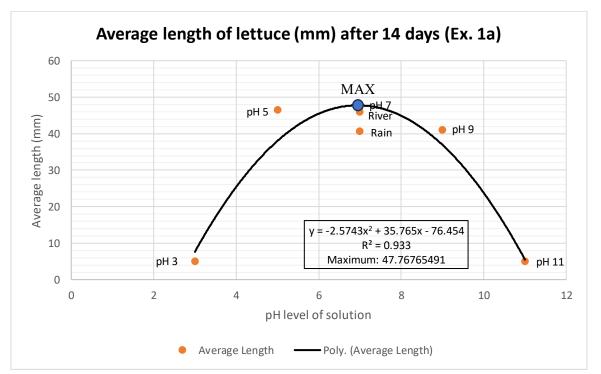
**Table 3b.** Number and average length of germinated lettuce seeds in Experiment 1b during the period of 14 days.

**Table 3c.** Number and average length of germinated grass seeds in Experiment 1b during the periodof 14 days.

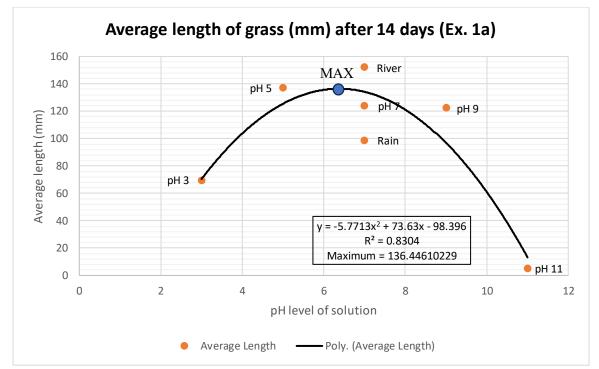
D				Gr	rass Growth Rate (	Experiment :	1b)			
A	Strong Ac	idic	Light Acidic		Neutra	ıl	Light Alka	line	Strong Alk	aline
У	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.	Avg. Length (mm)	No.
0	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
1	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
2	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
3	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
4	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
5	0	<sup>0</sup> / <sub>10</sub>	4.00	<sup>1</sup> / <sub>10</sub>	7.00	<sup>4</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
6	9.60	<sup>5</sup> / <sub>10</sub>	11.14	<sup>7</sup> / <sub>10</sub>	12.33	<sup>9</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>	0	<sup>0</sup> / <sub>10</sub>
7	13.33	<sup>6</sup> / <sub>10</sub>	20.00	<sup>9</sup> / <sub>10</sub>	23.00	<sup>10</sup> / <sub>10</sub>	20.00	<sup>1</sup> / <sub>10</sub>	8.67	<sup>3</sup> / <sub>10</sub>
8	26.67	<sup>6</sup> / <sub>10</sub>	36.67	<sup>9</sup> / <sub>10</sub>	43.10	<sup>10</sup> / <sub>10</sub>	35.00	<sup>1</sup> / <sub>10</sub>	18.33	<sup>3</sup> / <sub>10</sub>
9	31.13	<sup>8</sup> / <sub>10</sub>	49.22	<sup>9</sup> / <sub>10</sub>	57.40	<sup>10</sup> / <sub>10</sub>	40.00	<sup>1</sup> / <sub>10</sub>	26.67	<sup>3</sup> / <sub>10</sub>
10	44.38	<sup>8</sup> / <sub>10</sub>	63.11	<sup>9</sup> / <sub>10</sub>	72.50	<sup>10</sup> / <sub>10</sub>	50.00	<sup>1</sup> / <sub>10</sub>	29.25	<sup>4</sup> / <sub>10</sub>
11	50.50	<sup>8</sup> / <sub>10</sub>	77.00	<sup>9</sup> / <sub>10</sub>	85.6	<sup>10</sup> / <sub>10</sub>	60.00	<sup>1</sup> / <sub>10</sub>	35.00	<sup>4</sup> / <sub>10</sub>
12	57.50	<sup>8</sup> / <sub>10</sub>	84.56	<sup>9</sup> / <sub>10</sub>	100.2	<sup>10</sup> / <sub>10</sub>	63.00	<sup>1</sup> / <sub>10</sub>	37.75	<sup>4</sup> / <sub>10</sub>
13	64.88	<sup>8</sup> / <sub>10</sub>	96.00	<sup>9</sup> / <sub>10</sub>	109.4	<sup>10</sup> / <sub>10</sub>	63.00	<sup>1</sup> / <sub>10</sub>	33.20	<sup>5</sup> / <sub>10</sub>
14	72.50	<sup>8</sup> / <sub>10</sub>	104.78	<sup>9</sup> / <sub>10</sub>	115.9	<sup>10</sup> / <sub>10</sub>	66.00	<sup>1</sup> / <sub>10</sub>	36.60	<sup>5</sup> / <sub>10</sub>



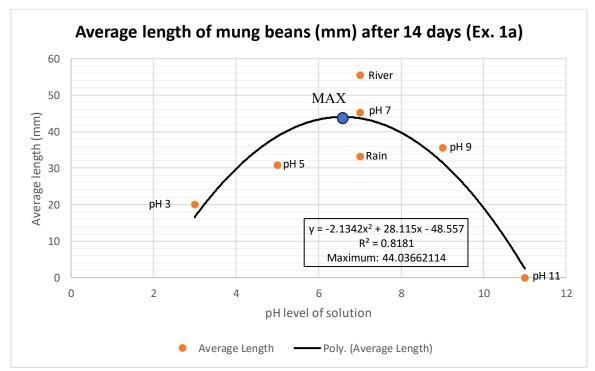
**Figure 3a.** This graph depicts the average length of wheat seeds in millimetres over a period of 14 days with a curve of best fit illustrating the relationship between pH levels and growth rate of wheat in Experiment 1a.



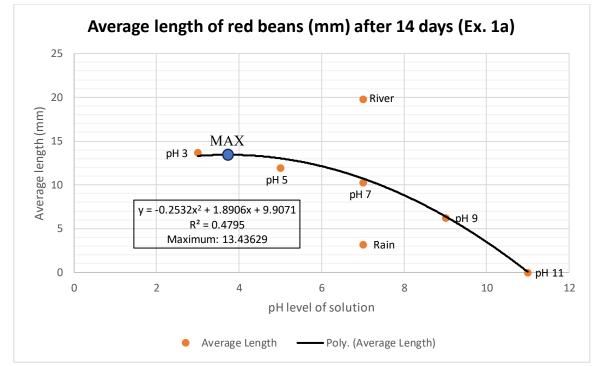
**Figure 3b.** This graph depicts the average length of lettuce seeds in millimetres over a period of 14 days with a curve of best fit illustrating the relationship between pH levels and growth rate of lettuce in Experiment 1a.



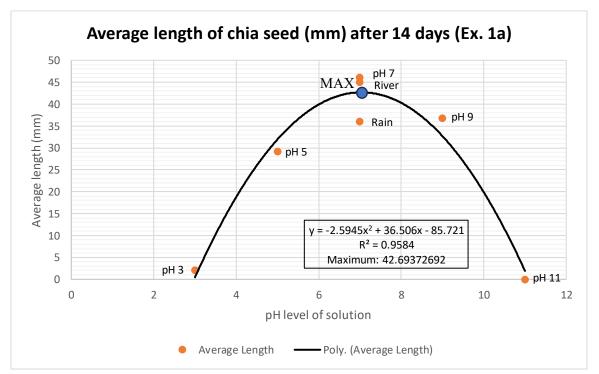
**Figure 3c.** This graph depicts the average length of grass seeds in millimetres over a period of 14 days with a curve of best fit illustrating the relationship between pH levels and growth rate of grass in Experiment 1a.



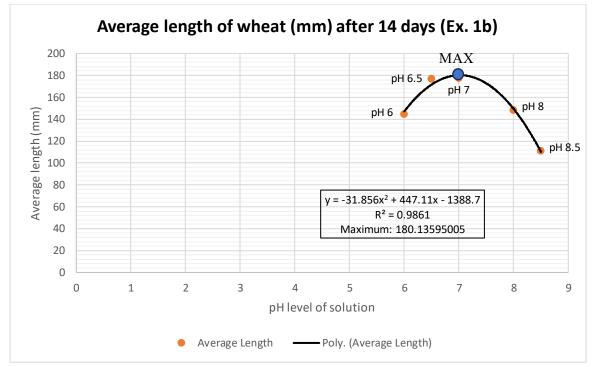
**Figure 3d** – This graph depicts the average length of mung beans in millimetres over a period of 14 days with a curve of best fit illustrating the relationship between pH levels and growth rate of mung beans in Experiment 1a.



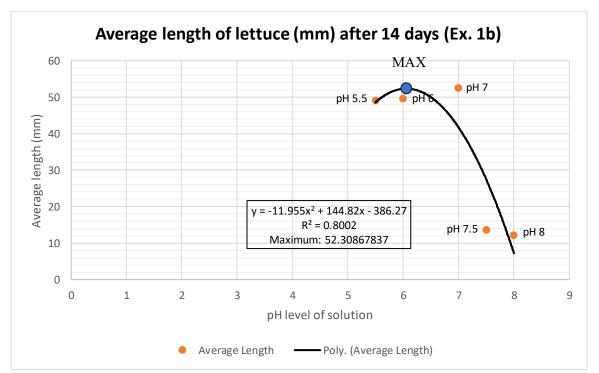
**Figure 3e.** This graph depicts the average length of red beans in millimetres over a period of 14 days with a curve of best fit illustrating the relationship between pH levels and growth rate of red beans in Experiment 1a.



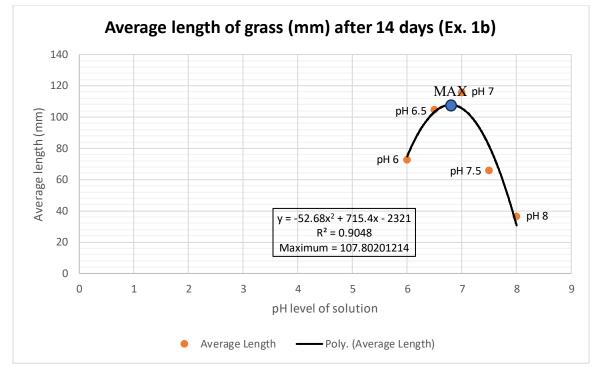
**Figure 3f.** This graph depicts the average length of chia seeds in millimetres over a period of 14 days with a curve of best fit illustrating the relationship between pH levels and growth rate of chia seed in Experiment 1a.



**Figure 4a.** This graph depicts the average length of wheat seeds in millimetres over a period of 14 days with a curve of best fit illustrating the relationship between pH levels and growth rate of wheat in Experiment 1b.



**Figure 4b.** This graph depicts the average length of lettuce seeds in millimetres over a period of 14 days with a curve of best fit illustrating the relationship between pH levels and average growth rate of lettuce in Experiment 1b.



**Figure 4c.** This graph depicts the average length of grass seeds in millimetres over a period of 14 days with a curve of best fit illustrating the relationship between pH levels and average growth rate of grass in Experiment 1b.

Placement	Mung bean	Red bean	Wheat	Lettuce	Grass	Chia seed
1 <sup>st</sup>	River	River	рН 9	рН 7	River	рН 7
2 <sup>nd</sup>	рН 7	рН 3	рН 7	рН 5	рН 5	River
3 <sup>rd</sup>	рН 9	рН 5	рН 5	River	рН 7	рН 9
4 <sup>th</sup>	Rain	рН 7	River	рН 9	рН 9	Rain
5 <sup>th</sup>	рН 5	рН 9	Rain	Rain	Rain	рН 5
6 <sup>th</sup>	рН 3	Rain	рН 3	рН 3	рН 3	рН 3
7 <sup>th</sup>	pH 11	pH 11	pH 11	pH 11	pH 11	pH 11

**Table 4.** The order of average length for wheat, lettuce, grass, mung bean, red bean, and chia seed on Day 14 in Experiment 1a.

**Table 5.** The order of average length for wheat, lettuce, and grass on Day 14 in Experiment 1b.

Placement	Wheat	Lettuce	Grass
1 <sup>st</sup>	Neutral	Neutral	Neutral
2 <sup>nd</sup>	Light acidic	Light acidic	Light acidic
3 <sup>rd</sup>	Light alkaline	Strong acidic	Strong acidic
4 <sup>th</sup>	Strong acidic	Light alkaline	Light alkaline
5 <sup>th</sup>	Strong alkaline	Strong alkaline	Strong alkaline

**Table 6.** The optimal pH value and maximum length calculated from model function of the polynomial graphs of average lengths of wheat, lettuce, grass, mung bean, red bean, and chia seed in Experiments 1a and 1b. Table 6 comprises of Tables 6a and 6b.

Graphs	Mathematical Model Equation	Optimal pH value
Figure 3a – Average length of wheat after 14 days (Experiment 1a)	$y = -5.8357x^2 + 78.502x - 111.57$	Model Function: $y = -5.8357x^2 + 78.502x - 111.57$ Derivative Function: $\frac{dy}{dx} = -11.6714x + 78.502$ X value when derivative function equals 0: $x \approx pH$ 6.70 Y value for x value above: $y \approx 152.43 mm$
<b>Figure</b> 3 <b>b</b> – Average length of <b>lettuce</b> after 14 days (Experiment 1a)	$y = -2.5743x^2 + 35.765x - 76.454$	Model Function: $y = -2.5743x^2 + 35.765x - 76.454$ Derivative Function: $\frac{dy}{dx} = -4.2684x + 28.115$ X value when derivative function equals 0: $x \approx pH$ 6.60 Y value for x value above: $y \approx 47.77 \ mm$
<b>Figure</b> 3 <b>c</b> – Average length of <b>grass</b> after 14 days (Experiment 1a)	$y = -5.7713x^2 + 73.63x - 98.396$	Model Function: $y = -5.7713x^2 + 73.63x - 98.396$ Derivative Function: $\frac{dy}{dx} = -11.5426x + 73.63$ X value when derivative function equals 0: $x \approx pH$ 6.38 Y value for x value above: $y \approx 136.45 mm$
Figure 3d – Average length of mung bean after 14 days (Experiment 1a)	$y = -2.1342x^2 + 28.115x - 48.557$	Model Function: $y = -2.1342x^2 + 28.115x - 48.557$ Derivative Function: $\frac{dy}{dx} = -4.2684x + 28.115$ X value when derivative function equals 0: $x \approx pH$ 6.60 Y value for x value above: $y \approx 44.04 mm$
<b>Figure 3e</b> – Average length of <b>red bean</b> after 14 days (Experiment 1a)	$y = -0.2532x^2 + 1.8906x + 9.9071$	Model Function: $y = -0.2532x^2 + 1.8906x + 9.9071$ Derivative Function: $\frac{dy}{dx} = -0.5064x + 1.8906$ X value when derivative function equals 0: $x \approx pH$ 3.73 Y value for x value above: $y \approx 13.44 mm$
<b>Figure</b> 3 <b>f</b> – Average length of <b>chia seed</b> after 14 days (Experiment 1a)	$y = -2.5945x^2 + 36.506x - 85.721y$	Model Function: $y = -2.5945x^2 + 36.506x - 85.721y$ Derivative Function: $\frac{dy}{dx} = -5.189x + 36.506$ X value when derivative function equals 0: $x \approx pH$ 7.04 Y value for x value above: $y \approx 42.69 mm$

Table 6b. For experiment 1b.

Graphs	Mathematical Model Equation	Optimal pH value
<b>Figure</b> 4a – Average length of <b>wheat</b> after 14 days (Experiment 1b)	$y = -31.856x^2 + 447.11x - 1388.7$	Model Function: $y = -31.856x^2 + 447.11x - 1388.7$ Derivative Function: $\frac{dy}{dx} = -63.712x + 447.11$ X value when derivative function equals 0: $x \approx pH$ 7.00 Y value for x value above: $y \approx 180.14 mm$
<b>Figure</b> 4 <b>b</b> – Average length of <b>lettuce</b> after 14 days (Experiment 1b)	$y = -11.955x^2 + 144.82x - 386.27$	Model Function: $y = -11.955x^2 + 144.82x - 386.27$ Derivative Function: $\frac{dy}{dx} = -23.91x + 144.82$ X value when derivative function equals 0: $x \approx pH$ 6.05 Y value for x value above: $y \approx 52.31 mm$
<b>Figure</b> 4 <b>c</b> – Average length of <b>grass</b> after 14 days (Experiment 1b)	$y = -52.68x^2 + 715.4x - 2321$	Model Function: $y = -52.68x^2 + 715.4x - 2321$ Derivative Function: $\frac{dy}{dx} = -105.36x + 715.4$ X value when derivative function equals 0: $x \approx pH$ 6.79 Y value for x value above: $y \approx 107.80 \ mm$

#### **Experiment 2**

**Table 7.** Number and average growth rate of germinated wheat seeds in different water content onDay 7 and Day 14. Table 7 comprises of Tables 7a to 7c.

Table 7a. Number and average length of germinated wheat seeds or	on Day 7 &14.
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Name	Average length on Day 7 (mm)	Number of germinated seeds on Day 7	Average length on Day 14 (mm)	Number of germinated seeds on Day 14
W1	0	0	0	0
W2	15	10	80	10
W3	35	10	170	10
W4	0	0	0	0
W5	0	0	0	0

 Table 7b. Number and average length of germinated lettuce seeds on Day 7 & 14.

Name	Average length on Day 7 (mm)	Number of germinated seeds on Day 7	Average length on Day 14 (mm)	Number of germinated seeds on Day 14
L1	0	0	0	0
L2	20	9	45	10
L3	30	8	50	10
L4	20	5	40	5
L5	0	0	0	0

 Table 7c.
 Number and average length of germinated grass seeds on Day 7 & 14.

Name	Average length on Day 7 (mm)	Number of germinated seeds on Day 7	Average length on Day 14 (mm)	Number of germinated seeds on Day 14
G1	0	0	0	0
G2	20	10	70	10
G3	20	10	90	10
G4	20	3	40	4
G5	0	0	30	3

**Table 8.** The order of average length for wheat, lettuce, grass, on Day 14 in Experiment 2.

Placement	Group	Days of water intake	Total water intake (ml)
1 <sup>st</sup>	3	Day 0: 50ml, Day 1, 2 & 7: 15ml	95
2 <sup>nd</sup>	2	Day 0: 50ml	50
3 <sup>rd</sup>	4	Day 0: 50ml, Day 1, 2 & 7: 30ml	140
4 <sup>th</sup>	5	Day 0 & 1: 100ml	200
5 <sup>th</sup>	1	-	0

#### **Experiment 1a**

#### Data analysis (Table 2, Figure 2)

Day 14 is selected as a reference time for analysis. On Day 14, wheat presents the optimal growth of an average length of 171.44mm at pH 9, followed by pH 7 (tap water), pH 5, pH 7 (river water), pH 7 (rainwater), pH 3, and pH 11 with the least increase of 29mm. Comparatively, for lettuce, the greatest growth occurs at pH 7 (tap water) with an average length of 47.22m, followed by pH 5, pH 7 (river water), pH 9, pH 7 (rainwater), pH 3, and pH 11 with the least growth of 5mm. For grass, pH 7 (river water) works the best (152.22mm), followed by pH 5, pH 7 (water), pH 9, pH 7 (rainwater), pH 3, and pH 11 (8mm). Mung beans show the greatest growth at pH 7 (River water) (55.44mm), followed by pH 7 (tap water), pH 9, pH 7 (Rainwater), pH 5, pH 3, and pH 11. Relatively, red beans display the maximum increase at pH 7 (river) (19.78mm), followed by pH 3, pH 5, pH 7 (tap water), pH 9, pH 7 (rainwater), and pH 11. Similarly, chia seeds depict optimal growth at pH 7 (tap water) (45mm), followed by pH 7 (River water), pH 9, pH 7 (rainwater), pH 5, pH 3, and pH 11.

#### The order of average growth rate (Table 4)

All plants in pH 11 conditions perform the worst, of which either have no growth (0mm for mung bean, red bean, and chia seed) or minimal growth (8mm for grass, 5mm for lettuce, and 29mm for wheat on Day 14). PH 3 is the second-worst condition occurs in five out of six plants. PH 7 (rainwater) keeps fifth place in wheat, lettuce, and grass. Comparatively, plants in pH 7 (tap water) conditions performed second best out of other pH groups.

#### The optimum pH values of all six plants (Table 2, Figure 3)

On Day 14, grass, mung beans, and red beans achieved the greatest growth in pH 7 (river water). Lettuce and chia seeds grow best in pH 7 group (tap water). In contrast, wheat grow fastest at pH 9 with 171.44mm and a difference of 20.08mm and 25.94mm compared with pH 7 (tap water and river water). The results conclude that pH 7 solutions (tap water and river water) are the optimum pH to achieve the best growth in plants.

#### The calculated optimal pH values (Table 6a)

Results show that the optimal pH range is between 6.05 and 7.04 for all plants except for red beans which presents a significant outlier illustrating an optimum pH of 3.73 and a downward curve.

#### The number of germinated seeds (Table 2)

None of the red beans or chia seeds germinated in the pH 11 solution. For wheat, lettuce, grass, and mung bean, a significantly lesser number of seeds germinated at a slower rate in the pH 11 solution than in other pH conditions. For example, 7 wheat seeds and 3 lettuce seeds germinated in pH 11 groups on day 2, respectively. Only 4 lettuce seeds germinated in pH 3 setting on day 2. For grass, 2 and 4 germinated seeds were observed in pH 5 and pH 9 solutions on day 2, whereas 3 germinated seeds in pH 3 solution on day 3, and 2 germinated seeds in pH 11 solution on day 4. This finding implies that both the numbers of germinated seeds as well as the germination and growth rates of all plants decrease in unfavourable pH conditions. Plant seeds tend to grow at a slower rate in both extreme acidity and alkalinity.

Most of the germinated seeds stop growing in extremely acidic environment and are susceptible to early death and invasion by fungus and other microorganisms. Red beans in an acidic environment became mouldy from Day 4, being worse in pH 3 solution than in pH 5 solution. Similarly, chia seeds suffered from some pinkish fungus in both acidic settings, from day 4 in pH 3 solution and from day 5 in pH 5 solution. Fungal invasion was apparent across all acidic and alkaline environments for wheat seeds and mung beans, with the worst being in pH 3 solutions, followed by pH 5, pH 11, and pH 9 solutions, with the earliest occurring from day 3. Fungi tend to habitat more intensively and grow at a faster rate in acidic lemon water than in alkaline lye water.

#### **Experiment 1b.**

#### Data analysis and the order of average growth rate (Tables 3 and 5, Figures 2 and 4)

The number and average growth rate of germinated seeds of three plants at five pH groups in soil are compared. All plants perform best in the pH condition of 7 (neutral), in which wheat grew 177.3mm, lettuce grew 52.6mm, and grass grew 115.9mm. Relatively, the light acidic condition of pH 6.5 is displayed as the second optimal pH condition for wheat, followed by light alkaline (pH 8), strong acidic (pH 6), and strong alkaline (pH 8.5). Contrastingly, lettuce and grass performed similarly with an order of neutral (pH 7), light acidic (pH 6 and 6.5), strong acidic (pH 5.5 and 6), light alkaline (pH 7.5), and strong alkaline (pH 8). It is evident that pH 7 is the optimum pH condition for wheat, lettuce, and grass.

#### The calculated optimum pH values (Table 6b)

Results show that the optimal pH value of wheat is 7, lettuce is pH 6.05, and grass is pH 6.76, respectively, all of which are near neutral.

#### The number of germinated seeds (Table 3)

Wheat germinated lesser and slower in alkaline soil than in neutral and acidic soils, with 6 germinated seeds in light alkaline soil and 4 in strong alkaline soil compared to 8 germinated seeds in neutral and acidic soils on Day 4. For lettuce on day 9, 10 seeds germinated in neutral soil, 9 in acidic soils, and 6 in alkaline soils, respectively. For grass on Day 13, 10 seeds germinated in neutral soil, 9 in light acidic soil, 8 in strong acidic soil, 1 in light alkaline soil, and 5 in strong alkaline soil, respectively. The finding strongly supports that soil pH affects the viability and quality of germination.

#### Graphs (Experiments 1a and 1b) (Figures 3 and 4)

The graph illustrates that plant growth rates decrease as extrinsic pH levels exceed the optimum pH range, represented by parabolic-shaped curves.

#### Experiment 2 (Tables 7 and 8)

All Groups 3 performs the best, followed by Group 2, Group 4, Group 5, and Group 1. Groups 4 and 5 show that plants with excessive amounts of water uptake will decrease their growth. Contrastingly, Group 1 shows no growth for all plants due to insufficient water imbibition to activate enzymes for germination. Group 5 demonstrate no growth for wheat and lettuce. Comparatively, Group 2 shows

more growth than Group 4 due to sufficient water intake to germinate, but insufficient enough to perform its fullest potential to grow as compared to Group 3.

#### **Discussion and Evaluation**

#### Data discussion

The results of Experiment 1 support the hypothesis that if the extrinsic pH is near neutral (pH 7  $\pm$  10%), seed germination will take place and the average plant height will be the greatest. Chemical reactions that occur during germination are controlled by enzymes. All enzymes have an optimum pH at which they can work best (Table 9). The experiment finding supports that enzymes usually function well within an optimum range of pH values. The impacted plant growth in unfavourable acidic and alkaline environments is caused by denaturation of essential enzymes in the plants, such as hydrolytic enzymes, amylase, and protease. Denaturation of enzymes is permanent, irreversible, and owing to the breaking of the hydrogen and ionic bonds that maintain the three-dimensional shape and active site of the enzyme. Once an enzyme is denatured, its biological functions are lost, causing damage to the plant and increased vulnerability to diseases, leading to a disruption in germination and growth or even cell death.

Plant	рН	Reference
Wheat	6.5	(Cornell University Cooperative Extension, n.d.)
Lettuce	6-6.5	(UC IPM, 2017)
Grass	6-6.5	(Beyond Pesticides, 2017)
Mung bean	6.2-7.2	(Ryczkowski, 2018)
Red bean	6-7	(Heirloom Organics, 2019)
Chia seed	6.5-8.5	(Benetoli da Silva et al., 2020)

**Table 9.** Recent studies showing the optimum pH range for each plant.

The results of Experiment 2 support the hypothesis that if the amount of water given to the soil is below or above the optimum amount of water, the germination of the plant will not occur, and its growth rate will decrease. Once the embryo of a plant receives the optimum amount of water imbibition, germination of seeds commences, allowing the activation of enzyme-mediated metabolic processes. Seeds with insufficient water imbibition will not commence germination. Adversely, excessive imbibition of water will cause increased turgor pressure, water stress and excessive osmosis in plant cells, causing vacuoles to burst, leading to a disruption in germination and growth or even cell death (Biology Online Editors, 2019).

#### Soil acidification

Soil acidification is naturally caused by leaching from increased amounts of rainfall. Soil acidity influences plant growth, production, and water use as it results in nutrient deficiencies in soil and plants and increases the impact of toxic elements, especially aluminium and manganese, affecting essential bacteria, earthworms, and other soil organisms (Agriculture Victoria, 2020). In addition, soil acidity affects essential soil biological functions including nitrogen fixation, and increases vulnerability to soil structure decline and erosion (Agriculture Victoria, 2020).

#### Soil alkalinity

Soil alkalinity commonly occurs in semiarid regions where there is poor rainfall distribution or within irrigated areas with poor water delivery, usually associated with salinity (A. Msimbira & Smith, 2020). Alkaline soils hinder root development by limiting water access to the roots, which diminishes plant growth. It causes deficiencies in phosphorus, zinc, and potentially iron, as well as boron toxicity (A. Msimbira & Smith, 2020). The high sodium content commonly results in soil structural problems, which can impact aerobic or highland crop systems (A. Msimbira & Smith, 2020).

#### Effects of climate change to agriculture and food production

Climate change certainly exerts a detrimental impact on agricultural production in regions of the world that are already experiencing water shortages due to declining water supplies, a rise in extreme weather phenomena including floods and severe storms, heat stress, and an increase in pests and diseases. This investigation simulates the impact of climate change on plants. It is evident that pH and water conditions inflicted by the exacerbation of climate change affect the germination and growth of plants. The burgeoning global food demand has urged more food production to feed the rising population, and climate change has been an adverse factor to our food supply. Increased temperatures and more turbulent weather patterns caused by climate change affect the soil pH and water levels. The accelerated evapotranspiration from plants and soils caused by rising temperatures influences the amount of water plants needed to thrive. Heat waves, extreme rainfalls, and droughts have caused severe disruptions in food production and availability, causing crop failures and rising prices of food commodities, hence inflicting populations in food insecurities and poverty.

#### Sustainable agriculture for soil management

Soil is a fundamental aspect of terrestrial ecosystems and agriculture. Climate change affects soil properties through changes in rainfall and temperature, which can cause soil erosion, organic carbon, nutrients, and pH, hence impacting our vegetation, water quality, and agricultural production (Gelybó et al., 2018). This investigation raises awareness and supports that managing soil pH and water levels in their optimal range is crucial for sustainable agriculture practises to obtain optimum plant growth and hence maximise crop yield for our society. Sustainable soil management principles, including selecting appropriate crops, managing nutrients, water cycles, and reforestation, can be used to maximise soil health (AdaptNSW, 2023).

#### **Random errors**

- 1. Human error specifically parallax errors in which measurements of each plant may not be exactly accurate.
- 2. Red beans and mung beans were purchased from supermarket and their viability was uncertain. Seeds have a shell life and lose their viability quickly; therefore, germination rates will reduce as time goes on.

#### **Systematic Error**

PH test strips cannot provide accurate pH values as they change colour in vast ranges. Systematic error can be minimised by using calibrated equipment that are reliable and functioning accurately including digital pH meter and weighing scale.

#### Limitation and improvement

- 1. Digital pH meter can be used for accurate and reliable reading for soil and liquids.
- 2. More trials of the experiment involving more pH ranges can be done to obtain average values whilst reduce random errors to increase reliability of results.
- 3. Alternative to manually measuring the length of each stem of plant repeatedly with a ruler, calibrated image measurement utilising cameras and software programmes can obtain data more accurately and efficiently (Figure 5).

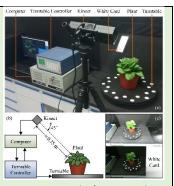


Figure 5. An example of measuring plant growth using software programs and calibrated digital imaging (Hu et al. 2018)

#### **Conclusion**

The experiment supports the hypotheses that If the pH level of the solution is near neutral (pH 7  $\pm$  10%), seed germination will take place and the growth rate in plants will be the greatest, and if the amount of water given to the soil is below or above the optimum amount of water, the germination of the plant will be negatively impacted, and its growth rate will decrease. Climate change affects soil pH and water level, and hence influencing seed germination and growth. As a result, our food production and security will be afflicted. Sustainable agricultural practices for soil management are crucial for optimum plant growth to maximise food yield for our society.

#### Word Count

- 2188 words
- Headings, titles, figure captions, tables, references, and logbook/journal are not included in the word count.

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### **OSA RISK ASSESSMENT FORM**

#### for all entries in ( $\checkmark$ ) $\Box$ Models & Inventions and $\Box$ Scientific Inquiry

This must be included with your report, log book or entry. One form per entry.

#### NAME: Chloe Yaan Yuit Yew

ID: <u>0445-012</u>

#### SCHOOL: Norwood International High School

#### Activity: Give a brief outline of what you are planning to do.

This experiment investigates the effect of extrinsic pH levels and water conditions on seed germination and plant growth by measuring the average length and number of germinated seeds of the chosen plants. This investigation also reflects on the impact of climate change on seed germination and plant growth as well as food production for our society.

Are there possible risks? Consider the following:

- Chemical risks: Are you using chemicals? If so, check with your teacher that any chemicals to be used are on the approved list for schools. Check the safety requirements for their use, such as eye protection and eyewash facilities, availability of running water, use of gloves, a well-ventilated area or fume cupboard.
- Sharps risks: Are you cutting things, and is there a risk of injury from sharp objects?
- Biological risks: Are you working with micro-organisms such as mould and bacteria?

Risks	How I will control/manage the risk
Chemical risks	Prudent laboratory safety practices were followed. Chemical contact was avoided by putting on personal protective equipment including an apron, safety glasses, safety gloves, enclosed footwear, and a surgical mask for preventing inhalation of chemicals. Hair was tied back so that hair did not contact with any chemicals.
Biological risks	The experiment was handled with care as soil contains living microorganisms including bacteria, fungi and protozoa and can cause irritation in nose, throat and lungs, and illnesses from hay fever, asthma to pneumonia-like illnesses if inhaled (bioaerosols). During observation, personal protective equipment was used to reduce the risk of contamination and biohazards including mould growth.
Sharp risks	When cutting plastic bags and cardboard, scissors and cutter knives were carefully handled to prevent cuts. The equipment and apparatus used in this experiment were carefully handled to prevent any incidents.

(Attach another sheet if needed.)

Risk Assessment indicates that this activity can be safely carried out.

RISK ASSESSMENT COMPLETED BY (student name(s)): Chloe Yaan Yuit Yew

SIGNATURE(S): Chloe Yew

 $\square$  By ticking this box, I/we state that my/our project adheres to the listed criteria for this Category.

TEACHER'S NAME: Wenting Yu

SIGNATURE: Wenting Yu

# **Scientific Journal**

18.4.23

soil ptt

# Jan 2023 till 16/4/2023

#### Generating topic of interest:

**General topic:** How does climate change affect germination and growth rate of plant?

**Research topic:** How do pH, light, water and temperature affect plant germination and growth in the context of climate change?

#### **Discussion of ideas & reading:**

Australian soils: pH changes due to climate change affecting plant growth and crop yield – flooding in NSW & Queensland 2022, bushfires in Sep 2019 - Mar 2020, dry climate etc.

Excessive light due to climate change, more intense precipitation.

# 17/4/2023 till 18/4/2023

Independent variables to investigate:

- pH: 3, 5, 7, 9, 11
- light: 4hrs, 8hrs, 12hrs, 16hrs, 20hrs, 24hrs
- water: 5, 10, 20, 30, 40, 50ml

**Plant ideas:** Mung bean, chives, sunflowers, lettuce, cherry tomatoes, snow peas, wheat, grass etc.

**Types of seeds:** Monocotyledonous, dicotyledonous, angiosperms, gymnosperms

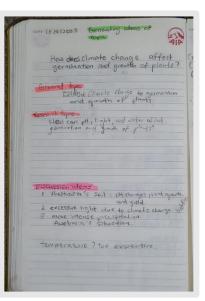
#### **Optimum pH for different plants:**

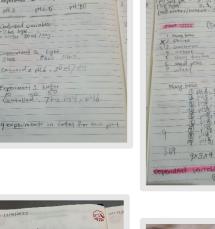
Wheat: pH 6 – 7 Lettuce: pH 6 – 6.5 Grass: pH 6 –7 Cherry tomatoes: pH 5 – 6.5 Mung bean: pH 6.2 – 7.2

		AIR
Types of seeds Monocolyledonou V. Grass (Zoysia)	is plants	
Dicotylectancus - Itethice - anyone Sunflowers - anyone - Sinflowers - anyone - snows peas - in - mung bead - i - mung bead - i - mung bead - i - mung bead - i - mung bead - i	s: anglespernis, the perperms, hadrep ruls colle. 	chemeleo, etta
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about tonuctors	6.0 - 6.5
Chemy-tomataes mens bany. General Wheat	6.2 - 7.2
Granwheat	6.0 - 7.0
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Thinking critically for temperature experiment about its procedure, materials and equipment required. The idea of investigating the effect of temperature on plant growth is not realistic or practical having considered lacking reliable methods due to limited resources including incubators and so on. Therefore, the temperature experiment is eliminated.





# 19/4/23

### Purchased materials from stores and websites:

- 1. Lawn seeds \$8.42 Bunnings Warehouse Brand: Garden Basics 1kg Tough & Hardy Lawn Seeds
- Lettuce seeds \$2 Big W Brand: D.T. Brown Iceberg lettuce
- Soil \$4.50 Mitre 10 Brand: Buy Right All-Purpose Potting Mix
- 4. **Digital pH meter** \$14.99 Amazon AU Brand: Techvida Digital pH Meter Tester





Independent Variables	<b>Experiment 1:</b> pH levels (using water, different concentrations of lemon juice and lye water)	
	<b>Experiment 2:</b> Water conditions (control group, water regularly, excessive amount of water)	
Dependent Variables	Germination and growth rate, measuring weight, plant height, number of germinated seeds	

# 20/4/23

### Developing ideas for Experiment 2: Water

Materials: 9 clean yogurt plastic cups, soil, plant seeds, water

3 types of plant seeds: Wheat, lettuce, grass

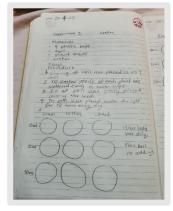
### **Procedure:**

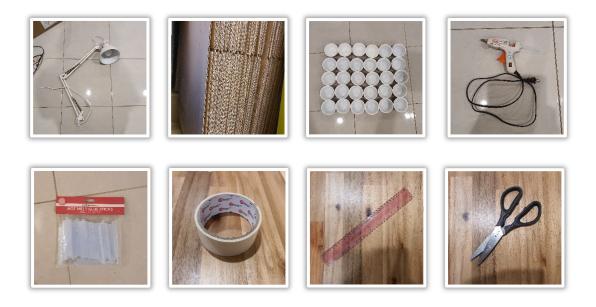
- 1. 60g of soil was placed in all 9 cups.
- 2. 10 seeds of each plant were scattered evenly in each cup.
- 3. 5g of soil was gently placed covering the seeds.
- 4. Each pot was watered with the set amount of water every day.

### Developing ideas for Experiment 3: Light

 Materials: 9 clean yogurt plastic cups, soil, plant seeds, water, 3 grow light lamps (\$25 x3), cardboard, 3 *socket timers (\$8 x3)*, cord extension (\$14), hot glue gun, glue sticks, masking tape, scissors







### 3 types of plant seeds: Wheat, lettuce, grass

#### **Procedure:**

- 1. 60g of soil was placed in all 9 cups.
- 2. 10 seeds of each plant were scattered evenly in each cup.
- 3. 5g of soil was gently placed covering the seeds.
- 4. Three pots of different plants were placed under lighting for 2 hours for 14 days.
- 5. Three pots of different plants were placed under lighting for 12 hours for 14 days.
- 6. Three pots of different plants were placed under lighting for 24 hours for 14 days.

#### Developing ideas for Experiment 1: pH

Materials: 9 clean yogurt plastic cups, soil, plant seeds, water

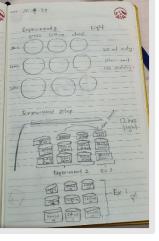
3 types of plant seeds: Wheat, lettuce, grass

**5 PH conditions:** Low pH x2, neutral, high pH x2

### Procedures:

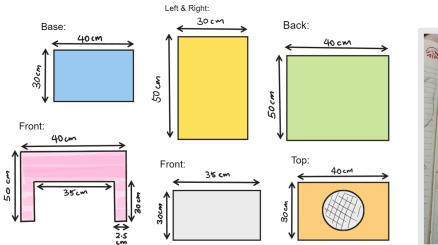
- 1. 60g of soil was placed in all 9 cups.
- 2. 10 seeds of each plant were scattered evenly in each cup.
- 3. 5g of soil was gently placed covering the seeds.
- 4. Each pot was watered with the set amount of water every day.





# 21/4/23

#### Making boxes to keep plants for Experiment 3: Light





#### **Developing ideas** for Experiment 3: Light:

Worst case scenarios: Bushfires in plants, light bulb burns out, thermal and fire risks from extensive running light bulbs.

What to buy: Socket timer x3, cord extension, dimmable light bulbs x3, grow lights x3

Propagators and incubators may be needed.

**Discussion with a retired geologist:** How to alter soil pH, soil chemistry, borrow self-made soil sieve.

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# 22/4/23

Visiting garden centres and grain stores: Magill Grain Store, Heyne's Garden Centre

**Discussion with garden workers:** Methods & toolkits of measuring and changing pH soil.

#### Results:

- use sulphur to decrease soil pH
- use garden lime to increase soil pH
- use Manutec Soil pH Test Kit to obtain pH of soil, \$27.42 - Bunnings Warehouse

#### Purchased materials and equipment from stores:

- 1. **Trowel** \$5.30 Bunnings Warehouse Full name: Trojan Stainless Steel Hand Trowel
- 2. Socket timer \$8 Kmart Full name: 3 Arlec Slimline 24 hour Analogue Timer
- Cord extension \$14 Kmart
   Full name: Arlec 4 Outlet Surge Protected Powerboard

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-	Filtering soil : 1. Soil
	2. Siever
	3. plastic bag
	4 stored trowel
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	Step 1
	A wide plastic bag was cut flat and
	was plared
	Control Vanobics for ex 2 dem
	A Equipment



Filtering soil using a sieve to remove large mulches that may prevent plant growth.

Materials: Soil, sieve, soft plastic bag, trowel, hard plastic bag





# 23/4/23 till 24/4/23

Purchasing materials from Bunnings Warehouse:

- 1. Manutec Sulphur Fine Granules \$16.95
- 2. Richgro Natural Garden Lime \$7.18



23. \$/2023 Went to Bur start Water

**Paperwork:** Working on procedures and adding on the materials and equipment list. Setting out layout and flowchart, and designing framework/components in the scientific report.

**Conducting pilot study for Experiment 2: Water** - to decide the amount and frequency of water needed to mimic climate change.

# 25/4/23

Producing distilled water using distillation method:

- 1. A metal rack and water were placed in the pot with the lid placed upside down on the pot. A bowl was placed on the rack and the water was set to boil.
- 2. Once water boils, ice cubes and a pair of long chopsticks was placed on the pot's lid with an ice bottle balanced securely on top of the chopsticks.
- 3. Distilled water was slowly obtained through this time-consuming process of evaporation.
- 4. Repeat the steps 1-3 until the desired amount of distilled water was obtained.



Calibration of digital pH meter:

The distilled water made was mixed with the provided solutes **to calibrate the purchased digital pH tester.** However, despite multiple times of calibration were attempted, the tester did not work, presenting false and unreliable data.

DATE 25. 4.20.	23	AIP
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Solution: Consider using traditional pH test strips, may not be

perfect. Despite reduced accuracy, it will still be able to differentiate the effect of pH to germination and growth rate.

#### Developing ideas to increase and decrease pH in soil and hydroponics:

Acids: Lemon juice, vinegar, lime juice, sulphur liquid/powder etc.

Alkali: Laundry detergent, lye water, alkaline water from supermarket, baking soda, garden lime etc.

Neutral: Is there any difference in pH among tap water, rainwater, and river water?

# 26/4/23 - 28/5/23

Continue working on data collection, developing ideas, researching for more information, and drafting report.

Thinking critically about the investigation.

The idea of Experiment 3: Light - is just not practical since there are insufficient resources and limited budget to conduct this experiment at home. Reluctantly, the idea is abandoned.

# 28/4/23

### Purchased Alkaline water - \$3.50

Full name: Alka Power Alkaline Water 1.5L, Coles. The alkaline water is labelled as pH 9 -10, however, the solution was repeatedly tested to be pH 8 using pH test strips.

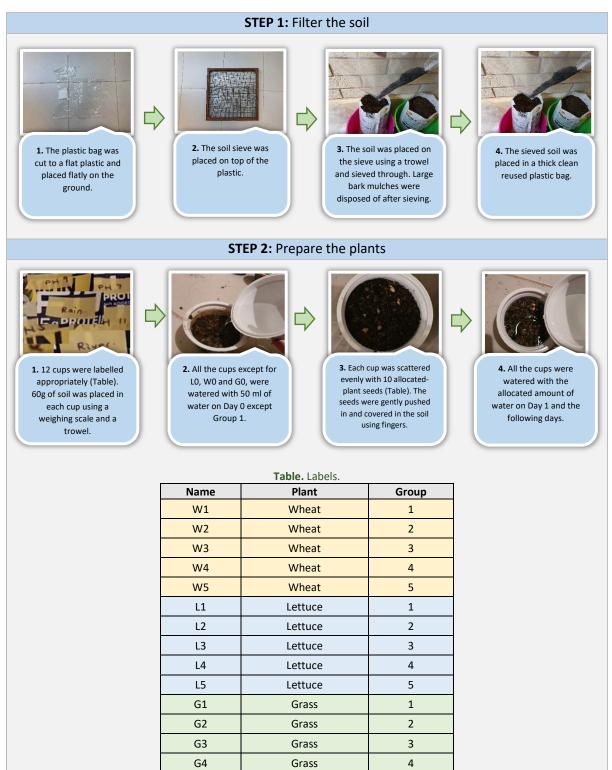
# 29/4/23

### **Conducting Experiment 2: Water**

### **Groups and Labels:**

Groups	Water amount	Days of water intake	Total water intake (ml)
Group 1	No water at all.	<ul> <li>(dry climate, desert)</li> </ul>	0
Group 2	Water once.	Day 0: 50ml	50
Group 3	Water regularly.	Day 0: 50ml, Day 1, 2 & 7: 15ml	95
Group 4	Water more.	Day 0: 50ml, Day 1, 2 & 7: 30ml	140
Group 5	Water the most.	Day 0 & 1: 100ml (flooding)	200

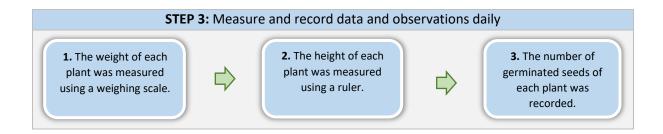
### **Procedure**



Grass

G5

5



# 29/4/23 till 2/5/23

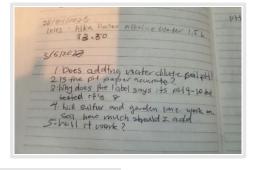
Developing ideas and working on report. Completing risk assessment:

Risks	Control/management
Chemical risks	Prudent laboratory safety practices were followed. Chemical contact was avoided by putting on personal protective equipment including an apron, safety glasses, safety gloves, enclosed footwear, and a surgical mask for preventing inhalation of chemicals. Hair was tied back so that hair did not contact with any chemicals. The equipment and apparatus were carefully handled to prevent any incidents.
Biological risks	The experiment was handled with care as the soil contains living microorganisms including bacteria, fungi and protozoa which can cause irritation in nose, throat and lungs, and illnesses from hay fever or asthma to pneumonia-like illnesses if inhaled (bioaerosols). During observation, personal protective equipment was used to reduce the risk of contamination and biohazards including mould growth.
Sharp risks	When cutting plastic bags and cardboard, scissors and cutter knives were carefully handled to prevent cuts.

# 3/5/23

### **Curiosity - questioning:**

- 1. Does adding water dilute soil pH?
- 2. Is pH test strip accurate and reliable?
- 3. Will sulphur and garden lime work on soil?



# 21/5/23

Determining the pH and molar of lye water:

$C_1 V_1 = C_2 V_2$	
Yu: Civi	
Vo. 660×0.1	
138-21 2 0 7715 34187 BA 1	
Solution Ketters 4.2 Molt	
-578M 10 (5) 5115M 15 (2)	Q.
-> 6.6r. 17 14	
-7 (N 1 3.78	
155 - 571 8 4	
1005 3783	Totals 4789.

K2CO3 LAP - 210 1 10 5 Trap V( k, w, ) = 500 - L = 0.5 L CO3 (aq) + H. Oci = HCO3 (aq) + OHing)  $\frac{\frac{2}{2}}{L} \times \frac{m \sigma T}{2} = \frac{m \sigma T}{L} = m \sigma T L^{-1}$ First dissolution constant, ka, is 4.45×10-7. Second descention ament, kaz is 5.6×10-11 N(t. 10,) = 4.18 × 0.5 = 2.1+ 15 m m commi k2 W3 caps + H2O cis = H co3 caps + Kt caps (4.7753M)  $[4_{2}0^{+}] = \frac{k_{1}[10_{3}^{2^{+}}]}{[100_{3}]}$ 100+100 = 200 cc ATP. 4.8M -> 2.4M 7:1 (1) [403] = K103 Kai -) 1.2M 1=3008 = 4.81 -> 0.5M 1=7 (-1) 4.46 × 10-7 = 10785078.07 M -> 1M. 1: 3.78 lg= 37.8g  $[H_{30}^{+}] = \frac{(4.44 \times 10^{-7})}{(0.7 \times 10^{-7} \times 10^{-7})} \times \frac{4.\times 10.14470}{75.07} 33$ e = M = 1.98 916×10 - 13 M 100g = 378g = 4-789 pH = -10g [H30+] = -log [ 1.9 8 916 × 10-13 ] = 12,70133028

# 28/5/23

Determining the pH of various solutions using pH test strips.

Ingredients to produce the pH solutions: Water, lemon juice, and lye water.

Making solution using dilution method

 $\boxtimes$  = selected pH solutions for experiment



PHI IOM LEMON 20MI Water 122 KJ PHI IOM LEMON 30MI Water 14 251 PHI IOM LEMON 50 MI Water 14 251 PHI IOM LEMON 90 MI Water 16 PHI IOM LEMON 90 MI Water 16395 PHI IOM LEMON 390 MI Water 16395	Allow and a los ( and a policity
V FH3 (Out lenon 390 at water 1:60 PH4 5ml lenon 495ml water boctus, bto PH5 50ml (0.01%) 15ml water boctus, bto PH5 50ml (0.01%) 25ml water 500+32 750 PH5.5 50ml (0.07) 50ml water 500+34 1000	25%
PHI3 10ml life 60ml water 1:6 1/7 PHI3 10ml life 60ml water 1:12 /13 PHI2 10ml life 120ml water 1:12 /13 PHI2 10ml life 190ml water 1:19 1/20 3	7. / 5.7. 2.7.

рН	Ingredients of solution	Concentration (%)
PH 1	10ml lemon, 20ml water	33.33
PH 1	10ml lemon, 30ml water	25
PH 1	10ml lemon, 50ml water	16.67
PH 1	10ml lemon, 90ml water	10
PH 2	10ml lemon, 190ml water	5
PH 2	10ml lemon, 390ml water	2.5
🔀 PH 3	10ml lemon, 590ml water	1.67
PH 4	5ml lemon, 495ml water	1
PH 5	50ml (1%) lemon, 15ml water	0.77
🔀 PH 5	50ml (1%) lemon, 25ml water	0.67
PH 5.5	50ml (1%) lemon, 50ml water	0.5
PH 13	10ml lye water, 25ml water	28.57
PH 13	10ml lye water, 40ml water	25
PH 13	10ml lye water, 60ml water	14.28
PH 12	10ml lye water, 120ml water	7.69
PH 12	10ml lye water, 190ml water	5
PH 11	10ml lye water, 290ml water	3.33
🛛 PH 11	10ml lye water, 490ml water	2
PH 10	5ml lye water, 995ml water	0.5
PH 10	100ml (0.5%) lye water, 100ml water	0.25

PH 10	50ml (0.25%) lye water, 50ml water	0.125
PH 10	50ml (0.125%) lye water, 50ml water	0.0625
🛛 РН 9	50ml (0.0625%) lye water, 50ml water	0.03125

Potential error: pH test strips cannot provide very accurate pH values.

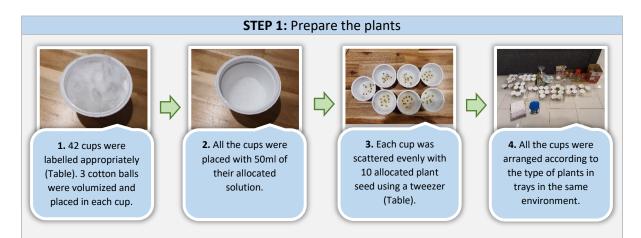
Better option is a digital pH tester which was not available at the time of experiment. The purchased pH tester was not functioning despite many times of calibration.

# 28/5/23 - 11/6/23

Conducting Experiment 1a: Wheat, lettuce, grass, mung bean, red bean, and chia seed

#### **Control Trial**

A control trial was conducted for both experiments to assess the effects of pH levels and water conditions on seed germination and growth.



# **Table.** The cups were labelled. The pH value was obtained by mixing the specific solution withwater using dilution method and measure with PH test strips.

Table 1. Label	Amount of solution	Solution
рН 3	50 ml	1.67% lemon water
pH 5	50 ml	0.67% lemon water
рН 7	50 ml	Tap water
рН 9	50 ml	0.03125% 4.78M lye water
pH 11	50 ml	2% 4.78M lye water
Rainwater PH 7	50 ml	Rainwater (from precipitation)
River water PH 7	50 ml	Surface river water (from Morialta Conservation Park)

### STEP 2: Measure and record data and observations daily

1. The weight of each plant was measured using a weighing scale.



2. The height of each plant was measured using a ruler.



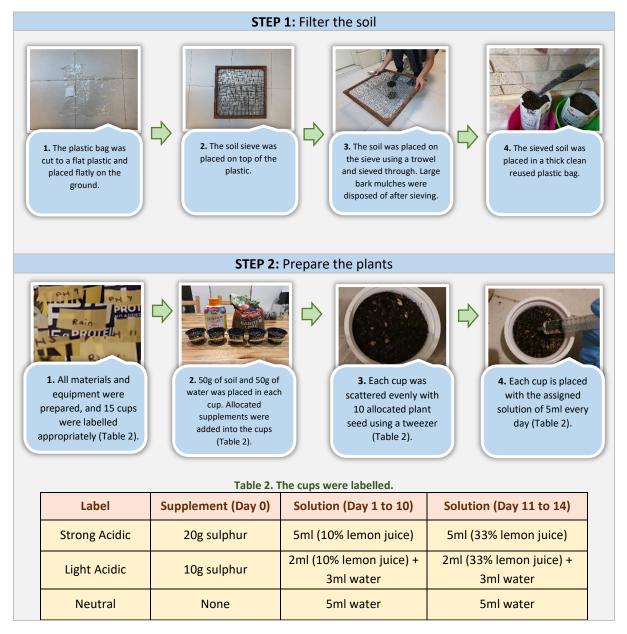
3. The number of germinated seeds of each plant was recorded.

Label	Plant	Amount of solution	Solution
pH 3	Mung Bean	50 ml	1.67% lemon water
pH 5	Mung Bean	50 ml	0.67% lemon water
pH 7	Mung Bean	50 ml	Tap water
рН 9	Mung Bean	50 ml	0.03125% 4.78M lye water
pH 11	Mung Bean	50 ml	2% 4.78M lye water
Rain PH 7	Mung Bean	50 ml	Rainwater (from precipitation)
River PH 7	Mung Bean	50 ml	Surface river water (from Morialta Conservation Park)
рН 3	Red Bean	50 ml	1.67% lemon water
pH 5	Red Bean	50 ml	0.67% lemon water
pH 7	Red Bean	50 ml	Tap water
pH 9	Red Bean	50 ml	0.03125% 4.78M lye water
pH 11	Red Bean	50 ml	2% 4.78M lye water
Rain	Red Bean	50 ml	Rainwater (from precipitation)
River	Red Bean	50 ml	Surface river water (from Morialta Conservation Park)
рН 3	Wheat	50 ml	1.67% lemon water
pH 5	Wheat	50 ml	0.67% lemon water
рН 7	Wheat	50 ml	Tap water
рН 9	Wheat	50 ml	0.03125% 4.78M lye water
pH 11	Wheat	50 ml	2% 4.78M lye water
Rain	Wheat	50 ml	Rainwater (from precipitation)
River	Wheat	50 ml	Surface river water (from Morialta Conservation Park)
рН 3	Lettuce	50 ml	1.67% lemon water
pH 5	Lettuce	50 ml	0.67% lemon water
pH 7	Lettuce	50 ml	Tap water
рН 9	Lettuce	50 ml	0.03125% 4.78M lye water
pH 11	Lettuce	50 ml	2% 4.78M lye water
Rain	Lettuce	50 ml	Rainwater (from precipitation)
River	Lettuce	50 ml	Surface river water (from Morialta Conservation Park)
рН 3	Grass	50 ml	1.67% lemon water
рН 5	Grass	50 ml	0.67% lemon water
рН 7	Grass	50 ml	Tap water
рН 9	Grass	50 ml	0.03125% 4.78M lye water
pH 11	Grass	50 ml	2% 4.78M lye water

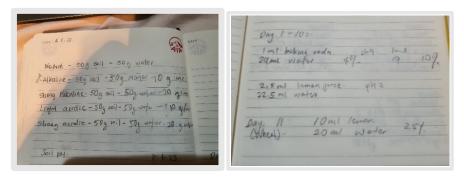
Rain	Grass	50 ml	Rainwater (from precipitation)
River	Grass	50 ml	Surface river water (from Morialta Conservation Park)
pH 3	Chia Seed	50 ml	1.67% lemon water
pH 5	Chia Seed	50 ml	0.67% lemon water
pH 7	Chia Seed	50 ml	Tap water
рН 9	Chia Seed	50 ml	0.03125% 4.78M lye water
pH 11	Chia Seed	50 ml	2% 4.78M lye water
Rain	Chia Seed	50 ml	Rainwater (from precipitation)
River	Chia Seed	50 ml	Surface river water (from Morialta Conservation Park)

# 4/6/23 - 19/6/2023

#### **Conducting Experiment 1b:**



Light Alkaline	10g garden lime	2ml (4% baking soda water) + 3ml water	2ml (10% baking soda water) + 3ml water
Strong Alkaline	20g garden lime	5ml (4% baking soda water)	5ml (10% baking soda water)
3	TEP 3: Measure and r	ecord data and observat	ions dally
<ol> <li>The weight of each plant was measured</li> </ol>		he height of each nt was measured using a ruler.	<b>3.</b> The number of germinated seeds of each plant was



Label	Plant	Supplement (Day 0)	Solution (Day 1 to 10)	Solution (Day 11 to 14)
Strong Acidic	Wheat	20g sulphur	5ml (10% lemon juice)	5ml (33% lemon juice)
Light Acidic	Wheat	10g sulphur	2ml (10% lemon juice) + 3ml water	2ml (33% lemon juice) + 3ml water
Neutral	Wheat	None	5ml water	5ml water
Light Alkaline	Wheat	10g garden lime	2ml (4% baking soda water) + 3ml water	2ml (10% baking soda water) + 3ml water
Strong Alkaline	Wheat	20g garden lime	5ml (4% baking soda water)	5ml (10% baking soda water)
Strong Acidic	Lettuce	20g sulphur	lemon juice)	5ml (33% lemon juice)
Light Acidic	Lettuce	10g sulphur	2ml (10% lemon juice) + 3ml water	2ml (33% lemon juice) + 3ml water
Neutral	Lettuce	None	5ml water	5ml water
Light Alkaline	Lettuce	10g garden lime	2ml (4% baking soda water) + 3ml water	2ml (10% baking soda water) + 3ml water
Strong Alkaline	Lettuce	20g garden lime	5ml (4% baking soda water)	5ml (10% baking soda water)
Strong Acidic	Grass	20g sulphur	lemon juice)	5ml (33% lemon juice)
Light Acidic	Grass	10g sulphur	2ml (10% lemon juice) + 3ml water	2ml (33% lemon juice) + 3ml water
Neutral	Grass	None	5ml water	5ml water

Light Alkaline	Grass	10g garden lime	2ml (4% baking soda water) + 3ml water	2ml (10% baking soda water) + 3ml water
Strong Alkaline	Grass	20g garden lime	5ml (4% baking soda water)	5ml (10% baking soda water)

# Results: Experiment 1a.

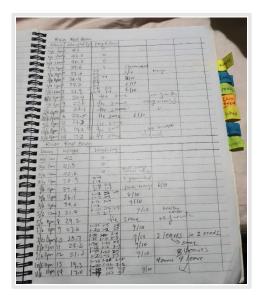
# Mung bean:

PH 3 Green Ren Phant of the pha	Hours Weight (2) Length (201) - De un (41) - De un (41)
PH7 Green Been Hours Weight (3) Longh (m) 27/6 1-6 H1 0 which is the set of the set o	PH II Green Bean Heurs Weight (g) Length (mm) (june 29% h = 411 0 29% h = 411 0 30% h = 411 0 29% h = 411 0 5% for 140.3 0 Sect transporter 30% h = 29.3 1.3 0 1/2 mp 1 5 6.7 14 22 1/2 mp 1 5 6.7 14 12 1/2 mp 1 5 6.7 14 12 1/2 mp 1 5 6.7 14 12 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1/2 0 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 0.3 17 5 mod by 100 1/2 mp 1 2 mp

Heurs	Weight (4)	Longth (cm)		11		
29/5 lan	43	0				
30K 100	41.8	0				
Soft lim	40.9	3-3 1-7 1-1	7 gamenated			Bel
31/5 11pm	39.3	3-20 112 1-3	9 pornerefe	1		-
1/6-11/00-	38.7	1-20 5-15 HI 1-10 1-4 5-17 2-11	9 germante			N
2/6 11pm	37.3		9110			
5/6 [[pm]	35.9	1-35 22024 1-30 2-15 2-45 2-20 1-15	9/10			Le
5/6 12Am	34.1	2-45 2-20 1-15	9/10	1		
5/6 upm	32.4.	2-30 2-20 1-2	9/10	the same		GI
6/6 Mpr 9	30.9	2-55 3-20 1-5		two seads	harlenes	C
- 7/6 lipe 10	28.7	1-30 1-20 1-12 1-6°2-25 1-15 1-6°2-25 1-15 1-9° 1-45 2-12 2-85 1-26 1-8	3 16/10		have lever	5
Styllar 1	26.8	10 1-45 2.12	9/10- 3	-lage len	res	
= g/b 1/m 12		2 951-50145			nis	
3 Kolo 14m 13	236	1= 110 1-100 1-50	-12 011	10		
W/ Man IL	1 21.5	-105 1-56 1-55 4-120 1-100 1-50	2-12 0	The.	and a second second	-
		1-115 1-62 1-2	1-3 /			
Reinf	Basa					-
Rain Gre						
	Jeight (5)	Length (am)				
29/5 lan 0	41	0				
30/5 [ hm ]	41.2	0				
39/5 110-2	31.1 13	-10 2-6	9 germinat	ed.		
		1-5 1-3		1 1.		
	38.2	2-6	9 acrimina			
31/5 1pm 5	38.6	2-6	and	year'		
31/5 1/pm 5 1/2 1/pm 5	38.6	-20 3-15 -10 1-20 1-4	9/10	4a1		
345 110- 3 46 110- 5 46 110- 5	38.6 37.3 36.2	20 3-15 10 1-20 1-4 1-12 2-15	9/10 9/10			
34/5 11pm 5 4/6 11pm 5	38.6 37.3 36.2	-20 3-15 -10 1-12 3-15 1-52 2-15 1-52 2-15	9/10 9/10	<u>+a</u>		
34/5 110- 3 4/6 110- 5 4/6 110- 5	373 36.2 34.5	-20 3-15 -10 -20 1-4 -12 3-15 -32 2-15 -25 1-12 1-1 -50 1-25 (-15	9/10 9/10	944		
345 1100 5 1/6 1100 5 7/6 1100 5 7/6 1100 5 5/4 120007	38.6 373. 36.2 34.5 33.2 33.2	-20 3-15 -10 -20 1-4 1-12 3-15 1-32 2-15 -35 -25 1-12 -1 -50 1-25 (-15 -45 2-20 1-3 -45 2-20 1-3	9/10 9/10			
3/15 1100 C 2/6 1100 C 2/6 1100 S 3/6 1100 b	38.6 373. 36.2 34.5 33.2 33.2	-20 3-15 -10 -20 1-4 1-12 3-15 1-32 2-15 -35 -25 1-12 -1 -50 1-25 (-15 -45 2-20 1-3 -45 2-20 1-3	9/10 9/10 10/10 1-10/10 1-10/10			THECOY
31/5 1100 5 1/6 1100 5 7/6 1100 5 7/6 1100 5 5/4 120007	38 .6 37 3 36 .2 34 .5 33 .2 33 .2 31 8 29 .7	$\begin{array}{c} -20 & 515 \\ -10 \\ -20 & 1-4 \\ -22 & 1-4 \\ -52 & 2-15 \\ -251 & 1-12 & -12 \\ -251 & 1-12 & -12 \\ -251 & 1-12 & -12 \\ -251 $	9/10 9/10 10/10 1-10/10 1-3 9/10	o two seeds b		T decoy
31/5 1100 5 1/6 1100 5 7/6 1100 5 7/6 1100 5 5/4 120007	38.6 373 36.2 34.5 33.2 31.7 2917 28.9	-20 515 -20 545 -22 544 -23 -15 -23 215 -32 215 -32 -15 -32 -15 -32 -15 -45 -20 1-3 -45 -20 1-3 -45 -20 1-3 -45 -20 -45 -20 -5 -5 -5 -5 -5 -5 -5 -5 -5 -5	9/10 9/10 10/10 1-10/10 1-3 9/11 t	o two seeds b	nuc loaves. have long	T Tecoy
21/5 11/00 1 1/6 11/00 5 1/6 11/00 5 5/6 11/00 6 5/6 11/00 7 7/6 11/00 7 7/6 11/00 7 7/6 11/00 7 7/6 11/00 7	38.6 373. 36.2 34.5 33.2 33.2 31.8 29.7 28.9	-20 315 -10 -20 1-4 -20 1-4 -20 1-4 -25 1-4 -25 1-42 1-1 -25 1-42 1-3 -45 2-20 1-3 -45 2-20 1-3 -45 2-20 1-3 -45 2-20 -1-20 2-15 -1-20 2-	9/10 9/10 10/10 1-10/10 1-3 9/11 1-3 9/11	o two preds l 3 seeds		THecog
215 117- 1 46 119- 5 7/6 119- 5 5/6 119- 6 5/6 119- 6 5/6 119- 6 6/6 119- 7 7/6 119- 10 8/619- 11	38.6 373 36.2 34.5 33.2 31.3 29.7 28.9 26.7 1 20.7 20.7 2	$\begin{array}{c} 200 3^{15} \\ +0 \\ 1-20 \\ +20 \\ +20 \\ +20 \\ +20 \\ +12 \\ +21 \\ +21 \\ +21 \\ +20 $	9/10 9/10 10/10 11 (0/10 1-3 9/10 1-3 9/10 1-3 9/10	two preds l 3 seeds 10 3 plant	have lears Acaves	
21/5 11/00 1 1/6 11/00 5 1/6 11/00 5 5/6 11/00 6 5/6 11/00 7 7/6 11/00 7 7/6 11/00 7 7/6 11/00 7 7/6 11/00 7	38.6 373.3 36.2 34.5 33.2 33.2 31.3 29.7 28.9 26.7 24.4.15	200315 +0 +0 +12 +12 +12 +12 +12 +12 +12 +12	9/10 9/10 10 10/10 10 10/10 10 10/10 10 10/10 10 10 10/10 10 10 10/10 10 10 10 10 10 10 10 10 10 10 10 10 1	two preds l 3 seeds 10 3 plant	have leaves Acaves 3 grow	<u></u> ک
215 117- 1 46 119- 5 7/6 119- 5 5/6 119- 6 5/6 119- 6 5/6 119- 6 6/6 119- 7 7/6 119- 10 8/619- 11	38 16 37 3 36 2 34 5 33 - 2 34 - 5 33 - 2 3 - 4 2 - 9 - 7       -	200315 +0 +0 +12 +12 +12 +12 +12 +12 +12 +12	9/10 9/10 10 10/10 10 10/10 10 10/10 10 10/10 10 10/10 10 10/10 10 10 10/10 10 10 10/10 10 10 10 10 10 10 10 10 10 10 10 10 1	two preds l 3 seeds 10 3 plant	have lears Acaves	<u></u> ک

Hours	Weight (1)	Length (ma)			
2915 am 01	41	0			
30/5 am 17	40.3	U	yours sterne	d	
30/5 11pm 2-1	38.4	2-10 5-5	8 germinated		
31/5 11pm 3	37.5	3-20 2-6			
1/6 1/00 4	36.1	1-20 1-1 1-6	& genningter	8/10	
2/6 11pm 5	34.9	9-23 1-12	light brown	8/10	
3/4 Mpm 6	33.2	5=30 2-5	9/10		
S/c 12am 7	31.7	2-45 1-40 1-	5 monthly for	the seed.	8/10
5/6 11pm 8	30,0	the same			mould.
5/6 mang	28.6	2-95 3-15		and the second s	have leaves
7/6 (4m 10	26+7	2-35 2-15		5 speds ho	e ( carest man of
16 17pm 1	24.2	2-62 315	8-/10	55 Source	and the second s
16 10pm 12	22.3	3 20 3 15	8/10-	Usame	- Laborez-
0/6 (lom 13	21.2	1-30 1-60 2-10		Egrowin	

# Red bean:



pH3 Red Bean		pH & less of pH II greate	st differen	in colour.
Hours Weight	5) Lever lh (cm)			
34/5 10 0 42	0			
30/5 100 41.6	0			
31/5 124-7 40.3	0			
\$1/5 lipe 3 38 5	= 1	3 germaneted		
1/0 11pm 1 37.1	5-1 2-2	mouldy spot	y 8/10 Day	Fernage
2/6 11 pm 5 35.4	2-2 +4	very mouldy.	8/14	ander of
3/4 11pm 6 33.7	1-12 2-2	glio mon	e needed than	phs lipdes
5/6 12mm 7 31.8	4-5 2:3	9/10		
5/611 7 29,6	the same	ng querte		
6/6 11pm 19 2714	2822	rid M	00101 1	
7/6/10-2518	1-13 3-5	10/10 V		wo leaves
8/6 ym 11 23 15	1-20 1-10 1-1		is her	nly mandaled.
9/0/m n 21.6	the same		- T	ming
16/6 11pm 13 20,1	1-30 100 100	Herend ditin 3	3plats	4
19/6 Rypn 14 17.7	1-90		2/10	
K. C.				
PHS Red Bear				
Hours Weight (3)				
27/15/4- 0 42	0			
30/= 1== 1 41.1	0			
sily 12m 2 39.9	0			
31/5 Mpm 3 38.5	3-3	discolouration y	germinded	
16 Mpm y 36. 9	2-8 2-2	spotty mouldy	6/10	
16 (1pm 5 3514	3-8 2-7	8/10	mondaly.	
1. Mpm 6 33.2	2-4 1-12	10/10	VEN MOU	ldy.
1- 1	4-8 1-2	10/10		
16 12an 7 31.5	2-12 3-5		h vary	worlds
12 mar 8 29.6	-the San		n very	
6 11pm 9 27.4	2-2046 1-3	10/10		a subject of the local division of the local
6 Hym 10 25. 3	the same			
	the so	ne fa		leaves.
8/6/1pm 11 23.4				
francisco and and and	1-25 MIS HIZ 220 4-6 1-3	(The same)	four	ent
1 million and the second second	1-25 1-15 +12 220 4-6 1-3 fle Sart	and the second s	four /	

PH7 Red Be			
Hours Weight (3)			
29/5 / 20 41	0		
30/5 lem 1 40.4	0	light evange	
31/5 12m 2 39.2 31/5 110m 3 37.8	5-2	3 germoneted	
	1-10 1-2	4/10	
2/6 1/pm 5 34.7	2-5	6/10	
3/6 11pm 6 32.6	1-7 1-6 1-2	8/10	
\$1612am 7 30.6	1-12 2-3 1-2 27.10 2-1 1-20 1-5 2-3 2-15 2-3	8/10	
\$16 Mar 28.0	the same	8/10	ne gente
#6/611pm 9 26.2	1=25 1-15 3-2.	8/10	j
> 1/6 Upm 12 2415	1-25 1-15 3-9	010 8/10	the same.
\$/6 mm 11 22.3		the sam	re mondy
3 16 lip 12 20.2	the Same		
10 100	the same	no	marila 1-
Tab Low 1	1116 200 (	V	
PH9 Red Bea	1		
	Length (cm)	Colour	
	o		
29/slan 42	0	yellow conton	
30/5/am 41.6	0	swarge cottar	
31/5 1200 40.3			
31/5 11 pm 39.0	3-1 1-6	Dark erange	
1/6 lup 37-8	1-2	Dark ange	4/10
-Line -	3-3 1-2 1-1		7/10
1 - P	and an	19/10	no-1 mouldy.
3/6 11pm 6 34.3	1-12 2-4 2-6 2-3 14 +20 35 3-1 1-8 13	9/10	
5/6 12am 7 31.9			mille
Jo 12 2916	the sa	1-12 3-6 1	A
6/6 11pm 7 2814-	7 the 500	= 1-20 1-3	3-1
10 Tr I	fle S	ame .	
7/6/1pm/10 26.2	FFG	-	
86 mm 11 24.2	The	Samt	leave.
0 (p 11m 12 2/19	I The	Some	1 Para
	of the	Same"	
	- portanting and a state of the	she.	V/

### Wheat:

= Hours We	ight (g)	Height (m)		
79/5 10m 0	42	0		
	40.0	Ð		
305 lan in 305 lan in	39.0	4	multi roots	10 germanoted
51/5 11pm 3.	37.8	2-17 1-7		
1/6 1/m 4	36.0	\$10 3-12	10/10	
2/6 11pm 5	3416	2-40 1-32 1-20	1-16 10/10	
3/10 April	32.6	2-75 4-45 2-65 2-30	10/10	
5/6 12007	30.7	2-100 2-79 1-56	10/10	
5/6 Mpm 8	2819	3-115 1-95 1-75	1-100 10/10	
4/6 1/100 9	27.2	7-138/1-130 1-185	1-85 Mojio	
7/0/1/20/10	25.1	1-152 1-148 1-1	1-101-125	10/10
Ste horn h	23.0	1-160 1-152 2-1	25 190	10/10
916/100/2	21.1	2-175 1-160 1	136 1-30	10/10-
10/61mm 13	19,5	2-170 2 2-		1011

Hours	Weight (3)	Length (cr)	Colour		
201/5 lam	42	0			
30/5 1am	41.6	0	seeds turned bya	14	
31/5 12mm	40.3	0	Dark orange relour (cotten)		
31/511pm	39.1	0	O germinet ed	trauid turner	black
1/6 Mpm	37.8	0	0/10	Black Seeds	
2/6 lipm 2	36.1	0	0/10	SAME BLA	cetter)
3/6 142-6 3	33.8	0	0/10	Black m	us d. i
5/6 12am 1	31.9.	0	010	8 moule	culay-
5/6 1200 3	30,0	0	0/10	Black	J
6/6 1mg	28,4	0	0/10		
76 11/10 :	26.2	0	0/10	1 1	the same
8/6 14m 11 :		0	010		
016 (ipm/12 -	22.0	0	olu 1	would y	Skimple,
10/6 lpn 13	20,1	0	0/10	100	home C

PH : Hours	3 Wheat Weight (a)		1	······	
25/20 Jan		0			
	1 41.5	0			
2-6-11pm -	2 40.7	Q-2 1-4 110			
31/5 11pm	38.7	2-3 1-7 5-6 1-1	I motding (pret	15 (1004)	
2/6 1/pm 4	36.6	3-5 3-5	I monded 10/10	extremely	
3/6 11pm 6	33.9	2-13 2-8 2-3	10/10	mondoy.	
5/6 12am 7	32.1	1-40 2-20 1-12	10/10	all montaly	
Sto lipm 8	29.5	2-25 2-162-4	10/10	one partich (ce	11001).
20 6/6 Mpr 9	28.0	2-35 2-15 1-5 1-85 (1-40/2-15 (1-3 1-45) 1-25 3-12			
- 1/6 (how 10	26.6	1-103 1-35 1-20 2-70 1-50 1-30 1	-15		
3/6 Mpm 11	23.8		-45 I-4		
3 9/6 lym 12	21.8	1-90 1-70 1-45 1-130 1-10 2-65 1-1185 1-90 1-5		0/10 norldy	
10/6 lipm 13	20.3	1-100 1-110 1-80	1 -10 1-15 10	10	
11/6 Upen 14	18.4	1-145 1-120 1-600	1-10 1-22	10/10	
PHS W	heat		house descriptions des de l'étamones	A non-resultion to the second s	
	e.54+ (4)	Length (mo			
29/5 lan 0	43				YNYDD CHTER COLLEGE CHTER CHTE
30/5/an 1	44.0	0			
3/5 11pm 2	1100	2-7 2-5 1/10			
	41 0 4	-10 01			
1 - p		1-15-12.2-8	2 moulded.		
1/6 1 pm 19	9012	1-13 2-1 1-5			
2/6 apry 5	38.6	2=2612-26 1-16		ulded 10/10	
3/4 Mpm 6	36:12	-60 E-110	10/10	spotty moul	dy. 5 seeds mo.
5/6 12am 7	2710 2	-100 2-80 2-60 - 85 2-70 1-55	10/10		-
5/6-11pm8	34-412	-120 2-100 11-90 -110 2-90 1-7	5 10/10.		
6/4 um 9		130 1-128 (1-115 1-100 150 1-122 2-10 + 8	1-80 10/10	2	
1. I have been a second	2061	152 4145 1.132	1-1161-110	10/10	
7/6 14m/0	CICP	145 1-138 1-12	6 1-1:8 1-100		
8/6 Mpm M	21.0 2-	150 2135 1-115		10/10.	
916 Man 12	2210 1-	100 1-155 1-145	1-110	10/10	
hold them 13	24.3 1:	175 +160 1-135	1-110	10/10	
11/1 1/ 11/	21.8 2-	105 1-150 1-14	0 1-145	10/10	

	7 Wheat			Clisceds.		の水水水学学生の	PH II	whent	Length (-)			
Hou	3 Weight	(g) Lengthian	n		-			Jershy	20 prove /			
- 215-10						R/s	Stys Iam O	413	0			
395 10						3/5 -	345 lam Id		7-2	7 generated		
30/5.14		1 8-2	9 germinited	7		34/4	30/ 11p= 20	9010	2-3 7-5	10 generated		
245 11p			10 germinete 10/10	a		315	345 lam ld 345 lam ld 346 llpm 2d 515 llpm 3d	37.1	4-5 1-2 14	10/10	2 mondy	
2/6 11pm	m 9d 3b.	- 11-401-26 2-1		7.89		16	46 lipm 4d	25.7	1-10 26 32	10/10	montay	4 stopped grassing
3/6 11 pm	6d 33.		10/10		8	2/6	2/6 (lym sd	22 0	2-12 2-6 8-1	10/10		and and a second s
5/6/201	172 210	2-90 1-80 4	N Jaha		t,		3/6 mpm 6d	2218	7 - 2 2 - 3 7 - 5 4 - 5 4 - 5 1 - 2 + 7 4 - 5 1 - 2 + 7 1 - 8 - 3 - 1 - 5 1 - 8 - 3 - 1 - 5 1 - 8 - 3 - 5 - 7 1 - 8 - 3 - 5 - 7 1 - 8 - 3 - 5 - 5 1 - 5 - 1 - 5 - 1 - 5 1 - 5 - 5 - 1 - 5 - 1 - 5 1 - 5 - 5 - 1 - 5 - 1 - 5 - 1 - 5 1 - 5 - 1	10/10		
s/6 lipm	8d. 29.	2 1-95 1-75 1-16 1-95 1-16 1-95	1-10 10/10		8		5/6120m 70	30.6	1-35 1-20 1-5	1/10	a little bit	
6/0 11pm	90/ 28.1	1-120 1-120 1-100 PL	10/10		1		5/6 upm 8d	29.0	1-25 1-20 1-5	me) 7/10	money	
	108 261	2 1-16-135-1-122	1-112 1-103	10/10			5 6/6 Mar 10	27.0	1-45 2-30 1-8	1010 7/10	-	
	1d. 23.6	1-152 1-140 2-1	2-715	10/10.			7/6/pm 100	Elio	the same	1 7/10	+	
	RA 2117	1-165 -150 4	-130 2-126 S	Addio			- franking -	27 1	1-40	1/10		
10/0 lipm 1	30/ 19,5	1-175 1-150 34	2-130	1911			9/6/10 1201	201	1-92 1-25 1-6 2-45 1-25 1-6 3-30 1-25 1-6 2-97 1-25 1 2-32 1-7	7/10		
11/6 lign 1	4d 17.5	H175 3-150	1/35	10/11			OFTIMISM	2019	3-30 1-25 1	-61 7/10		
	wheat	13100 21101	<u></u>			2	11/611pm 14d	18.9	2-30 1-2	Y		
The second second second second	Weight (3)	Lenst (cm)					Rain Whe	at	cenghith (*			
- 1	41	0					Rt lan 0	42	0			
245 Jam 0 275 Jam 1d	39.4						221	41.2	0			
							off and	40.5	3-7] 7-2) ~	10 geores	Col	
30/5 11pm/2d	38.5	2-5 8-2					39/5 11pm 20		3-20 1-12 2-5			
31/5 [lpm 3d.	37.91	3-12 7-5					31/5 11pm 3d	38.9	1-20 5-10 1- 4-15 1-6 1-38 1-26 3-1 2-33 3-27	9 10/10		
1/6 1/pm/40	25.5 1	1-18 1-12 +5 1-15 2-10 1-3 1-35 3-32 1-23	2 moulded				16 llym 4d	36.9	4-15 -26 3-1	2 10/10		
2/6 1/pm /5d			1-2 1910	5 monided			2/6 1pm 50	35.7	2-33 3-27	FO 1 -	1 mail	ded
3/6 11pm 6d	32.3 2	-70 9-80 1-2 -65 1-35 -100 2-85 1-60 -95 2-80 +			2men prist		ali una ba	34.3	1 65 2-40	and an and the fordation and	1	and a second
	30.5	-65 1-35	10/10.	all mouldy	dend		3/6 upm 6d	32,1	2-901-701-	49 10/10		
3/6 12 am 7d	30.5 3	-95 780 .	9/10	all monely	1 mould	9	5/6 12am 70		3-80 3-60	5 3-651 1	0/10	
36 Mpm Fol		-122 4115 1-85	9/10	marido	n the seed.	1	5/1 Myon 81.	29.8			12-75 LC	0/10
6/6 1mgd	27.2 1-	1401-136 1-123	9110	mouldy		9	6/6.11pm 9/d	28.9	La transmission	1-120 1- 103 2-	1-84	10/10
1/6 16m/102	25.2 1-1	1401-136 1-123 1383-128 1-100 154 1-1082-192 1- 1502-195 1-137	15 040				7/11/2/10/	27.9	1-135 1-12; 1-130 1-117	1-107)1-10	11-80	
Sta hom ud.	220 11	502-145 1-137 70 1-120	9/10	whithould			7/ 11pm 10d		1-135 1-125	1-110 1-85	1 1	
	5,0 3-1	60 3-145	-100 9/10.	one s	1.	#	8/6/imild	2511	2-130 1-120		10/	10
9/6 Mar 120	20.7 1	10 1-150 1-120 10 3-145 10 3-145 2-160 1 15 1-16 2-160 1 15 1-165 2-185 10 1-170 1-160 10 1-170 1-170 10 1-170 10 1-170 1-170 10 10	-150 9/00	two len	4 Cmg	# 50	9/64pm 12d	229	H140 2-120	2-100		
0/6 lipm 13d	19 2 11	80 1-170 1-16	1-142				121	212	1-155 2-130	1-190 1-80	101	Contraction of the second seco
the april 14 d	2-	187 1-174 1-155	1-140 91			3	10/6 lipm 13d	21.3	1-155 2-130 2-145 1-110 1-160 1-140 2-155 1-139	1-105 1-95		10/10
The working of	16.8 4-1	001100100	1.00	7/10		-	116 Mpm 140	18.]	2-155 1-139	1-1001-85		Accounting

### Lettuce:

P43	lettuce		
Hours 30/5 100	Length	Wershit 39.4	
30/5 120	~10	38.9	
31/5 110		37.8	10 generated
1/4 Ilyou	3 2-3	35.9	when high berman sects
Alt Ilpus	3-9	341.6	c/10 all bending down short steve with Let
36 Up	56	32.5	
> 5/6 12an	16	28.8	10/10 mondy NO GROWTH GU
6/10- Mpm S	6	27.3	the came no get
3 7/6 Wym"		25.2	to/10 Mouldy
8/6 (you 10)	5	23.4	one leave
916 up 1	5	- 21.4	presan
Co/6/140-12	15	19.5	10/00
116 Ilym 1	5 5	1810	10/10 the leaves
12/6 liper 14		16.5	10 fis the record
PH 5			
30/5 lam			
31/5 12gm			
31/5 11 pm	5		10 germinaled
51/5 1.0-1	9-10		9/10
1/6 11pm	1-8 4-0	35.5	10/10
26 Mpn	3-5 2-10		10/10
lin I	2-15 2-15	33,9	and a second discount of the second discount
300-1	2-10 1-15	\$2,3	9110
	1-452-25/1-1	2 30.8	10/10 NOT Mouldy.
	4-401-30at		10/10/
	40 1-25 1-	29.1	- Automation of the second sec
Old Um de	1-50 3-30 1-1	· 27.6	1 (0/10
6/6 Upm Sa	2-50 3-35	10 26.1	10113
7/6 11pm 9			10/10
7/6 11pm 9	1 0 0 10 1.		
7/6 11pm 9 /6 11pm 10	260 \$ 40 1.	A	
7/6 11pm 9 /6 11pm 9 /6 11pm 10	2-2-25	22.1	(0/10 -) -
16 11pm 9 6 11pm 10	260 \$ 40 1.	A	10 -27

PHT Lettuce		
Hows Longth	Weight	
3995 lam 0 0	39.3	
31/5 12an 0 31/5 11pm-2 6	37.8	10 germanifed
	56.3	9700
216 you 9 3-18 2-12	35.0	9/10
3/6 11pm 5 5-32	33.1	9/10
5/6 1247 6 4-40		9/10
5/6 (1Pm7 5%	3011	9/10 one typy demple same
6/6 Mpm 8 2-95 2-42	28.3	
6/6 lipm & 275 249 7/6 lipm 9, 3-45 1-40	27.4.	9/10
8/6 Mm 10 the some	25.2	9(1)
9/6/man 11. the some	23.Z	gla
10/6 lign 12 the same	22.1	19/10
11/6 4 13 the same	19-8	9/10 47.22
126 11p 19 the sure	18.5	9/10 41.22
PH 9 Lettuce		
Hour Lough		
29r lang 500	40.3	
31/5 1200/ 0	39.2	02
31/5 1/pm 7 6	37.8	PILO germinded
	36.1	
10 1-20 6-15	34.6	10/10 2 leaves between of
26 11pm 4 1-18 2-12		10/10 2 leaves between of
5/6 1/ pm 3 1-27	32,5	Idat mouldy 10/10
5/6 [2am 6 6-35]	31,1	10/10
\$ 5/6 11pm 7 4-45235.	9 29,1	
6/6 11pm 8 4-45 2-35 me	1 27.8	1011
6/0 mp 0 4-40 Sam		10/10
7/6 hpmg the same		1
all limito the som	1. 24.3	and a second sec
= 9/6 mm 11 - fre same	22.3	ANTERNA CONTRACTOR CON
10/6 Hom 12 the sam	20.3	10/10
= 10/6 1mm 12 the som	18.	4 10/10
11/8 1/m/3 pe Same. 12/6 1/m 14. 2-45 2-55	16.	41.0

PH 11 Lett	4°C.	
Hours Length	Weight	
37510mp0	40.7	
3/15 12-1 0	39.7	
- 3/5 llpm2 2	38.8	1 4 germaretade
1/6 11pm3 4-3	37.0	8/10
21611 11 2-1 -1	36.5	black the (seeds) \$/10
3/6 11 11 5-6	33.9	brownish stem bend down stem.
5/6120 6 5 the sa	me. 32.5	brownish of em bend dewn stem. black 2 dat montaly
5/6 up 17.5 the same	29.5	stepped gring brank
Elerimit She same	28,6	1 July 1
7/0/mm Ahe same		8/0
P/6 Cipulo the sine.	2514	8/10
9/61/m 11 0	23,7	8/10
10/6/10-12/ 5405 Sale.	223	8/10
4/6 lients the same		8/100
2464-14 -1	18.3	8110

Rain Letture	40.3		
31/5 12mm 0	39.2		
31/5 11pm 6	38.3.	10 germanot	ol.
1/b 11pm 3 10	37.0	8/10	1 digga period
2/6 (1/2 4-13 4-12	35.5	9/10	
3/6 14-5 632	33.6	8/10	little monthly
5/6 12am 6 3-30	32.0		affle mentay
576 14227 7-40	30.5	8/10	mouldy same.
1/6 more 8 the same.	29.1	8/10	money serve
7/6 (pour 9) the source	27.0	8/10	
8614210 the same	25.4	8/10	
916 April the same	23.0	8/10	
Into them 12 the scure	22.1	3/10	
1/6 Mpn 13 thesame	20,1	8/10	
elle um H the sam.	18.5	8/10-	
375 lamo 03	40.3		
31/15 2001 0	39.2		
81/5 11pm2 6	37.8	10 germone	fed-
	35.9	9/10	
16 11pm 3 10 12:20 3-15	35.5	9110	
16 Ilpn 4 3-17 1-12	33,4	9110	
16 April 5-25	31.8	10/10	
16 12am 6 6-45 1-5		10/10	
6 Mps 7 8-50 1-5	30.1	CALLED BY AND ADDRESS OF TAXABLE PARTY.	
16 11 pm 8 18-50 1-5	29.1	- arrest and a second s	the same
16 1ypm 9 8-50 1-51	27.3	10/10	thesame
6 Mar 10 +55 -5	2510	10/10	thesome
6 lips 11 the same	23.1	10/10	0 0101
2/6 hom 12 the source	22.1	10/10	7 growing
6 Upr 13 flc sene	20,6	10/10	
	Construction of the owner owner of the owner ow	10/10-	46.0

*		
py 7 Grass		
39/5 (an 0 0 39.4		
395 1/pm 1 0 38.5		
31/5 1/pm 2 1 37.0	Sgermineted	
1/6 (1ph 3 =-1-3 2/1 (1ph 3 =-1-3 2/1 (1ph 4 = 2-6 2-4) HO	10 germinted	
190 -10 (1pm 1 3-5 2-3 3912	1910	
3/6 11pm 5 320 3-16 1-3 32.2 5/6 12am 6 200 3-46 -15 30.0	10/10	
	10/10	
	10/10	
6 4 mm 9 - 10 27 5 10 25.0 7/6 mm 9 - 11 27 5 10 25.0 8/6 4 mm 10 213 27 5 10 23.3	10/10	
8/6 upm 10 2/10 278 2313		
9/6 14m 11 3-125 2-95 1-10 21.3	10/10	
2/6 Upp 11 322 2+87 bit 2+13 1/6 Upp 12 3+24 bit 3+13 1/6 Upp 12 1+25 1+35 1+35 1+35 1/6 Upp 13 1+35 2+35 1+05 1+05 1/6 Upp 13 1+05 2+35 1+05 1+05 1/6 Upp 14 1+35 2+15 1+05 1/6 Upp 14 1+35 2+15 1+05 1/6 Upp 14 1+35 2+15 1+05 1/6 Upp 15 1+05 1+05 1/6 Upp 15 1+05 1/6	(-30 10/10	
11/6/4m 13 1-100 2-125 4-105 1-100	19 10/10	
2 12/6 (Lpm 14 2-150 1-135 2-115 1-90)	160 10/10 1240.	
2		
PH9 Gruss		
= 3-75 (an 0 0 40.1		
378- 11pm 1 0 38.9		
31/5 /1pm 2 1 37.3	4-germonofed.	
1/6 11pm 3. 1 36.2	( he	
2-8 1-2	6/10	
-1 7-10/2-23 1-15	7/10	
- 3/6 11pm 5 24 2-20 1-12 32,5	10/10	
5/6 12am 6 2-55 3-40 1-20 31.1	10/10	
5/6 120m 6 2-45 1-50 1-13 311 5/6 11pm 7 2-80 66 2-55 2-50 6/6 11pm 8 1-102/1456 2-55 2-50 6/6 11pm 8 1-102/1456 1-55 2-55	15 10/10	
6/6 11pm 8 1-108/1-95 1-75 1-65, 26	18 19/10	
7/6 Mpm of 1-135 1-95 2-80 1-45 2	500 10/10.	
K/6 Up 10 7-150 1-115 3-95 11-78	310 10/10	
010 10 1-125 1-110 1-85 1-60 -	23.1 10/10	
16 upm 11 3-120 2-100 1-65 3	20.8 10/10	
$\begin{array}{c} c_{16} & iipmi & i=16 \ / 2 \ / 1 \ / 1 \ / 6 \ / 1 \ / 6 \ / 1 \ / 6 \ / 1 \ / 6 \ / 1 \ / 6 \ / 1 \ / 6 \ / 1 \ / 6 \ / 1 \ / 6 \ / 1 \ / 1 \ / 6 \ / 1 \$	18.6 10/10	
W/6 11m 13 1-170 1-135 1-125 1-105 1-95	17.0 10/10	
11/6 100 1-100 2-130 1-100 1-70 1-10	5 15.1 10/10 122.5	

## Grass:

PH 3 One		survive in b Shan pld 1	all philipping and a grant of the
30/5 100 01 0	40.5		
5 3 × 11/2 1 0	34.9		
3/15 1/e 2 0	38.4		
2/2 (you 4 Fi		10	
8/4 / en 5 24		lio Milla	
5/6 12am 6 2+2200	31.2- 8	110	
5/6 120m 6 2.20 25 5/6 lipm 7 2.20120		110 mouldy Slip provid	
0/0 11/2 8 1-58-2 1-	26-7 5	Slip mould	
States 10 95-725	F4 -110	1/10 2000	
= 9/6 kpm 11 2 25 100		9110	
10/6 Rpm 12 1-18 1-15	1-20 19.2	9/10	
1/6 kyn 13 1-120 1-91	1-40 2-20	2/12 17.30	
12/6 11pm 14 10 200	0 2 40	9/10 150	
PH 5 Grass			
39/5 land 0			
375/1m1 0	3914	discolour alade	a collar ( 2 gen
31/5 [lpn-2]	38.0		sk
1/6 1 pm 3/ 1	36-3	10/10	
2/4 11/2- 4 8-51-2	34.9	10/10	
2/1 110m 5 2-16 1-10 1-11	32.5	10/10	
	31.3	10/10	
	29,5	10/10	mouldy
		10/10	prakish mavida
66 1pm8 - 802-101-8	70 2501	10/10	sant
7/6 11pm 9 2-105 -001- 7/6 11pm 9 3-98 275 8/6 11pm 102 00 1-100 2	-20° 0 1-90	Lolia	1
8/10 14/1 / 2-126 1-105 1	-90 23.4		
96 ym 11 7-120 400 1	70 20.8	and the second s	
10/6 14m 12 1-140 1-90	-75 19.		
10/6 11/m 12 1-140 (-90 11/6 11/m 15 2-133 7:13 11/6 11/m 15 2-133 7:13 2/6 11/m 19 2-140 7 2/6 11/m 19 2-145 1-150	2100 (7)	9 6/10	
	-120 1-126	10/10	137.0

32/5 lan 0	0 4	0.5		
3-15 11pm 21		7.0		
31/5 lipm 2	5-1-1-1 -		germinited	
2/6 11pm 2	27 1-3 7	6·3 -	7 germaded	
2/1 1/10 5			0/10	
5/6 Damb	2- 45 2-20 -		10/10	
the lyn 7	1-70 2-80 -95 1-25	28.7	10/10	
6/6 inpre 8	2-40-1-15 1-70-2-60-1-45 2-65-2-55-1-9 3-75-1-55 1-55 1-55 1-55 1-55 1-55 1-55 1-55 1-55 1-55 1-62 1-12 1	26.8	10/10	
7/6 lipn 9 !	-93 2-85 1-62 1-2	5 25,0	10/10	
8/6 11 por 10 2	-90 - 75 1-35	22,5	10/10	
		20.8.	10/10	
0/6 lym 12 2	-95 2-70 115 +95 1-85 1- 115 +95 1-85 1- 115 1-90 3-80 115 1-90 1-93 110 2-115 2-15 110 2-15 1-85	18.6	10/10	
a lile lyn vs 2-11	15 1-90 1-48	.17.3	10/10	
3 (2/6 1/m 14 +	1-105 1-85	15.4	10/10	78.5
3				
- Inver	Grass			
3951an O				
3/5-11pm 1	0			
31/51/pm 2		38.8	7 generat	
\$16 Um 3	7-1 1-3		8 germin	efed
2/1 1my	4-8 1-2	35.9	8119	
3/6 11pm 4 3/6 11pm5	1-27 1-15 2-10	33.7	9/10	
5/h Banh	2 55 2-45 1-3	31.6	9110	
5/6 [han]	1-90 1-75 1-60 1-90 4-70 1-50	29.7	9/10	
	1-110 1-95 1-70 1-95 4-76 1-62	27.7	9/10	
	1-133 1-100 1-85	25.8	9/10	
710 mm 2	-115 3-95 -75			
\$110 1 pm 10 2			9/10	
	-155 7=150 1-110 -135 7=125 1-100	1-95 21.5		
I lolo 11pm 12,	1-165 2-152 1-11	19.8	9/10	
1/6 (lpm 13	-145 3-120 1-4 1-170/-150 2-130 1-155 1-125 1-125 [-180 1-155 2-160 3-150	1-120 17.9		
12/6 Mpm 14	1-180 1-155	1-135 16.0	9/10	(52.22
-16 Lbw 11	2-160 5-100			

PHIL Grass			pH 11 not survive
30/5 lam 0 0	39.8		
345 Ilpm 1 O	39.1		
30/3 1pm 2. 0-	37.9		
1/6 lipm 3 0	36.2		
2/6 l/pm 4 2-1	34.5	2/10	
3/6 11pm 5 1	32.5	2/10	Stopped growing.
5/6 12am 6 1	31.0	2/10	1
576 11 pm 7 1	28.5	2/10	J
6/6 11pm 8 3-3	2667.1	5/10	brownish.
7/6 Upm 9. 3-5 1-2	24.8	6/10	J
8/6 1400 10 3-5 1-4	22.6	6/40	V.
9/6/1/m11 3-83-6	20,8	6/10	V
10/6 Mp-12 3-10 3-6	19,2	6/10	
11/6 14pm 13 the same	17.0		
2/6 lips 14. 37 Re save		6112	
the te save	15.1	6/10	0 8.0

# Chia seed:

PH3 Chie		PH 30	or Mouldy	-					-
	n Seed		ma surve		PH7 Clim Seed	40.7 0	5		
			-		3-95 11pm 0	38.8		crease in stal	
30/5 /1pm 0.	40.6	0	5		31/5 lipni 1		0		
31/5 /1pm 1	39.4		In Grease in size		1/0 11/0 2 2/6 11/0 3	256		/10	
2/6 11pm 2 2/6 11pm 3	37.6 36.1	0	5		216 11 pm 9 516 12 am 5 516 12 am 5 516 12 am 5 516 11 pm 6 616 11 pm 8 16 11 pm 8 16 11 pm 9		e than 6 7	1/10 invisible.	
= 3/6 11pm 4	34.3	5. (inot)	litte menior 1/10	223.	46 11pm 7	33.3 (51 m 31.5 29.7 (1,1) 4-13 27.6 (7 5-20 3-13 25.9 (12-40 2-40	5	7/10	
5/6 1244 5 949		2. (rort) 2/11	o pinkish mondaly		5/6 120m 2	29.7 11-71 4-13	1-10	7/10	
5/6 12pm 6	29.7	2. 2/1	o stopping in	A	2/6 11pm 0	27.6 17 3-18	1-15	7/10	
6/6 (1pm 7	28.3	-2 1/10	) mouldy F		elle inom 1	25.9 39.212-40	5-370	7/10	
7/6 Upm 8	26.4	2/ 1/10	Same 9		16 11pm 0 16 11pm 9	25-1 2/122-40 5		7110	
8/6 (1pm 9.	23.7	2/ 1/10	210		76 mar 1	21.6 4214 3-45	1-40	7/10	
9/6 up 10	21.1	2/ 1/10	Y		9/6 up (D	19,9 42.14. the 5		7/10	-
10/6 11pm 11		2/ 1/10			iole lipm 11			7/10	
0/6 11p 12	16.6	24 1/10			116 11pm 12	15.7 93.57 5-45		7/10 [43.57]	
12/6 1912 13					12/6 11pm 13	13.1 45.00 7		7/10	
136 11pm 14	12.7				136 11pm 14	and I have been a started and the			
PH 5 Chia					PH9 Cura Seed				
					29-110-0	40,6		noverse Pri	2.0
30/5 11pm 0	40.6	0		34	21/5 11pm /	39.0			
31/5 11pm 1	39.8		RASE IN DIZE		it lipm 2	37.0	3	1/10	
1/6 11pm 2	37.5		Charle III and		31/5 lipm 1 1/6 lipm 2 2/6 lipm 3	3611	2 (root)	3/10	
2/6 11pm 3.	36.7 3 34.2 9.2	3-3 1-5 5/1 1-1 5/1 1-6 5/1	14	-	2/6 (1/11) 11	33,6			
5/6 lipmy	34.2. 9.2	4-10 1-6 51			3/6 Upm 34	31.9 30.2 438 4- 28.3 9.14 5 26.3 22.11 5 23.9 27.42 5 3.9 27.42 5 4.9 27.42 5 5 2.9 27.42 5 2.9 27.52	1-4 (sten)	8/10	
5/6 12am 5	32. 4	4 51			\$16 Mpm 5	7.0 2 4.38 4-	3 5-	8/10	
5/6 11pm 6	0	4 5/1 1-1035 01		2 23	s/6 lipm b	78.3 9.14 25	5 2-1	7/10	
616 Mpm 7	28.3 9.6 1- 26.4.14.8 1- 24.1 178 1-	1-10 3-5 5/1	is moned of	5	5/6 11pm 6 6/6 11pm 7	203 2711 1-90	1-20 1-12	7/10	
7/6 11pm 8	2017 10	5 1-12 5/10	only one Strangerky. i		7/6 Mpm 8	261 22-11 22	2-30 1-2	7/10	
8/6 Wpm 9	2017.11.81-	2 1-12-6 5/10	Same		216 upn 9.	23.9 21.42 2-3	2-30	7/10.	
9/0 /1m10	29.1 118 1-	5 2-6 5/10			9/0 lpm 10	2116 32.49 3-6	0 1-2	7/10. 98	alcai
10/0 Mpm (1	24.5 22.4 1-0	to 1-15-2-6 5/1	0		10/6 lipm 11	19.9 32.93 the	5ame	7110	
11/6 1/m p	20,3 23.9 1-	45 2-6 5/				17.6 3.14 3-6	0 1-30	7/10 33	5.29
	29.1 178 1- 22.3 2.4 1- 20.3 2.34 1- 18.1 26.2 1- 15.9 29 2-	10 1-30/1-6 51		E	11/6 lp 12	15,435,29 24	0 1-50	7/10	
		30 1-6 51	The second secon		12/6 Hpm 13	23.9 27.42 1.5 21.6 32.431-9 19.9 32.43 He (7.6 3.44 54 15.4 55.29 25 13.3 56.86 25	0 2-35 1-	7100	
12/6 11pm 3	15.9 2912-9	-90 1-6 71	10 29.2	F	13/6/11pm14	1/			
	13.9 29 2-9	1011							
12/6 11pm 3	13.9 292 th	e some 5	110						
12/6 11pm 3	13.9 292 th	e source 5	(0			the water	The second second		
12/6 11pm 3	13.9 292 th	e somme s	((*			Sec. Sec.	1		
12/6 11pm 3	13.9 292 th	e same 5	((*						
12/6 11pm 3	13.9 292 th	esame s	((*						
12/6 11pm 3	15.9 292 th	e same s	((*						
12/6 (1pm 13 12/6 (1pm 14	13,9 292 th	e source 5			2	Q. (			
12/6 (1pm 13 13/6 (1pm 14 	13, 9 292 th	e Sonne S dea		**	River Chra.				
126 /1pm 13 126 /1pm 14 	13,9 292 th	e source 5			295 Upm O	40.8		0	
126 11pm 13 126 11pm 14 	13,9 292 th Chia Seed. 40.7 38.9	e Sonne S dea			295 Upm O	40.8		0 0	inc
126 (1pm 13 126 (1pm 14 -245 (1pm 1 -31/5 (1pm 1 1/4 (1pm 2	(13, 9 292 th (13, 9 292 th (13, 9 292 th (13, 9 292) (13, 9 292)	e Sonne S dea			22/5 lipm 0 31/5 lipm 1	40.8		<i>o</i> 0	37
	13,9 292 th Chia Seed. 40.7 38.9 37.1 37.1	e Sonne S dea		- Callan	22/5 lipm 0 31/5 lipm 1	40.8	3.17 5.	<i>o</i> 0	37
PH 11 	13.9 292 th Chia Seed. 40.7 39.9 37.1 36.1 36.1 34.2	e Soma S dea 0 0 0 0		Nessee	795 lipm 0 345 lipm 1 16 lipm 2 216 april 3 3/6 lipm 4	40.8 39.0 37.1	7 210	0 -4 -2-5	5/1
	13.9 292 th Chia Seed. 40.7 38.9 38.9 38.1 34.2 34.2 32.9	den 0 0 0 0 0 0 0 0 0 0 0 0 0		HALAAAA	795 lipm 0 345 lipm 1 16 lipm 2 216 april 3 3/6 lipm 4	40.8 39.0 37.1 36.1 34.2	7 210	0 -4 -2-5	5  1 6  10
PH 11 -245 llpn 14 -245 llpn 14 -345 llpn 1 -345 llpn 1 -345 llpn 2 -346 llpn 3 -316 llpn 2 -36 llpn 3 -316 llpn 3 -316 llpn 3	13.9 292 th Chen Seed. 40.7 38.9 37.1 34.9 34.9 34.9 20.9 20.9	den O O O O O O O O O O O O		Sectoral a	795 lipm 0 34/5 lipm 1 16 lipm 2 26 april 3 3/6 ilpm 4 5/6 Daw 5	40.8 39.0 37.1 36.1 34.2 32.4	7 2-10 2-6 7.67 5	0 2 -5 2 -5 2 -5 2 -5	5  1 6  10 6 /10
	(13.9 292 th (13.9 292 th 40.7 38.9 37.1 34.2 24.2 20.9 28.4 34.2 28.4 2.2 28.4	e Simme S den O O O O O O O O O O O		Secondary and a second	25 lpm 0 345 lpm 1 16 llpm 2 216 llpm 3 316 llpm 4 516 llpm 4 516 llpm 6	40.8 37.1 36.1 34.2 32.4 30.2	7 2-10 7.67 5 8.35 1-13	0 -4 -2 -2 -3 -2 -3 -3 -3 -3 -3 -3 -3 -3 -3 -3 -2 -5	5  1 6  10 6 /10 6 /10
216 11pm 13 216 11pm 14 215 11pm 14 2315 11pm 1 2315	13.9 292 11 and Seed. 40.7 38.9 37.1 34.2 24.7 26.7 26.7 26.7	e Simal S dea 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		CACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA	225 lipm 0 345 lipm 1 1/6 lipm 2 216 lipm 3 3/6 lipm 9 5/6 lipm 9 5/6 lipm 6 6/6 lipm 6	40.8 39.0 37.1 36.1 34.2 32.4 30.2 28.8	7 2-10 7.67 5 8.35 1-13	0 -4 -2 -2 -3 -2 -3 -3 -3 -3 -3 -3 -3 -3 -3 -3 -2 -5	5 6/10 6/10 6/10
246 llpn 13 -246 llpn 14 -245 llpn 14 -245 llpn 1 -245 llpn 1 -246 llpn 3 -246 llpn 3 -246 llpn 4 -546 llpn 9	(13.9 292 11 (13.9 292 11 38.9 38.9 38.9 34.1 34.2 34.2 24.3 24.4 24.4 24.4	den den den den den den den den		Sagagggggggggggggggggggggggggggggggggg	235 (1pm 0 345 (1pm 1 1/6 (1pm 2 246 (1pm 3 3/6 (1pm 9 5/6 12am 5 5/6 11pm 6 12 m 7 1/6 11pm 8	40.8 39.0 87.1 36.1 34.2 32.4 30.2 28.8 27.0	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	0 -4 -4 -4 -5 -4 -5 -5 -5 -5 -5 -5 -5 -5 -5 -5	5 6/10 6/10 6/10 6/10 6/10
	13.9 292 10 Chia Seed. 40.7 38.9 31.1 34.2 20.7 28.8 24.4 24.8	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		<u>a a a a a a a a a a a</u> a a a a a a a a	235 (1pm 0 345 (1pm 1 1/6 (1pm 2 2/6 (1pm 3 3/6 (1pm 4 5/6 (1pm 4 5/6 (1pm 6 12 am 5 6 (1pm 7 6 (1pm 7 6 (1pm 7 6 (1pm 7)	40.8 39.0 37.1 36.1 34.2 32.4 30.2 28.8	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	0 -4 -4 -4 -2 -5 -5 -5 -5 -5 -5 -5 -5 -5 -5	5 6/10 6/10 6/10
246 11pm 13 -246 11pm 14 -245 11pm 14 -245 11pm 10 -215 11pm 10 -216 11pm 2 -216 (1pm 2 -216 (1pm 2) -216 11pm 11 -216 11pm 12 -216	13.9 292 # Chen Seed. 40.7 38.9 57.1 34.2 22.9 28.4 24.4 24.4 24.4 24.4 24.4 24.4 24.4 24.6 24.6 24.6 24.6 24.6 24.7 20.7 24.7 20.7 24.7 20.7 24.7 20.7 24.7 20.7	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		<u>a a a a a a a a a a a</u> a a a a a a a a	235 (1pm 0 345 (1pm 1 1/6 (1pm 2 2/6 (1pm 3 3/6 (1pm 4 5/6 (1pm 4 5/6 (1pm 6 12 am 5 6 (1pm 7 6 (1pm 7 6 (1pm 7 6 (1pm 7)	40.8 39.0 87.1 36.1 34.2 32.4 30.2 28.8 27.0	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	0 -4 -4 -2 -5 -5 -5 -5 -5 -5 -5 -5 -5 -5	5 6/10 6/10 6/10 6/10 6/10
246 llpn 13 126 llpn 14 295 llpn 14 295 llpn 1 14 llpn 2 216 llpn 5 216 llpn 5 216 llpn 5 216 llpn 5 516 llpn 6 516 llpn 7 716 llpn 9 216 llpn 19 216 llpn 11 116 llpn 12	13.9 292 th and 292 th 40.7 38.9 37.1 34.2 34.2 28.4 24.4 24.4 24.4 24.4 24.4 24.4 24.4 20.2 17.3 (r. 1)	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		ALADDODDO.	795 lipn 0 24/5 lipn 2 1/6 lipn 2 21/6 lipn 3 31/6 lipn 3 31/6 lipn 3 51/6 lipn 6 1/6 lipn 6 1/6 lipn 7 1/6 lipn 9 1/6 lipn 7 6 lipn 10	40.8 59.0 87.1 36.1 34.2 32.4 30.2 28.8 27.0 24.8 27.0 24.8 22.9	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	0 22-5 2-5 2-5 2-5 2-5 2-5 2-5 2-5 2-5 2-	5 6/10 6/10 6/10 6/10 6/10 6/10 6/10 6/10 6/10 6/10 6/10
246 11pm 13 246 11pm 14 2915 11pm 14 2915 11pm 10 2915 11pm 10 2916 11pm 12 216 (1pm 12 216 (1pm 12 216 (1pm 12 216 (1pm 12) 216 (1p	13.9 292 11 and 292 11 40.7 38.9 37.1 34.2 34.2 28.9 26.4 24.9 26.4 24.9 26.4 24.9 20.2 17.3 16.1	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	d have not an allo	ALADDODDO.	245 lipn 0 245 lipn 2 16 lipn 2 216 lipn 3 316 lipn 3 316 lipn 4 516 lipn 4 516 lipn 6 16 lipn 6 16 lipn 7 16 lipn 7 16 lipn 10 6 lipn 10 10 lipn 10	40.8 59.0 87.1 36.1 84.2 32.4 30.2 28.8 27.0 24.8	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	с 0 2 - 5 2 - 5 - 7 - 76 -	5 6/10 6/10 6/10 6/10 6/11 6/11

375 1pm 0 4. 1	40.7 0	
3/5 11pm. 1	39.4 0	1/10 5/10 5/10 5/10 5/10 5/10 6/10 6/10
1/6 11pm 2	37.5 0	
2/6 1/m 3	361 3.67 2-3	3/10
26 Ilpm 4	34.6 8.40 3-6	5/10 invisibe.
5/6 12am 5	33.3 5.00 4-5	5/10
5/6 mpm 6.	31.1 9.00 14 140 1-	5/10
66 11pm 7	29.6 14.9 2-18 1-	\$ 5/10
7/b. 11pm 8	27,7 2333 2-5 1-4	(1)
8/6 upm 9	2719 200 2-30 1-6 2513.1451 3-85 1-6 729 2181 1-95 2-35	6/10
9.6 up 15	229 27.83 1-45 2-35	6110
0[6 1pm 1]	21.0 30.83 5-40 2-10	
11/6 lbpm 12	186 31.83 1-46 1-15	6/10
12/6 1(pm 13	16:4 04 2-40 1-11	6/10
36 11pm 14	1614 34 7-42 1-40 1414 36 2-43 2-45 2-	6/10 34.0 E

216 Mpm 3	361	3.11 2-4	6/10	
3/6 1/pm 4	34.2	7 2-10 2-5	6/10	
5/6 12 am 5	32.4	7.67 \$ 2-10 25	6/10	
5/6 11pm 6	3012	8.33 1-13 2-5	6/10	
6/6 Upm 7	2818	16.33 1-22 2-15 2-18 1-10	6/10	
7/6 11/200 8	27.0	34.17 2-40 1-30	6/10	
816 Mpn 9	2418	35.83 2:40 1-30.	6/10	
916 Mpm 10	22.9	41.00 2- 45 1-36	6/10	
10/0 11000 11	21.2	41 the same	6/10	
W/6 your 12	18.9	41.67 2-45 4-40.	6/10	
12/6 16m 13		43 2-45 4-42	6/10	43.
12/1 1/200 -1	111 /			
13/6 11pm 14	14.6	43 the same.	6/10 ·	
Day 7 2. 251 pH7		43 the game.	6//0 -	
Day 783. 1st pH7 2nd RNor		4) the same	6//0 -	
Day 7 2. 251 pH7		47 - 47 Sarre	6/10 ·	
Day 787 ISt PH7 2nd RNST 3rd Rain		47 the Same.	6//0 ·	
Day 789: ISt PH7 2nd RNor 3rd Rain 4th pH9			6//0 ·	
Day 787 ISt PH7 2nd River 3rd Rain 4th PH9 5th pH5	Mo		6//0 ·	
Day 789: ISt PH7 2nd RNor 3rd Rain 4th pH9	Mo		6//0 ·	
Day 787 ISt PH7 2nd River 3rd Rain 4th PH9 5th pH5	Mo		6//0 ·	
Day 787 ISt PH7 2nd River 3rd Rain 4th PH9 5th pH5	Mo		6//0	
Day 787 ISt PH7 2nd River 3rd Rain 4th PH9 5th pH5	Mo		6//0	

# Results: Experiment 1b.

# Wheat:

Neutral.	hArcat				
46 0	1>10				
5/6 /1pm 1 45	106.4/111.				
6/6 11pm 2 t5 7/6 11pm 3 +5	109.2/119				
8/6 Ihan 4 +5	113.4/ 118.		3 giornized.	ho trew	
2 9/10 1/pn 5 +5	117,71 122.			05	
10/6 Mpn 6 -15	120.9/ 125			1	
11/6 1/1- 7 15	172.9/127	S-50 1-60 1-45	1-20 10/1	L	
12/6 11pm 8 +5		500 5 4.7			
13/6 11pm 9 +5	126.6/131.	and a state of the	1-75		
14/0 11pm 10 45	129.7/134			10/10	
16/6/1pm 12 45	132.81 137	S (1) +1455 1 11	5 1-145	10/1	0
17/6 11pm 13 45	134.7 / 31	$ \begin{array}{c} s & (s_1) \\ s & (s_1) $	130 1460	10135	
18/6 11pm 14 +5	157 9 1 4	1 9 1772 - 17 2 G 100	1-105		
19/6 14m 15 +0	139.2	185-11-192 4-19			********
Light Acit	Hre Wheat	+(	0.9		
46 0	>105.6/>1	5.6			de
5/6 lipm1 +5	15.6/ 120.7	0			
6/6 ligne ts	118,4/12317				
7/6 11pm 3 45	122.6/ 1216	F.6725	3/10		
	125,3 / 130,8 9	state .	5/10	mand rea	
9/6 14pm 5 4273 1	28.0/ 133,32		\$/19	05	
10/6 (m 6 -12)-13 1	31.11 136.139	1-50 6-40 2-1	0 11/1	4	
11/6 1mm 7 +6-13	133.41 138-7 53		10/16	1	
12/6 11pm 8 +6)+3-	135.6/140.781	1-85 2-75	11	1	
13/6 11pm9 +61+3	137.6/ 142.7 1	1-115 3-110	1-102	1/11	
14/6 11pm 10 + 0+3	42,81 14-91	2-150 3-120	1-10.4	11/11	
15/6 [lom 11 + 6/+3 cm	14361 (48.4	31=150 4-140		ulu	142.27
	14101190.7		5 1-1Ua		
16/6 Man 12 +12+3	14.6/ 1971	2-160 2-15	1-145	nfu	155.00
1716 11pm 13. 7(3+3	146.9 151.8	5-170 1-160	1-140	lla	163.81
8/6/pm 14 +0+3	49.9/154.9	4-180 1-170	1-175	11/11	176.81
1966 Norm 15. to:	151,71	1-200 2-100	1-175 1-15	1	178.90

	Alkalme- 1	Wheat	+ 109		
4/b	A >	1053 1 7 115	3		
5/6 110		115.3/ 120.2	. 0		
6/b . 11pm	2 15	118.5/ 123.3	5 0	2/10	
The lip	3 75	122.9/128.1	1		
357 8/6 11pm		125.0/ 13.9.3		6/10 10/10	YE 1
glu ilm		27.5 (32.9	17.1 1-20 1-6		
10/6 War		30,6/13518	31 2-25	10110 3-40 10/1 1-40 10/1	
ille lign		34.6/139.0	72.1 2-78 1-65	2-68 19	10 1 1
12/6 (1pm 14/6 110m		36.2/141.1	9.7 1-105 2-75	2-95	0/10
13/6 11pm 14/6 11pm		39.5/ 144.2		10 1-90	10/10
- tothe	1 400 1	43.1 /148.2	122 115 910		12/10
156 lim		44.1109.4	128 - 2150 14	36 (+V20 25	10/10
17/6 11pm	3. +075	146.5/ 151.3.	1410 -160 A 1485 -1765 1485 - 1765 1641 -1775	-160 1-125	10/10
18/6 10m 1		49.3 154.3	1485 JELES	1-150 1-180	01/01
19/10 11pm 15		151.3	1601 -174 4	+170 1-156 1.	172
		weat.	47.06		
416		11/2127	1 0		and the second se
5/6 (lyn	1 +5 12-	1.1/ 132.4	b		
6/4 lipm		time tang mener contained and the	0		
The Hor	1 15 133	5.7/ 138	8 0	0/10	
500 × 8/6 110m 4	15 133 10 134	=1'140.8'	2U	4110	Convit
3/6 1/20 5	15) 138	211 112 1	1-12 5-	· · · · · · · · · · · · · · · · · · ·	
1816 Har 6	4 100	2/146.4	3-30 1-1	12 mil line	
Ula llen 7	10 191	3 148.0	E-25 445 255		
126 11 9	145	2 0-10-15	3-40 1-	15- 10/10	39.5
13/61/00 9	145	19/13017			10/10 56.6
Contraction and the first successive statements	10 147	2/152.5	145 3-85 1- 290 2-15 1- 2-00 2-80 3-95 1-85	45 1	0/10 79.5
1916 Up 10	150	171155.7	3-95 1-85	1-50	10/10 87.0
15 16 lips []	(5) 153.	71 159.0	1-115 1-95 5-110 2-90	1-50 1-90 1-60	10/00 100.20
16/10 1/m 12	+(5) 1550	1160.0	8125 1-11	0c 2-193	
176 1m13	15 157	21162.5	1-133 2-1	20 1-96 1-	10/10 109.
(8/6 llon 14	AR IN		1-122 1-1	20 1-98 1-125 1-90 1-1	0 10/10-110.
19/6 11pm 15	10 162	2165.4	2-128 2.	-94 1 10-	
11 IS IS PARTED	10. 162.	2 1	1-96 1-134 1-	24 1-112 1-6	Eo 10/00 112.1

Strens	Acridic	Wheat.	+20	9		
4/011p 0	> 101	3.81 2100.0				
5/6 11pm 1	+5 126	8/ 131.				
	05 130	2/ 135.5	0			
	+5 136	1.3/ 139,5	5			
	5) 136	14/ 1415			-/10.	
9/6/1m 5 1	5 130	1.2/ 144.1	213 1-30 2	23 1-6 18	1/10/05	
toll lin 6 4	3 142	1/147.4	35.1 4-40 2	35 -8 1		
146 Mars 7 46	31 140	1.3/ 149.5	51 2-69 2		Vollov	
12/6 11pm 8 +1	6) 146	4 /151.5	113 1-10 2	15 1-13	10/10-	1
the or q t	0 149	2.3/ 153.3	13.1 2-110 2- 13.1 4-105 1	15 1-15	10/10	1
14161mm 10 4	5 al51	51 156.6	02 2 1-130 1	105 1-18	10/10	1
(5/6 1/pm 11 9	5) 0010 154	1.2 159.2	1-150	-125 1-20 2-120	10/10	122.51
66 [ mm ] 2 4		55 160.5	1-160	1-158 1-135 5-145 1-20		134.5
		7.2/162.4	1-165	1150 1140		13251
		0.2 165.0	1-178	1-160 1-190	1-155 1-24	1449
9/6 floom 15 +		2.2	1-192		1-150	158.9
1 0 upper in 1	[b	La L	20/28	1-155 1-153	1-140	150-11

### Lettuce:

Neutral. Let	tuce	
5/6 11jun 0	108.8 0:	
6/6 11pm 1 +3	106.5/111.8 0	
7/6 upm 2 +5	110,5/115.5 15 1/10	
8/6 llm 3 to	112.0 6 1/10	
9/4 Man \$ 151	109.9/114.6 3 9-2 8/10	3.5
with line 5 +5	112.5/112.2-5 1-12 2-8 10/10 105	10.5
11/1 11m 5 +5 V	115.11 120.1 120 10/10	16.8
10/11/11/1 1/10	117.5/ 2-40 1-25 10/10 all have	29
12/6 10m 1 10	113.8/ 119.0 2-45 1-25 1-42 10/10	38
13/6 11pm 9 + 19	116 91 7-18 250 1-42 1-28 10/10	4
1100 0000	114.8/ 198 256 352 1-45 1-30 million 10/n	4
15/6 1/pm (0 -15	110,2 2-58 L60 1-487-58 20 10/10	5
16/6 (lam 1/ 70	0-10 -58 1-38 ded 1	52
17/611pm 2 15	11 216 11 2 56 1 255 1,20 the	52
1816 11pm 13 -1	116.0/ 4 2-56 1-60 1-36 sund	
19/6 11pm 14	113,6 the same	52

Light flord	he follower ?
616 Mpm 1	103.47 100.0
7/6 11pm 2	109.61 125 0 109.61 125 0 109.61 124 124 210 210 Count re 5107.41 1124 124 125 160 Count re
8/6 Min 3.	10916 0 1-9 2 3/10 Control sec
9/6 yr 900	3 107.4/ 112.4 1-1 1-18 6/10 44.17
10/6 1pm 5 10+1	113.0/1180 2131-10 1-7 8/10 20.67
7/6 1/m 2 8/6 1/m 3 9/6 1/m 40+ 1/6 1/m 5 10+3 1/6 1/m 5 10+3 12/6 1/m 7 10+3	115.0 + 30 20 10 10 10 30.44 FOR
12/6 (1pm 7 +10+3	111. 9/116-7 1-35 1-36 1-35 9/10 36.99 mm
	114.7/ 340 -29 45 9/10 42.89
14/6 (10 9 +00 15/6 (10 10 40+3	112.14/117.3 155 245 130 143 slaged 49.67
116 10 10 10	
166 1/10m 11 +	110 16 11519 the same 355 9/10 49.07
18/6 1pm 13 + 0	110 16 115:19 the same The 1945 111 110 16 115:19 the same 35° 9/10 49:17
1916 11pm 14	110.6 the same give inter
1110 14	
Strong Acidic	Letinel
5/6 Mpm 0	129.2 0
616 - hpm 1	126,9/134.7 0
7/6 lipm =	132_2/137.4 1
8/6 Hpm 3	134.0) 0 1-10 1-4 Alin what i cars
gloup y +0	121, 11126, 2 18 1-3 7110
10/6 1/m 5 +3	
11/6 11pm 6 75	137.3 / 142.14 2/15 1/2 1/2 1/2 1/2 1/2 1/2 1/2 1/2 1/2 1/2
12/2 (lam 7 40)	129.41 1-5 40 230 2-25 110 -0.17
the line of the	136 1/ 141.1 2+48 2+40 1-25 9/10 58.56
Hill & D	29 al 1.58 20 1-42 9/10 44 br
146 april 9 10	1-34 2.40 + 34
15/6 11pm 10 +6)	138.0 3-60 3-95 WEAK 10 53.44
16/6 llpm 11 fo	138:0 3-60 5-45 40 9/10 53:44
17/6 (lpm 12 + 3)	100,41140,1 2468 1-50 1010
	1381 How The same, to IN- 49.18
18/614pm 13 +0	Doil the owner in the state
	135.2 the same 10/10 49.18
18/614pm 13 +0	135.2 the same 10/10 49.1

Ligh D1k 516 lipm 0	118.6 0	
b/b hpm 1	1165/1216 D	
-7// 1 mm 2	119,6/124.6 1/10 Xotter Warten	
5/6 Mpm 3	121.5 3 3/10 cand see 2	
9/6 lym 4 42	121.5 3 3/10 cand see 3 213.19.0 124.1 33 2-4 9/10 4.25 213.119.0 124.1 33 2-4 9/10 4.25	
9/6 kpm 4 46 10/6 kpm 5 49 13/6 kpm 6 104 12/6 kpm 7 10 4 13/6 kpm 8 4043	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	
12/6 Myr / 10-1	is the fit is the fit	
13/6 11pm 8 10/12 14/16 11pm 9 10	126.5/ 120 1-13 6/10 11.8	
15/6 110 10 to	43 1179, 51 129, 41 140 1-15 7/10 AU 12.	
16/6 (long 11 +0		.71
1010 10m 11 150 t	12512 the sent. The Statk 12 B 12215 127.6 125 212 The 13	
18/6 Hon 13 +0	12513 the same 1 13	5.71
	1223 The same U L 13	
Stong. Alla	cellure Lettuce.	
5/6 11pm 0	128,8 0	
5/6 11pm 0 6/6 [hom]	128,8 0 (26,1/131,4 0 yen	» ·
5/6 11pm 0 6/6 11pm 1	128,8 0 128,1/131,4 0 129,9/134,1 0 1/10 2003 week	
5/6 11pm 0 6/6 11pm 1 7/6 11pm 2	128.8 0 128.1/134.4 0 very 129.9/134.1 & 1/10 sod() weeks 129.6 410 count see low	
5/6 11pm 0 6/6 11pm 1 7/6 11pm 2 8/6 hpm 3	128.18 0 128.1/131.4 0 129.1/131.4 0 129.1/131.4 1 1 10 131.6 4 100 cond see long 131.6 410 cond see long	
5/6 11pm 0 6/6 11pm 1 7/6 11pm 2 8/6 11pm 3 9/6 11pm 3 9/6 11pm 4 45	128.18 0 128.1/131.4 0 129.1/131.4 0 129.1/131.4 1 1 10 131.6 4 100 cond see long 131.6 410 cond see long	
5/6 11pm 0 6/6 11pm 1 7/6 11pm 2 8/6 1pm 3 9/6 1pm 4 15 10/6 1pm 5 10	128.18 0 128.1/131.4 0 129.1/131.4 0 129.1/131.4 1 1 10 131.6 4 100 cond see long 131.6 410 cond see long	
5/6 11pm 0 6/6 11pm 1 7/6 11pm 2 8/6 1pm 3 9/6 1pm 4 to 10/6 11pm 4 to 10/6 11pm 6 to	128.7 0 128.7 1931.4 0 129.9 [124.7] 4 1/10 Sold[] - hitden 138.6 4 10 conf. see Tay 129.0 [134.7 2 2 4] 10 conf. see Tay 139.0 [134.6] 20 2 2 4 10 2 4 139.0 [134.6] 20 2 4 10 2 4 1	5.5 5.5 7.25
5-16 lipm 0 616 lipm 1 716 lipm 2 816 lipm 3 916 lipm 4 16 1016 lipm 6 + 5 116 lipm 6 + 5 126 lipm 7 + 0	128.7 0 128.7 1931.4 0 129.9 [124.7] 4 1/10 Sold[] - hitden 138.6 4 10 conf. see Tay 129.0 [134.7 2 2 4] 10 conf. see Tay 139.0 [134.6] 20 2 2 4 10 2 4 139.0 [134.6] 20 2 4 10 2 4 1	5.5 5.5 7.25
5-16 11pm 0 616 11pm 1 716 11pm 2 816 11pm 3 916 11pm 4 16 1016 11pm 6 +(5) 1216 11pm 6 +(5) 1216 11pm 7 +0 1316 11pm 8 +10	128.7 0 128.7 1931.4 0 129.9 [124.7] 4 1/10 Sold[] - hitden 138.6 4 10 conf. see Tay 129.0 [134.7 2 2 4] 10 conf. see Tay 139.0 [134.6] 20 2 2 4 10 2 4 139.0 [134.6] 20 2 4 10 2 4 1	5.5 5.5 7.25
5/6/1pm 0 6/6/1pm 1 7/6/1pm 2 2/6/pm 3 9/6/pm 4/75 10/6/1pm 5/75 11/6/1pm 6/75 11/6/1pm 7/50 12/6/1pm 7/50 12/6/1pm 7/50	128.72 0 128.7/131.4 0 4/10 502(1) hits 129.6/134.7 6 4/10 502(1) hits 131.6 4/10 const see tray 129.0/134.7 20 4/10 134.6/134.7 100 100 4/10 134.6/134.7 100 100 4/10 134.6/134.7 100 100 4/10 135.2/138.3 200 4/10 135.2/138.7 200 4/10 136.2/138.7 200 4/10 136.2/100 4/100	5.5 5.5 7.25
5-16 11pm 0 616 11pm 1 716 11pm 2 816 11pm 3 916 11pm 4 16 1016 11pm 6 +(5) 1216 11pm 6 +(5) 1216 11pm 7 +0 1316 11pm 8 +10	128.7 0 128.7/131.4 0 4/10 5027 hits 129.6/124.7 6 4/10 5027 hits 131.6 4/10 5027 hits 131.6 4/10 125 4/10 134.6/134.7 125 4/10 135.7 125 4/10 134.6/134.7 125 4/10 135.7 125 4/10 155.7 125 4/100 155.7 125 4	7.25 7.25 9 11.6 12.
5/6/1pm 0 6/6/1pm 1 7/6/1pm 2 2/6/pm 3 9/6/pm 4/75 10/6/1pm 5/75 11/6/1pm 6/75 11/6/1pm 7/50 12/6/1pm 7/50 12/6/1pm 7/50	128.75 0 128.7118.4 0 400 sold hits 129.7118.4 0 410 sold hits 131.6 410 sold for sold for hits 131.6 410 131.6 410 131.6 410 131.6 410 134.711 50 100 100 134.711 50 100 100 134.711 50 100 100 134.711 50 100 100 100 134.711 50 100 100 100 134.711 50 100 100 100 134.711 50 100 100 100 134.711 50 100 100 135.711 50	5.5 5.5 7.25 9 9 11.6 12.
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5-16 lipn 0 616 lipm 1 716 lipm 2 216 lipm 3 916 lipm 4 45 1016 lipm 6 40 116 lipm 6 40 116 lipm 7 40 134 lipm 7 19 134 lipm 7 19 146 lipm 9 19	128.7 0 128.7/181.4 0 4/10 5027 hits 129.7/184.7 0 4/10 5027 hits 131.5 4/10 2027 hits 129.0 1154.0 4/20 4/10 134.0/181.1 10 10 4/10 134.7/1 325 4/10 134.7/1 325 4/10 10 1044-149 135.2 128.3 4/0 5/10 20 6/10 134.7/1 10 10 104 20 6/10 134.7/1 10 105 100 20 6/10 134.7/1 105 100 20 6/10 135.7/1 105 100 20 6/10 135.7/1 105 100 20 6/10 135.7/1 105 100 20 6/10 135.7/1 105 100 20 6/10 136.7/1 105 100 20 6/10 137.1 10 100 100 100 100 100 100 100 100 10	5.5 5.5 7.25 9 9 11.6 12.

### Grass:

Light Acidic Grass	
5/6 11 m 0 117.8 0	
	715.0 120.3
all lug 4 f233 119.6/124.7 0	4
10/6 11 5 +0+3 122.6/127.4 1-4	1/10
12/6 11pm 7 70 127.8/ 1-12 1-10	1-35 235 9/10 20 1-28 1-28 9/10 20 1-01-47 2-26 1-22 9/10 36.67
	11 Life 293 130 Olin 49-62
≥ 14/6 11pm 9 -10 127.6/ 1	-83 135 100 [30 9/10 63,11
1576 11pm 10 1000 12513130 1	105 1-90 1-75 2-70 9/10 77
10 10 11 10 12. 12. 12. 12. 12. 12. 12. 12. 12. 12.	LILE 1-40 1-65 , 42 9/10 84,56
1/10 101 10 10	125 3-100 1-55 1-95 9/10 96.0
	-122 1-104 1-70 -132 4:110 1-70 -125 1-105 1-105 9/10 104.78
Strong Acidic Grass	Gt
5/6 lipm 0 128.1 0	1
6/6 1hm 1 126.2/131,3 0	
- 7/6 hom 2. 30,5/ 13514. 0	
8/6 11m 3 132.3	
1/6 lipm 4 ( 130,0) 135,0 0	2
10/1 1/m + +10 133,311381-	0 2-19 5/10 9.6
1/6 Mar 6 to 13517/140.7	Liniz .
	<u>515 6/10 13.53</u> 2-35 2-25 f/10 26.67
= 14/(11pm 9 10 137,4/	-50 1-40 1-14 1-8 0110
-V-fs- t- internet	
	- 1-25
	- 1-25
	- 1-25
	1-65 1-35 1-50 1-20 8/10 57.5

2 -	-		-
1 . 7 811 1.	0		6
Light. Alkaline			5
6/6 lipmo (18.3 6/6 lipm) 15 116,5/			6
6/6 /10m ] 15 11615/ 7/6 110m 2 35 121.0/	126,4 0	Ney moret	
7/6 llpm 2 15 [2].0/ 2/6 llpm 3 0 123.1		watery	6
G16 11mm 4 4(2)+3 120151	125.1 0		-
Polethon 5 +09/77 1254	128.0 0		-
11/1 and 6 7 (613 123.8)	130.8 0	plic	
12/11/0 7 +0 127.9/		*/10	-
13 (110MX 447) 12913		1/10	
W/61 mg tu 12/2		1/10.	
15/11/0 10 -10 0 1291	IT IF I'U	1/10 .	
Toll I have a	127.4 63.		
The strain the state	and seems the stress of the second	1/10	
IT IN O IV	1.	1/10.	-
19/6/10 14 to 121.6	0.0	and a second defense of the second defense o	
Strong. Alkaline.	Gtrass.		
	28.2 0		
6/6 lym 1 +5	25.9/130.60	- 1	
4/6 11pm 2 +5 1.	29.5/134.70	here were	
alb 110m 3. 10 1	31.3/ 0	Wotery	
GID MM 9 +0 1.	28.6/ 133.8 0		
10/6 lym 5 + 1 1	31.61 1367 0		
11/6 1ym 6 + 5 13	54.1 (139.5 0	3/10.	8.67
12/6 11pm 7 0 1.	54.1 (139.5 0 36.41 12-8 32.9/137.9 14 1-25 5.9 1-35	-710	18.33
	32.9/137.9 118 1-22	3/10	26.67
14/6/10m7 +0 13	1-25		29.25
15/6 1/m 10 15 13		1-2 4/10	
16/6 11m 11 to 13	4.6/ 1-42	1-33 1-15 4/10	35 ===
17/6 1m 12 to (3	31.5/136.7. 1-47	1-37 4/10 1-37 1-10 1/10 h	37.75
		1-22 <b>5</b> 10	33.2
	31.6 150	1-22 <b>9</b>  10 ∆ 1-40 1-10 5/10	36.6
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1195/ 1-82 1-60 1-51 2-45 10/10 57.4
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113/120 72 13 5 9/10 125 119.8/ 140 13 120 14 10/10 03 116.5/121.2. 155 15 156 156 10/10 43.1 119.5/ 120 156 156 146 10/10 43.1 119.5/ 120 166 156 146 10/10 57.4
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[195] 122 For 235 140 10/10 57.0
1.02 1.02 1.00 .05 2.05 . 5-
1/12/12/20190 2.70 1.20 10/10 10/10 12.
115 ( ) + 110 1295 1-88 - 80 /-60 /
5,5/120.8 2-15 1-105 2901-120 3mushraam 10/10 100
11866 +10 1-8 1-88 +80 1-68 12/00



# Observations:

### Mung bean

Epigeal germination occurs.

# 9/6/23

Borrowed garden pH meter from teacher.

# 10/6/23 - 21/6/2023

#### Working on report.

# 22/6/2023

#### Measuring soil pH on day 15 with lab assistance.

#### Procedure:

- 1. A decent amount of each type of soil was placed on different watch glasses using a spoon. The spoon was rinsed between intervals so that soil did not contaminate each other.
- 2. A decent amount of universal indicator was placed on each soil samples on the watch glasses.
- 3. Barium sulphate was placed on each soil sample.
- 4. The pH of each soil samples was indicated using a pH colour tool.

#### **Results:**

Wheat	рН
Strong Acidic	6
Light Acidic	6.5
Neutral	7
Light Alkaline	8
Strong Alkaline	8.5

Lettuce	рН
Strong Acidic	5.5
Light Acidic	6
Neutral	7
Light Alkaline	7.5
Strong Alkaline	8

Grass	рН
Strong Acidic	6
Light Acidic	6.5
Neutral	7
Light Alkaline	7.5
Strong Alkaline	8

#### **Conclusion:**

- 1. If the pH level of the solution is near neutral (pH 7  $\pm$  10%), the germination of seeds will occur and the growth rate in plants will be the greatest.
- 2. if the amount of water given to the soil is below or above the optimum amount of water, the germination of the plant will be negatively impacted, and its growth rate will decrease.
- 3. Climate change affects soil pH and water level, and hence affect seed germination and growth. As a result, our food production and security will be affected.
- 4. Sustainable agricultural practices for soil management are crucial for optimum plant growth to maximise food yield for our society.

# 23/6/2023 - 30/6/2023

### Working and finishing report and journal.

#### Submit:

- 1. Cover sheet
- 2. Risk assessment form
- 3. Scientific Journal
- 4. Scientific Report



