

## Summary table with the results of SSF technology application in agriculture over the past 5 years

Date: February, 2026

<b>Institution / Organization</b>	<b>Country</b>	<b>What Was Done</b>	<b>Result</b>
Volcani Institute	Israel	Seed germination trial (sunflower)	+14% germination; -24% dead seeds
Great Zimbabwe University	Zimbabwe	Seed germination trials (cereals)	Maize +6.5%; Pearl millet +40.7%; Rapoko +25.2%; Sorghum +21.3%
Great Zimbabwe University	Zimbabwe	Seed germination trials (legumes)	Common bean +88.9%; Cowpeas +54.2%; Round nuts +87.3%; Round nuts +71%
Agricultural Research Council	South Africa	Seed germination and seed vigour assessment	+30% germination; +20% SVI
Federal University of Agriculture	Nigeria	Seed germination and seed vigour assessment	+17% germination; +58% SVI
Tripoli University	Libya	Seed germination and seed vigour assessment	+20–23% germination; +34–40% SVI
Ege University	Turkey	Seed germination trial (eggplant)	~+500% germination (from low baseline)
Mezagri Laboratory	France	Early-stage germination trial (chickpea)	+26% germination after 4 days
Wageningen University	Netherlands	Controlled germination trial	92% germination vs 55% baseline
Independent academic trial	Finland	Home-based controlled germination (barley, oat)	Barley +7%; Oat +39% germination
Discovery Seed Labs	Canada	Zero-fertilizer comparative yield trial	Yield only -22% vs 100% fertilizer control
Discovery Seed Labs	Canada	Post-harvest quality analysis (wheat)	+4% protein content
SGS North America	United States	Controlled soil nutrient uptake analysis	~+60% phosphorus uptake

<b>Location / Farmer</b>	<b>Country</b>	<b>What Was Done</b>	<b>Result</b>
Corn farmer	Uganda	Full-season field application	33% increase in yield
Corn farmer	China	Cultivation on highly acidic soil	Successful harvest obtained
Winter wheat farm	Kazakhstan	Field production	34% increase in yield
Rice farm	Thailand	Normal growing conditions	27% increase in yield
Rice farm	Thailand	Severe drought conditions	10% increase in yield
Baby corn farmer	Thailand	Field production	Much larger plants; more ears per plant; farmer doubled income
Wheat farm	Israel	Field production	3.7% increase in yield
Corn farm	Italy	Reduced fertilizer input	Same harvest with 50% reduction in fertilizer use
Rice farm	Italy	Field production	19% increase in yield
Olive grower	Italy	Orchard production	20% increase in fruit weight and size; record polyphenol levels
Linen farm	France	Fiber yield assessment	12.5% increase in fiber yield ( $\approx$ 500 kg/ha)
Beetroot farm	France	Field production	10% increase in yield
Wheat farm	Spain	Field production	27% increase in yield
Rice farm	Spain	Field production	9.3% increase in yield
Linen farm	Russia	Fiber yield assessment	75% increase in fiber yield
Sunflower farm	Ukraine	Field production	37% increase in yield
Coffee farm	Colombia	Field production	13% increase in yield
Rice farm	Colombia	Reduced NPK input	13% increase in yield and 25% reduction in NPK use
Onion farm	Dominican Republic	Field production	17% increase in yield
Green pepper greenhouse	Dominican Republic	Greenhouse production	30% increase in yield
Cotton farm	Australia	Field production	17% increase in yield
Potato farm	Sweden	Activated fertilizer applied	Larger, healthier potatoes
Onion farm	Niger	Field production	Larger onions
Corn farm	South Africa	Field production	Larger, healthier plants
Black-eyed peas grower	Botswana	Field production	35% increase in yield



# Optima Quanta 2024 Germination with Varying Water Amounts

Study Number:  
C372P3201

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## **Introduction**

SGS North America Inc., located in Brookings, SD is a full-service seed testing laboratory. Founded in 1993, the company has worked with over 1500 seed company accounts from 43 states and several countries. SGS Brookings location employs several full-time seed analysts including Registered Seed Technologists, Registered Genetic Technologists, and Certified Genetic Technologists. The staff holds Master of Science degrees in Biological Sciences, Agronomy, Biology, Soil Fertility, Ag Education, and Computer Science. The laboratory conducts seed treatment, germination, vigor, herbicide tolerance, physical and genetic purity, and GMO (ELISA/protein, DNA/PCR, bioassays) testing.

## **Overview of Experiment**

The following experiment was conducted to determine the biological effect of SSF on the germination and early growth characteristics of seeds when subjected to varying water amounts.

*Table 1: Study Treatments*

Sample	Description	Sample	Description
1A	100% Water	2A	100% Water
1B	75% Water	2B	75% Water
1C	50% Water	2C	50% Water
1D	25% Water	2D	25% Water

## **Procedure:**

### **Seed Treatment Application:**

Sample 1, control, was not submitted to any SSF treatment prior to planting. The seeds for Sample 2, treatment, were treated remotely using SSF technology. These seeds remained in the laboratory throughout the process but were treated remotely by the client. A video file featuring the seeds of Sample 2 was prepared and sent to the client. The client organized the remote treatment of the test group seeds. Seventy-two hours after receiving confirmation from the client regarding the SSF seed treatment procedure, the laboratory began testing Sample 2.

### **Germination Procedure:**

Sample 1 was planted on November 7, 2024. Sample 2 was planted on December 9, 2024, using the same equipment and germinator as Sample 1. Each sample was divided out into subsamples that received either 100, 75, 50, or 25% water (Table 2). These subsamples were planted in 4 replicates of 200 seeds each on a tray containing crepe cellulose paper and water rates as directed (Table 2). In total, each sample had 16 replicates (4 at each watering amount). Samples received a first count on day 7 and a final count on day 10 in which normal seedlings, abnormal seedlings, and dead seeds were recorded according to AOSA rules.

*Table 2: Water Rates for Each Sample*

	100% Water	75% Water	50% Water	25% Water
<b>Sample 1</b>	700 ml/tray	525 ml/tray	350 ml/tray	175 ml/tray
<b>Sample 2</b>	700 ml/tray	525 ml/tray	350 ml/tray	175 ml/tray

Table 3: Germination Data for Sample 1

Sample	Description	Rep 1				Rep 2				Rep 3				Rep 4				Mean				Comments
		1st Count (7 day)	Normal	Abnormal	Dead	1st Count (7 day)	Normal	Abnormal	Dead	1st Count (7 day)	Normal	Abnormal	Dead	1st Count (7 day)	Normal	Abnormal	Dead	1st Count (7 day)	Normal	Abnormal	Dead	
1	100% Water	199	196	1	3	200	196	3	1	197	194	2	4	194	193	1	6	197.50	194.75	1.75	3.50	DS
1	75% Water	199	196	2	2	199	195	2	3	199	197	3	0	198	193	5	2	198.75	195.25	3.00	1.75	DS
1	50% Water	198	195	3	2	197	195	2	3	200	196	3	1	199	198	1	1	198.50	196.00	2.25	1.75	LB, SS
1	25% Water	197	196	1	3	199	199	0	1	199	198	1	1	198	198	0	2	198.25	197.75	0.50	1.75	SS

Abbreviations: Decayed Seedling (DS), Leaf Blowout (LB), and Stunted Shoot Growth (SS)

Table 4: Germination Data for Sample 2

Sample	Description	Rep 1				Rep 2				Rep 3				Rep 4				Mean				Comments
		1st Count (7 day)	Normal	Abnormal	Dead	1st Count (7 day)	Normal	Abnormal	Dead	1st Count (7 day)	Normal	Abnormal	Dead	1st Count (7 day)	Normal	Abnormal	Dead	1st Count (7 day)	Normal	Abnormal	Dead	
2	100% Water	199	198	1	1	198	199	1	0	199	198	1	1	199	200	0	0	198.75	198.75	0.75	0.50	SL
2	75% Water	197	198	0	2	197	198	0	2	198	198	0	2	199	199	0	1	197.75	198.25	0.00	1.75	
2	50% Water	200	200	0	0	195	194	2	4	198	198	0	2	199	199	0	1	198.00	197.75	0.50	1.75	SS
2	25% Water	198	198	0	2	198	198	0	2	196	196	0	4	200	200	0	0	198.00	198.00	0.00	2.00	

Abbreviations: Shredded Leaves (SL) and Stunted Shoot Growth (SS)

Table 5: Dry Shoot Weights for Sample 1

Sample #	Water Amount	Rep 1	Rep 2	Rep 3	Rep 4	MEAN
		Shoots	Shoots	Shoots	Shoots	Shoots
1	100%	6.721	6.178	5.794	6.549	<b>6.311</b>
1	75%	5.702	5.588	6.133	5.610	<b>5.758</b>
1	50%	4.612	4.397	3.406	4.407	<b>4.206</b>
1	25%	0.807	0.681	0.431	0.712	<b>0.658</b>

Table 6: Dry Shoot Weights for Sample 2

Sample #	Water Amount	Rep 1	Rep 2	Rep 3	Rep 4	MEAN
		Shoots	Shoots	Shoots	Shoots	Shoots
2	100%	4.418	4.179	3.434	3.702	<b>3.93325</b>
2	75%	3.793	3.987	3.814	4.342	<b>3.984</b>
2	50%	2.340	2.908	2.710	2.427	<b>2.59625</b>
2	25%	0.153	0.445	0.000	0.092	<b>0.1725</b>

Sample 2, Rep 3 did not have green shoots to harvest.

Table 7: Dry Root Weights for Sample 1

Sample #	Water Amount	Rep 1			Rep 2			Rep 3			Rep 4			Mean		
		Germ Paper Before (Dry)(g)	Weight of Paper & Roots After (Dry) (g)	Root Weight (g)	Germ Paper Before (Dry) (g)	Weight of Paper & Roots After (Dry)(g)	Root Weight (g)	Germ Paper Before (Dry)(g)	Weight of Paper & Roots After (Dry) (g)	Root Weight (g)	Germ Paper Before (Dry)	Weight of Paper & Roots After (Dry)	Root Weight	Germ Paper Before (Dry) (g)	Weight of Paper & Roots After (Dry) (g)	Root Weight (g)
1	100%	103.5	128.3	24.8	116.7	143.8	27.1	117.3	142.4	25.1	104.3	128.5	24.2	110.5	135.8	25.3
1	75%	105.0	130.8	25.8	117.8	143.4	25.6	105.2	131.0	25.8	117.6	144.3	26.7	111.4	137.4	26.0
1	50%	104.9	135.2	30.3	118.1	148.0	29.9	118.2	154.9	36.7	105.1	135.1	30.0	111.6	143.3	31.7
1	25%	117.4	159.4	42.0	105.1	148.4	43.3	117.8	161.0	43.2	105.3	149.0	43.7	111.4	154.5	43.1

Table 8: Dry Root Weights for Sample 2

Sample #	Water Amount	Rep 1			Rep 2			Rep 3			Rep 4			Mean		
		Germ Paper Before (Dry)(g)	Weight of Paper & Roots After (Dry) (g)	Root Weight (g)	Germ Paper Before (Dry) (g)	Weight of Paper & Roots After (Dry)(g)	Root Weight (g)	Germ Paper Before (Dry)(g)	Weight of Paper & Roots After (Dry) (g)	Root Weight (g)	Germ Paper Before (Dry) (g)	Weight of Paper & Roots After (Dry)(g)	Root Weight (g)	Germ Paper Before (Dry)	Weight of Paper & Roots After (Dry)	Root Weight
2	100%	109.4	140.2	30.8	111.1	141.9	30.8	109.5	140.5	31.0	110.9	142.1	31.2	110.2	141.2	31.0
2	75%	109.8	142.2	32.4	111.3	144.1	32.8	109.7	142.3	32.6	111.4	142.9	31.5	110.6	142.9	32.3
2	50%	110.0	146.9	36.9	111.2	146.8	35.6	109.6	145.1	35.5	110.9	148.1	37.2	110.4	146.7	36.3
2	25%	109.4	156.7	47.3	110.5	156.0	45.5	108.6	155.6	47.0	111.1	156.2	45.1	109.9	156.1	46.2

## Statistical Analysis

### Basic Analysis

Table 9: Mean of Sample 1 and Sample 2 Data

Treatment	Normal Seedlings	Shoot Weight	Root Weight
1A	194.75	6.31	25.30
1B	195.25	5.76	25.98
1C	196.00	4.21	31.73
1D	197.75	0.66	43.05
2A	198.75	3.93	30.95
2B	198.25	3.98	32.33
2C	197.75	2.60	36.30
2D	198.00	0.17	46.23

Table 10: Variance of Sample 1 and Sample 2 Data

Treatment	Normal Seedlings	Shoot Weight	Root Weight
1A	2.250	0.170	1.580
1B	2.917	0.065	0.243
1C	2.000	0.294	11.029
1D	1.583	0.026	0.537
2A	0.917	0.199	0.037
2B	0.250	0.065	0.329
2C	6.917	0.068	0.767
2D	2.667	0.037	1.183

Table 11: Standard Deviation of Sample 1 and Sample 2 Data

Treatment	Normal Seedlings	Shoot Weight	Root Weight
1A	1.500	0.412	1.257
1B	1.708	0.255	0.492
1C	1.414	0.542	3.321
1D	1.258	0.160	0.733
2A	0.957	0.447	0.191
2B	0.500	0.254	0.574
2C	2.630	0.261	0.876
2D	1.633	0.192	1.087



## I. Final Germination Analysis

### Overall Final Germination Analysis for Sample 1 and Sample 2

Two Sample t-test

```
data: x$NormalSeedlings and y$NormalSeedlings
t = -3.864, df = 30, p-value = 0.000554
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-3.439196 -1.060804
sample estimates:
mean of x mean of y
195.9375 198.1875
```

Assuming an  $\alpha=0.05$  and from the results of the Two Sample T-Test for Normal Seedling Germination, we obtained a p-value 0.000554 for Samples. Since the p-value for Samples is less than 0.05, we reject the null hypothesis and conclude that Sample 1 and Sample 2 means for Normal Seedling Germination are significantly different. Sample 2 has a greater mean for Normal Seedling Germination than Sample 1.

### Final Germination Analysis for Sample 1 and Sample 2 for 100% Water

Two Sample t-test

```
data: x$NormalSeedlings and y$NormalSeedlings
t = -4.4956, df = 6, p-value = 0.004123
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-6.177156 -1.822844
sample estimates:
mean of x mean of y
194.75 198.75
```

Assuming an  $\alpha=0.05$  and from the results of the Two Sample T-Test for Normal Seedling Germination, we obtained a p-value 0.004123 for Samples. Since the p-value for Samples is less than 0.05, we reject the null hypothesis and conclude that Sample 1 and Sample 2 means for Normal Seedling Germination are significantly different. Sample 2 has a greater mean for Normal Seedling Germination than Sample 1.

### Final Germination Analysis for Sample 1 and Sample 2 for 75% Water

Two Sample t-test

```
data: x$NormalSeedlings and y$NormalSeedlings
t = -3.3717, df = 6, p-value = 0.01501
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-5.1771558 -0.8228442
sample estimates:
mean of x mean of y
195.25 198.25
```

Assuming an  $\alpha=0.05$  and from the results of the Two Sample T-Test for Normal Seedling Germination, we obtained a p-value 0.01501 for Samples. Since the p-value for Samples is less than 0.05, we reject the null hypothesis and conclude that Sample 1 and Sample 2 means for Normal Seedling Germination are significantly different. Sample 2 has a greater mean for Normal Seedling Germination than Sample 1.



## Final Germination Analysis for Sample 1 and Sample 2 for 50% Water

Two Sample t-test

```
data: x$NormalSeedlings and y$NormalSeedlings
t = -1.5945, df = 6, p-value = 0.1619
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-6.336531  1.336531
sample estimates:
mean of x mean of y
 195.25   197.75
```

Assuming an  $\alpha=0.05$  and from the results of the Two Sample T-Test for Normal Seedling Germination, we obtained a p-value 0.1619 for Samples. Since the p-value for Samples is greater than 0.05, we fail to reject the null hypothesis and conclude that Sample 1 and Sample 2 means for Normal Seedling Germination are not significantly different.

## Final Germination Analysis for Sample 1 and Sample 2 for 25% Water

Two Sample t-test

```
data: x$NormalSeedlings and y$NormalSeedlings
t = -0.24254, df = 6, p-value = 0.8164
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-2.772219  2.272219
sample estimates:
mean of x mean of y
 197.75   198.00
```

Assuming an  $\alpha=0.05$  and from the results of the Two Sample T-Test for Normal Seedling Germination, we obtained a p-value 0.8164 for Samples. Since the p-value for Samples is greater than 0.05, we fail to reject the null hypothesis and conclude that Sample 1 and Sample 2 means for Normal Seedling Germination are not significantly different.

## **II. Dry Shoot Weight Analysis**

### Overall Dry Shoot Weight Analysis for Sample 1 and Sample 2

Two Sample t-test

```
data: x$ShootWeight and y$ShootWeight
t = 2.22, df = 30, p-value = 0.03412
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.1250348  2.9979652
sample estimates:
mean of x mean of y
 4.2330    2.6715
```

Assuming an  $\alpha=0.05$  and from the results of the Two Sample T-Test for Dry Shoot Weight, we obtained a p-value 0.03412 for Samples. Since the p-value for Samples is less than 0.05, we reject the null hypothesis and conclude that Sample 1 and Sample 2 means for Dry Shoot Weight are significantly different. Sample 1 has a greater mean for Dry Shoot Weight than Sample 2.



## Dry Shoot Weight Analysis for Sample 1 and Sample 2 for 100% Water

### Two Sample t-test

```
data: x$ShootWeight and y$ShootWeight
t = 7.824, df = 6, p-value = 0.0002301
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 1.633781 3.120719
sample estimates:
mean of x mean of y
 6.31050  3.93325
```

Assuming an  $\alpha=0.05$  and from the results of the Two Sample T-Test for Dry Shoot Weight, we obtained a p-value 0.0002301 for Samples. Since the p-value for Samples is less than 0.05, we reject the null hypothesis and conclude that Sample 1 and Sample 2 means for Dry Shoot Weight are significantly different. Sample 1 has a greater mean for Dry Shoot Weight than Sample 2.

## Dry Shoot Weight Analysis for Sample 1 and Sample 2 for 75% Water

### Two Sample t-test

```
data: x$ShootWeight and y$ShootWeight
t = 9.8656, df = 6, p-value = 6.256e-05
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 1.334192 2.214308
sample estimates:
mean of x mean of y
 5.75825  3.98400
```

Assuming an  $\alpha=0.05$  and from the results of the Two Sample T-Test for Dry Shoot Weight, we obtained a p-value  $6.256 \times 10^{-5}$  for Samples. Since the p-value for Samples is less than 0.05, we reject the null hypothesis and conclude that Sample 1 and Sample 2 means for Dry Shoot Weight are significantly different. Sample 1 has a greater mean for Dry Shoot Weight than Sample 2.

## Dry Shoot Weight Analysis for Sample 1 and Sample 2 for 50% Water

### Two Sample t-test

```
data: x$ShootWeight and y$ShootWeight
t = 17.341, df = 6, p-value = 2.357e-06
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 2.715815 3.608185
sample estimates:
mean of x mean of y
 5.75825  2.59625
```

Assuming an  $\alpha=0.05$  and from the results of the Two Sample T-Test for Dry Shoot Weight, we obtained a p-value  $2.357 \times 10^{-6}$  for Samples. Since the p-value for Samples is less than 0.05, we reject the null hypothesis and conclude that Sample 1 and Sample 2 means for Dry Shoot Weight are significantly different. Sample 1 has a greater mean for Dry Shoot Weight than Sample 2.



## Dry Shoot Weight Analysis for Sample 1 and Sample 2 for 25% Water

Two Sample t-test

```
data: x$ShootWeight and y$ShootWeight
t = 3.8763, df = 6, p-value = 0.008205
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.1789396 0.7915604
sample estimates:
mean of x mean of y
 0.65775  0.17250
```

Assuming an  $\alpha=0.05$  and from the results of the Two Sample T-Test for Dry Shoot Weight, we obtained a p-value 0.0028205 for Samples. Since the p-value for Samples is less than 0.05, we reject the null hypothesis and conclude that Sample 1 and Sample 2 means for Dry Shoot Weight are significantly different. Sample 1 has a greater mean for Dry Shoot Weight than Sample 2.

### III. Dry Root Weight Analysis

## Overall Dry Root Weight Analysis for Sample 1 and Sample 2

Two Sample t-test

```
data: x$RootWeight and y$RootWeight
t = -2.0241, df = 30, p-value = 0.05195
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-9.9193778 0.0443778
sample estimates:
mean of x mean of y
 31.5125  36.4500
```

Assuming an  $\alpha=0.05$  and from the results of the Two Sample T-Test for Dry Root Weight, we obtained a p-value 0.05195 for Samples. Since the p-value for Samples is greater than 0.05, we fail to reject the null hypothesis and conclude that Sample 1 and Sample 2 means for Dry Root Weight are not significantly different.

## Dry Root Weight Analysis for Sample 1 and Sample 2 for 100% Water

Two Sample t-test

```
data: x$RootWeight and y$RootWeight
t = -8.8873, df = 6, p-value = 0.000113
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-7.205602 -4.094398
sample estimates:
mean of x mean of y
 25.30  30.95
```

Assuming an  $\alpha=0.05$  and from the results of the Two Sample T-Test for Dry Root Weight, we obtained a p-value 0.000113 for Samples. Since the p-value for Samples is less than 0.05, we reject the null hypothesis and conclude that Sample 1 and Sample 2 means for Dry Root Weight are significantly different. Sample 2 has a greater mean for Dry Root Weight than Sample 1.



### Dry Root Weight Analysis for Sample 1 and Sample 2 for 75% Water

Two Sample t-test

```
data: x$RootWeight and y$RootWeight
t = -16.797, df = 6, p-value = 2.844e-06
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-7.275038 -5.424962
sample estimates:
mean of x mean of y
 25.975   32.325
```

Assuming an  $\alpha=0.05$  and from the results of the Two Sample T-Test for Dry Root Weight, we obtained a p-value  $2.844 \times 10^{-6}$  for Samples. Since the p-value for Samples is less than 0.05, we reject the null hypothesis and conclude that Sample 1 and Sample 2 means for Dry Root Weight are significantly different. Sample 2 has a greater mean for Dry Root Weight than Sample 1.

### Dry Root Weight Analysis for Sample 1 and Sample 2 for 50% Water

Two Sample t-test

```
data: x$RootWeight and y$RootWeight
t = -20.556, df = 6, p-value = 8.622e-07
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-11.554051 -9.095949
sample estimates:
mean of x mean of y
 25.975   36.300
```

Assuming an  $\alpha=0.05$  and from the results of the Two Sample T-Test for Dry Root Weight, we obtained a p-value  $8.622 \times 10^{-7}$  for Samples. Since the p-value for Samples is less than 0.05, we reject the null hypothesis and conclude that Sample 1 and Sample 2 means for Dry Root Weight are significantly different. Sample 2 has a greater mean for Dry Root Weight than Sample 1.

### Dry Root Weight Analysis for Sample 1 and Sample 2 for 25% Water

Two Sample t-test

```
data: x$RootWeight and y$RootWeight
t = -4.843, df = 6, p-value = 0.002872
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-4.779159 -1.570841
sample estimates:
mean of x mean of y
 43.050   46.225
```

Assuming an  $\alpha=0.05$  and from the results of the Two Sample T-Test for Dry Root Weight, we obtained a p-value 0.002872 for Samples. Since the p-value for Samples is less than 0.05, we reject the null hypothesis and conclude that Sample 1 and Sample 2 means for Dry Root Weight are significantly different. Sample 2 has a greater mean for Dry Root Weight than Sample 1.

## **Summary**

The remote SSF treatment method had a significant effect on seed germination, dry shoot weight, and dry root weight.

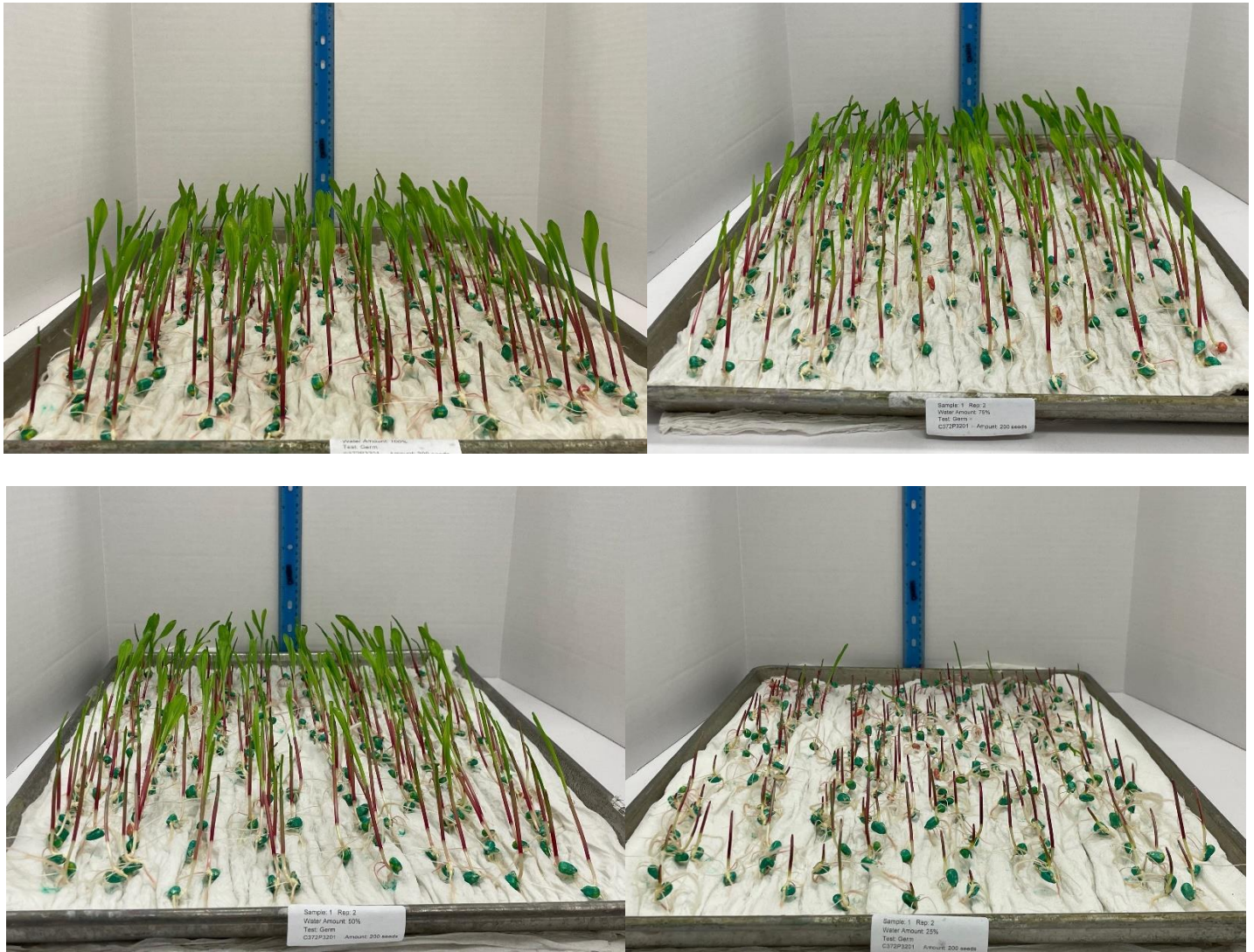
**Germination:** Overall germination was found to have significance with the treated sample, Sample 2, having 1-2% greater germination than Sample 1. Upon further look, significance was found in 100% and 75% water but no significance was found in 50% and 25% water supply. Some potential factors to consider are that Sample 1 and Sample 2 were not grown at the same time, sample size is relatively small with a difference of a few seedlings, only one lot of high vigor corn seed was used, and water was the only stress factor verses heat, insects, soil nutrient make up, etc.

**Dry Shoot Dry Weight:** Overall dry shoot weight was found to have significance with the untreated sample, Sample 1, having 31–38% greater dry tissue weight than Sample 2. Upon further look, this was found to be a significant factor for 100%, 75%, 50%, and 25% water supply. Some potential factors to consider are that Sample 1 and Sample 2 were not grown at the same time, sample size is relatively small with difference by only a few grams, seedlings were only grown for 10 days, only one lot of high vigor corn seed was used, and water was the only stress factor verses heat, insects, soil nutrient make up, etc.

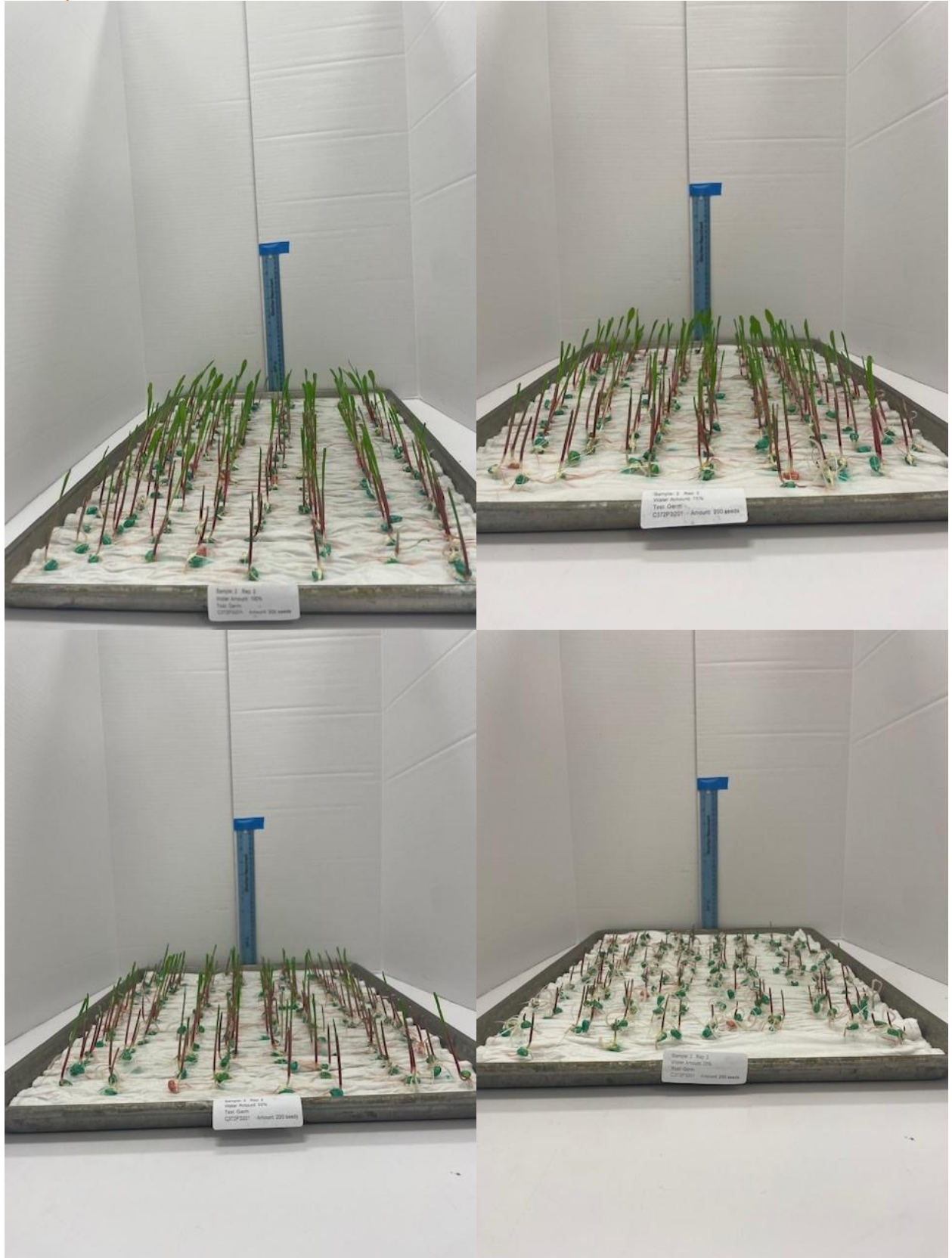
**Dry Root Dry Weight:** Overall dry root weight was not found to have significance between samples. However, upon further look, this was found to be a significant factor for 100%, 75%, 50%, and 25% water supply, with greatest significance in the 75% and the 50% water supply samples of 10-22%. Some potential factors to consider are that Sample 1 and Sample 2 were not grown at the same time, sample size is relatively small with difference by only a few grams, seedlings were only grown for 10 days, only one lot of high vigor corn seed was used, and water was the only stress factor verses heat, insects, soil nutrient make up, etc.

In conclusion, this study found some significance in germination, dry shoot weight and dry root weight; however, to better understand and quantify these results it is recommended that this study be repeated. Should this study be repeated, it would be advised to increase the length of germination time, add additional replications, add additional lots of seed with different levels of seed vigor, and have both Sample 1 and Sample 2 seeds planted at the same time and in the same space.

**Appendix A: Day 7 Germination Photos**

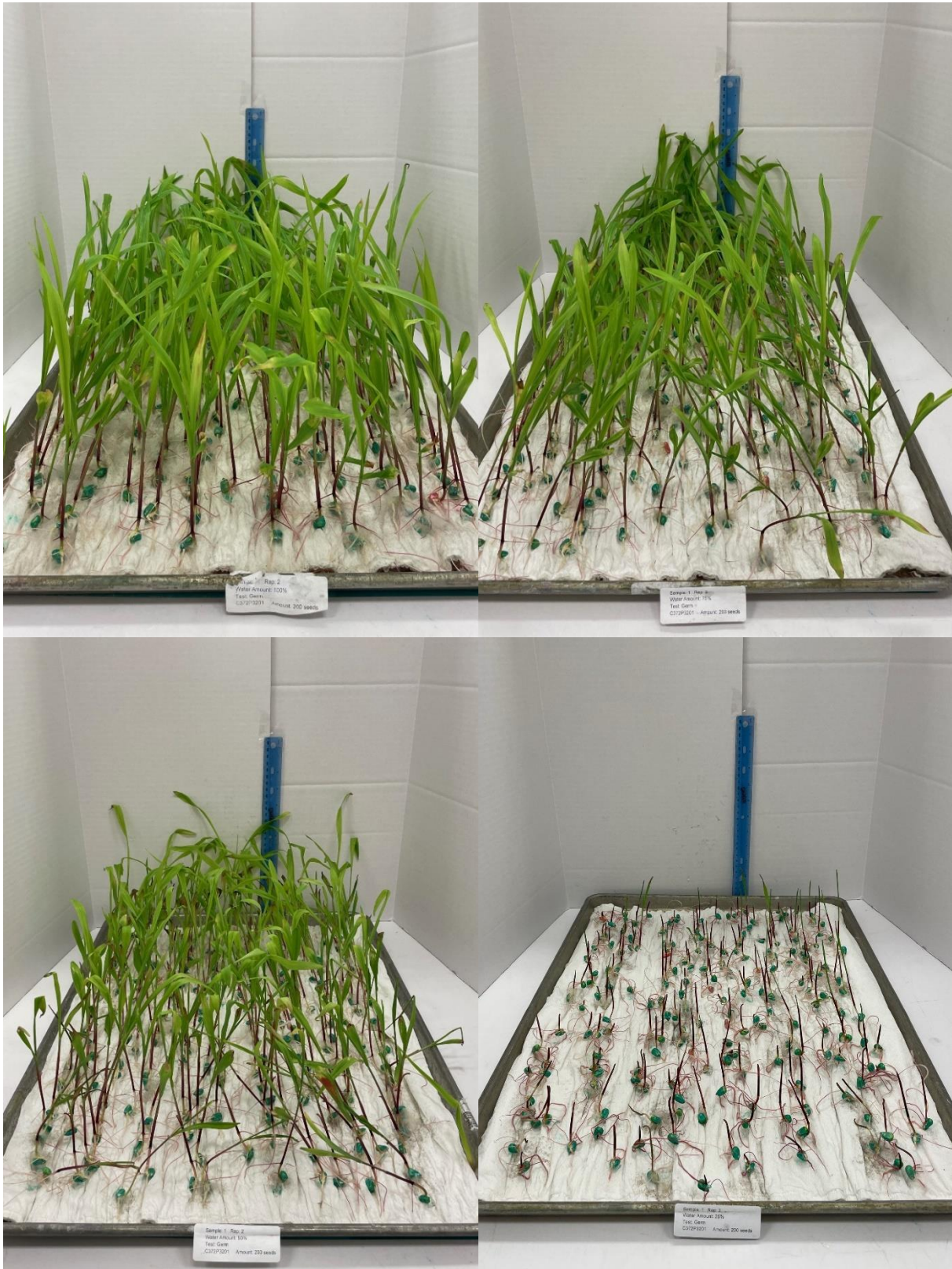


Sample 1: 100% Water (Top Left), 75% Water (Top Right), 50% Water (Bottom Left), and 25% Water (Bottom Right).

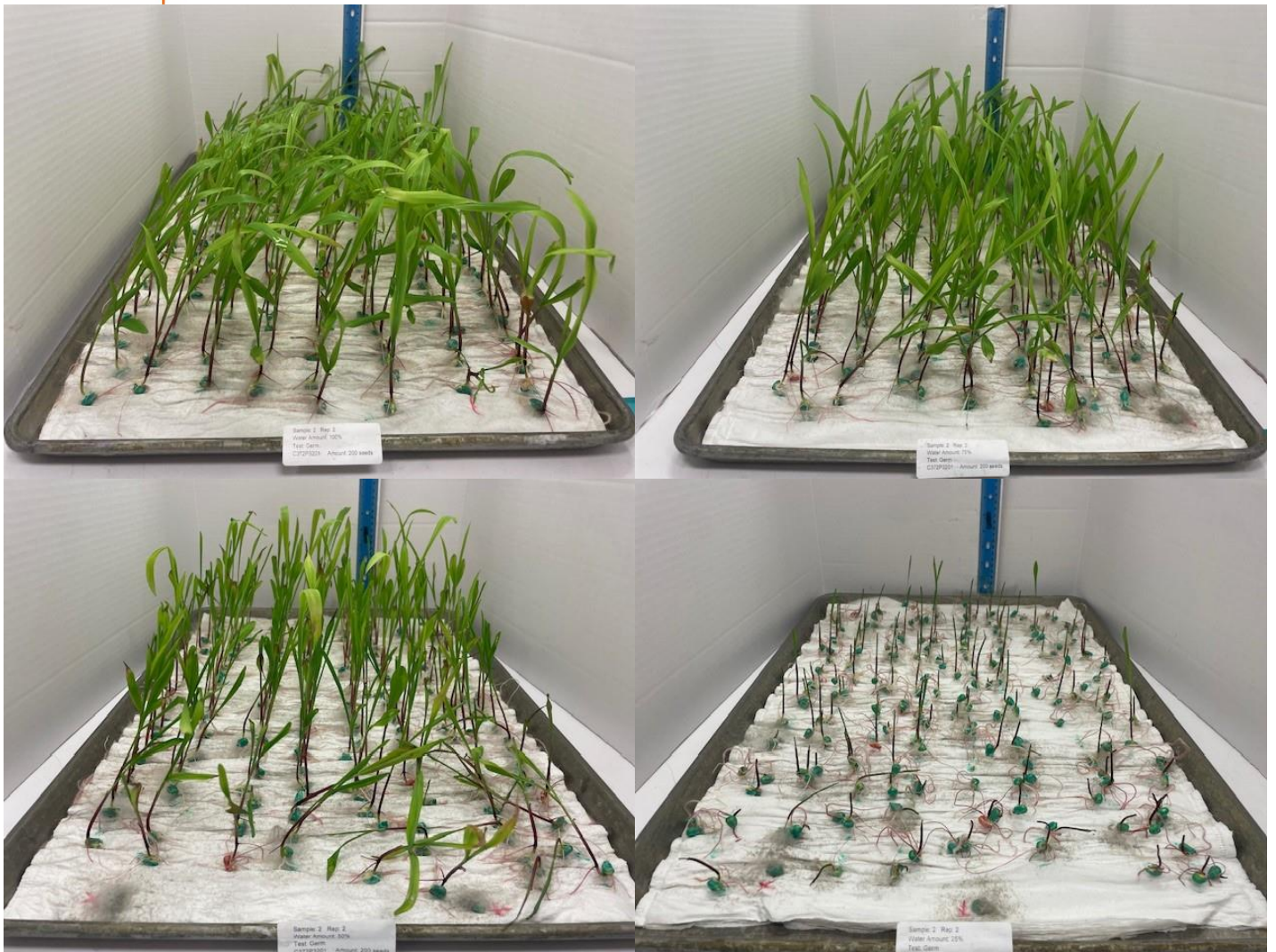


Sample 2: 100% Water (Top Left), 75% Water (Top Right), 50% Water (Bottom Left), and 25% Water (Bottom Right).

**Appendix B: Final Germination Photos**



Sample 1: 100% Water (Top Left), 75% Water (Top Right), 50% Water (Bottom Left), and 25% Water (Bottom Right).



Sample 2: 100% Water (Top Left), 75% Water (Top Right), 50% Water (Bottom Left), and 25% Water (Bottom Right).



# Optima Quanta 2025 Soil Nutrient Testing: Part One

Study Number:

C372P3583

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July 21, 2025

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## **Introduction**

SGS North America Inc., located in Brookings, SD is a full-service seed testing laboratory. Founded in 1993, the company has worked with over 1500 seed company accounts from 43 states and several countries. SGS Brookings location employs several full-time seed analysts including Registered Seed Technologists, Registered Genetic Technologists, and Certified Genetic Technologists. The staff holds Master of Science degrees in Biological Sciences, Agronomy, Biology, Soil Fertility, Ag Education, and Computer Science. The laboratory conducts seed treatment, germination, vigor, herbicide tolerance, physical and genetic purity, and GMO (ELISA/protein, DNA/PCR, bioassays) testing.

## **Overview of Experiment**

The following experiment was conducted to determine the biological effect of SSF on the soil content of Nitrogen (N), Phosphorus (P) and Potassium (K) before and after activation of quantum copy.

*Table 1: Study Treatments*

Sample	Description
1	Control – untreated soil
2	Quantum Activated NPK soil

## **Procedure:**

### **Soil Treatment Application:**

Local, field soil was used for testing for both samples and was stored at ambient temperature for the duration of the study. Sample 1, control, was not submitted to any SSF treatment prior to testing. The soil for Sample 2 was treated remotely using SSF technology by the client. A video file featuring the soil of Sample 2 was prepared and sent to the client. The client organized the remote treatment of the test group soil. Seventy-two hours after receiving confirmation from the client regarding the SSF seed treatment procedure, the laboratory began testing Sample 2. Both Sample 1 and Sample 2 were shipped using next day delivery to the laboratory for soil analysis.

### **Soil Testing Procedure:**

Sample 1 was tested for soil analysis on May 20, 2025. Sample 2 was tested for soil analysis on May 30, 2025 (test time one), using the same equipment as Sample 1. Each sample was divided into four replicates prior. Soil testing evaluated soil for organic matter, phosphorus (P1, P2, and Olsen bicarbonate phosphorus), potassium, magnesium, calcium, soil pH, cation exchange capacity, percent base saturation (%K, %Mg, %Ca), and nitrate within the soil.

Table 2: Soil Data

Date Tested	Sample	Rep	Description	Organic Matter		Phosphorus						Neutral Ammonium Acetate (Exchangeable)						Soil pH	Cation Exchange Capacity	Percent Base Saturation (Computed)				Nitrate-N (FIA)			
						P <sub>1</sub>		P <sub>2</sub>		Olsen Bicarbonate P		Potassium		Magnesium		Calcium				%K	%Mg	%Ca	%H	Surface		Total Lbs/A	
						PPM	Rate	PPM	Rate	PPM	Rate	PPM	Rate	PPM	Rate	PPM	Rate							ppm	lbs/A		depth (in)
						Percent	Rate	PPM	Rate	PPM	Rate	PPM	Rate	PPM	Rate	PPM	Rate										
5/20/2025	1	1	Control- Untreated Soil	2.9	M	8	L	33	M	16	H	229	H	555	VH	3917	H	7.6	24.8	2.4	18.6	79.0	0	37	67	0-6	67
	1	2	Control- Untreated Soil	2.9	M	8	L	31	M	16	H	215	H	534	VH	3758	H	8	23.8	2.3	18.7	79.0	0	37	67	0-6	67
	1	3	Control- Untreated Soil	2.9	M	11	L	32	M	15	H	215	H	521	VH	3743	H	7.9	23.6	2.3	18.4	79.3	0	36	65	0-6	65
	1	4	Control- Untreated Soil	3.0	M	7	L	33	M	18	H	226	H	543	VH	3813	H	7.7	24.2	2.4	18.7	78.9	0	39	70	0-6	70
Average of Sample 1				2.9	M	8.5	L	32.3	M	16.3	H	221.3	H	538.3	VH	3807.8	H	7.8	24.1	2.4	18.6	79.1	0.0	37.3	67.3	0-6	67.3
5/30/2025	2	1	Quantum Activated NPK Soil	2.7	M	13	L	29	M	15	H	194	H	543	VH	3612	H	7.9	23.1	2.2	19.6	78.2	0	36	65	0-6	65
	2	2	Quantum Activated NPK Soil	2.8	M	14	L	32	M	15	H	212	H	590	VH	3786	H	7.9	24.4	2.2	20.2	77.6	0	34	61	0-6	61
	2	3	Quantum Activated NPK Soil	2.9	M	13	L	31	M	15	H	214	H	574	VH	3891	H	7.5	24.8	2.2	19.3	78.5	0	35	63	0-6	63
	2	4	Quantum Activated NPK Soil	2.7	M	14	L	33	M	15	H	200	H	564	VH	3857	H	7.7	24.5	2.1	19.2	78.7	0	37	67	0-6	67
Average of Sample 2				2.8	M	13.5	L	31.3	M	15.0	H	205.0	H	567.8	VH	3786.5	H	7.8	24.2	2.2	19.6	78.3	0.0	35.5	64.0	0-6	64.0

Rate Abbreviations: Low (L), Moderate (M), High (H), Very High (VH)

## Statistical Analysis

### Basic Analysis

Table 3: Mean of Sample 1 and Sample 2 Data

Sample	Organic Matter %	Phosphorus 1 PPM	Phosphorus 2 PPM	Olsen Bicarbonate P PPM	Potassium PPM	Magnesium PPM	Calcium PPM	Soil pH	Cation Exchange Capacity	% K	% Mg	% Ca	Nitrate PPM	Nitrate lbs per Acre	Nitrate Total Lbs per Acre
1	2.93	8.5	32.25	16.25	221.25	538.25	3807.75	7.8	24.1	2.35	18.6	79.05	37.25	67.25	67.25
2	2.78	13.5	31.25	15	205	567.75	3786.5	7.75	24.2	2.18	19.58	78.25	35.5	64	64

Table 4: Variance of Sample 1 and Sample 2 Data

Sample	Organic Matter %	Phosphorus 1 PPM	Phosphorus 2 PPM	Olsen Bicarbonate P PPM	Potassium PPM	Magnesium PPM	Calcium PPM	Soil pH	Cation Exchange Capacity	% K	% Mg	% Ca	Nitrate PPM	Nitrate lbs per Acre	Nitrate Total Lbs per Acre
1	0.003	3	0.917	1.583	53.583	206.25	6210.25	0.033	0.28	0.003	0.02	0.03	1.583	4.25	4.25
2	0.009	0.333	2.917	0	92	386.917	15447	0.037	0.567	0.003	0.203	0.23	1.667	6.667	6.667

Table 5: Standard Deviation of Sample 1 and Sample 2 Data

Sample	Organic Matter %	Phosphorus 1 PPM	Phosphorus 2 PPM	Olsen Bicarbonate P PPM	Potassium PPM	Magnesium PPM	Calcium PPM	Soil pH	Cation Exchange Capacity	% K	% Mg	% Ca	Nitrate PPM	Nitrate lbs per Acre	Nitrate Total Lbs per Acre
1	0.05	1.732	0.957	1.258	7.32	14.361	78.805	0.183	0.529	0.058	0.141	0.173	1.258	2.062	2.062
2	0.096	0.577	1.708	0	9.592	19.67	124.286	0.191	0.753	0.05	0.45	0.48	1.291	2.582	2.582



## Organic Matter Percent Analysis for Sample 1 and Sample 2

Two Sample t-test

```
data: x$OrganicMatterPercent and y$OrganicMatterPercent
t = 2.7775, df = 6, p-value = 0.0321
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.01785166 0.28214834
sample estimates:
mean of x mean of y
 2.925    2.775
```

Using a two-sample t-test with a significance level of  $P < 0.05$ , the comparison of the control, sample 1, to sample 2 determined that the control had significantly more organic matter ( $t = 2.7775$ ;  $df = 6$ ;  $P = 0.0321$ ). The soil analysis testing found that the control had greater organic matter and resulted in 5.11% more organic matter than sample 2.

## Phosphorus 1 PPM Analysis for Sample 1 and Sample 2

Two Sample t-test

```
data: x$Phosphorus1PPM and y$Phosphorus1PPM
t = -5.4772, df = 6, p-value = 0.001547
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-7.233715 -2.766285
sample estimates:
mean of x mean of y
 8.5    13.5
```

Using a two-sample t-test with a significance level of  $P < 0.05$ , the comparison of the control, sample 1, to sample 2 determined that sample 2 had significantly more phosphorus 1 ( $t = -5.4772$ ;  $df = 6$ ;  $P = 0.001547$ ). The soil analysis testing found that sample 2 had greater phosphorus 1 and resulted in 58.82% more phosphorus 1 than the control.

## Phosphorus 2 PPM Analysis for Sample 1 and Sample 2

Two Sample t-test

```
data: x$Phosphorus2PPM and y$Phosphorus2PPM
t = 1.0215, df = 6, p-value = 0.3464
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-1.395392 3.395392
sample estimates:
mean of x mean of y
 32.25    31.25
```

Using a two-sample t-test with a significance level of  $P < 0.05$ , the comparison of the control, sample 1, to sample 2 determined that sample 2 did not have significantly more phosphorus 2 ( $t = 1.0215$ ;  $df = 6$ ;  $P = 0.3464$ ). The soil analysis testing found that the control had greater phosphorus 2 and resulted in 3.10% more phosphorus 2 than sample 2.



## Olsen Bicarbonate Phosphorus PPM Analysis for Sample 1 and Sample 2

Two Sample t-test

```
data: x$OlsenBicarbonateP.PPM and y$OlsenBicarbonateP.PPM
t = 1.9868, df = 6, p-value = 0.09413
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-0.2894816  2.7894816
sample estimates:
mean of x mean of y
16.25      15.00
```

Using a two-sample t-test with a significance level of  $P < 0.05$ , the comparison of the control, sample 1, to sample 2 determined that sample 2 did not have significantly more Olsen bicarbonate phosphorus ( $t=1.9868$ ;  $df=6$ ;  $P=0.09413$ ). The soil analysis testing found that the control had greater Olsen bicarbonate phosphorus and resulted in 7.69% more Olsen bicarbonate phosphorus than sample two.

## Potassium PPM Analysis for Sample 1 and Sample 2

Two Sample t-test

```
data: x$PotassiumPPM and y$PotassiumPPM
t = 2.6936, df = 6, p-value = 0.03588
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
1.488035  31.011965
sample estimates:
mean of x mean of y
221.25    205.00
```

Using a two-sample t-test with a significance level of  $P < 0.05$ , the comparison of the control, sample 1, to sample 2 determined that the control had significantly more potassium ( $t=2.6936$ ;  $df=6$ ;  $P=0.03588$ ). The soil analysis testing found that the control had greater potassium and resulted in 7.34% more potassium than sample 2.

## Magnesium PPM Analysis for Sample 1 and Sample 2

Two Sample t-test

```
data: x$MagnesiumPPM and y$MagnesiumPPM
t = -2.4225, df = 6, p-value = 0.05169
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-59.2972852  0.2972852
sample estimates:
mean of x mean of y
538.25    567.75
```

Using a two-sample t-test with a significance level of  $P < 0.05$ , the comparison of the control, sample 1, to sample 2 determined that sample 2 did not have significantly more magnesium ( $t= -2.4225$ ;  $df=6$ ;  $P=0.05169$ ). The soil analysis testing found that sample 2 had greater magnesium and resulted in 5.48% more magnesium than the control.



## Calcium PPM Analysis for Sample 1 and Sample 2

Two Sample t-test

```
data: x$CalciumPPM and y$CalciumPPM
t = 0.28879, df = 6, p-value = 0.7825
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-158.7987 201.2987
sample estimates:
mean of x mean of y
3807.75 3786.50
```

Using a two-sample t-test with a significance level of  $P < 0.05$ , the comparison of the control, sample 1, to sample 2 determined that sample 2 did not have significantly more calcium ( $t=0.28879$ ;  $df=6$ ;  $P=0.7825$ ). The soil analysis testing found that the control had greater calcium and resulted in 0.56% more calcium than sample 2.

## Cation Exchange Capacity Analysis for Sample 1 and Sample 2

Two Sample t-test

```
data: x$CationExchangeCapacity and y$CationExchangeCapacity
t = -0.21736, df = 6, p-value = 0.8351
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-1.225757 1.025757
sample estimates:
mean of x mean of y
24.1 24.2
```

Using a two-sample t-test with a significance level of  $P < 0.05$ , the comparison of the control, sample 1, to sample 2 determined that sample 2 did not have significantly more cation exchange capacity ( $t= -0.21736$ ;  $df=6$ ;  $P=0.8351$ ). The soil analysis testing found that sample 2 had greater cation exchange capacity and resulted in 0.41% more cation exchange capacity than the control.

## Percent Potassium Analysis for Sample 1 and Sample 2

Two Sample t-test

```
data: x$X.K and y$X.K
t = 4.5826, df = 6, p-value = 0.00376
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
0.08155701 0.26844299
sample estimates:
mean of x mean of y
2.350 2.175
```

Using a two-sample t-test with a significance level of  $P < 0.05$ , the comparison of the control, sample 1, to sample 2 determined that the control had significantly more percent potassium ( $t=4.5826$ ;  $df=6$ ;  $P=0.00376$ ). The soil analysis testing found that the control had greater percent potassium and resulted in 7.45% more percent potassium than sample 2.



## Percent Magnesium Analysis for Sample 1 and Sample 2

Two Sample t-test

```
data: x$X.Mg and y$X.Mg
t = -4.134, df = 6, p-value = 0.00612
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-1.552103 -0.397897
sample estimates:
mean of x mean of y
18.600 19.575
```

Using a two-sample t-test with a significance level of  $P < 0.05$ , the comparison of the control, sample 1, to sample 2 determined that sample 2 had significantly more percent magnesium ( $t = -4.134$ ;  $df = 6$ ;  $P = 0.00612$ ). The soil analysis testing found that sample 2 had greater percent magnesium and resulted in 5.24% more percent magnesium than the control.

## Percent Calcium Analysis for Sample 1 and Sample 2

Two Sample t-test

```
data: x$X.Ca and y$X.Ca
t = 3.1379, df = 6, p-value = 0.02012
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
0.1761574 1.4238426
sample estimates:
mean of x mean of y
79.05 78.25
```

Using a two-sample t-test with a significance level of  $P < 0.05$ , the comparison of the control, sample 1, to sample 2 determined that the control had significantly more percent calcium ( $t = 3.1379$ ;  $df = 6$ ;  $P = 0.02012$ ). The soil analysis testing found that the control had greater percent calcium and resulted in 1.01% more percent calcium than sample 2.

## Nitrate PPM Analysis for Sample 1 and Sample 2

Two Sample t-test

```
data: x$NitratePPM and y$NitratePPM
t = 1.9415, df = 6, p-value = 0.1002
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
-0.4556165 3.9556165
sample estimates:
mean of x mean of y
37.25 35.50
```

Using a two-sample t-test with a significance level of  $P < 0.05$ , the comparison of the control, sample 1, to sample 2 determined that sample 2 did not have significantly more nitrate ( $t = 1.9415$ ;  $df = 6$ ;  $P = 0.1002$ ). The soil analysis testing found that the control had greater nitrate and resulted in 4.70% more nitrate than sample 2.



## Nitrate Pounds Per Acre Analysis for Sample 1 and Sample 2

Two Sample t-test

```
data: x$Nitratelbs.A and y$Nitratelbs.A
t = 1.9673, df = 6, p-value = 0.09671
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.7923448  7.2923448
sample estimates:
mean of x mean of y
 67.25    64.00
```

Using a two-sample t-test with a significance level of  $P < 0.05$ , the comparison of the control, sample 1, to sample 2 determined that sample 2 did not have significantly more nitrate pounds per acre ( $t=1.9673$ ;  $df=6$ ;  $P=0.09671$ ). The soil analysis testing found that the control had greater nitrate pounds per acre and resulted in 4.83% more nitrate pounds per acre than sample 2.

### Summary

The remote SSF treatment method had a significant effect on phosphorous 1 and percent magnesium levels within the soil. The control was significantly more effective for organic matter percent, potassium, percent potassium, and percent calcium levels. No significance was found between the control and the remote SSF treatment method for phosphorous 2, Olsen bicarbonate phosphorous, magnesium levels, calcium, cation exchange capacity, nitrate, and nitrate pounds per acre levels. However, the results did find that remote SSF treatment method did create a slight increase for the magnesium levels within the soil.

Although differences were observed between the control and the remote SSF treatment method treatment, phosphorous 1 was the only test that produced notable results that would be of interest to growers. Phosphorous 1 levels were also positively affected by the remote SSF treatment method and resulted in a 58.82 percent increase for sample 2. This would create increased levels of Phosphorous 1 available in the soil that is readily available for plant uptake at the time of treatment. To further understand and quantify these results additional testing should be conducted with additional replications, multiple soil types, and increased testing time points conducted alongside the control at time of sampling.