Problem Statement

In the experiment, we took PES (commercially available medium) in which we have replaced nitrate and phosphate.

Now for Nitrate source it was replaced with Urea and for phosphate it was replaced with DAP, also we have check the combined

Effect of Urea and DAP as a source of nitrate and phosphate respectively.

Initial weight of the Ulva in triplicate given below and increased weight on 21st day (also we have given for 7th and 14th day increased weight in mg). this biomass was grown in 250ml of medium

Now we have to do prediction of If we could scale up for 20000 litre tank what will be production output per day per cycle (21 days) per year

When we altered medium

Condition 1. What happens when if we only replace with Urea in the medium? (asper the data provided)

Condition 2. What happens when if we only replace with DAP in the medium? (asper the data provided)

Condition 3. What happens when if we replace combining Urea and DAP? (asper the data provided)

1) Urea under consideration

```
     medium     sample   day_0   day_7   day_14   day_21
0    Control   growth_1   559.7   825.2   1367.3   1694.8
1    Control   growth_2   547.8   905.9   1493.1   1888.8
2    Control   growth_3   559.8   868.6   1454.0   1702.6
3     Lower    growth_1   460.3   709.5    994.5   1416.3
4     Lower    growth_2   496.5   700.5    976.5   1318.0
5     Lower    growth_3   475.1   974.5   1376.1   1830.3
6    Actual    growth_1   593.6   915.8   1518.3   2303.3
7    Actual    growth_2   483.0   910.5   1644.2   2222.0
8    Actual    growth_3   544.3   926.4   1632.4   2413.3
9    Higher    growth_1   596.5   794.4   1231.1   1728.0
10   Higher    growth_2   576.6   729.9   1236.5   1679.6
11   Higher    growth_3   525.6   928.2   1499.8   1986.7
```

1.1 Urea with Controlled concentration

Data provided:

header = ["medium","sample","day_0","day_7","day_14","day_21"]
data = [["Control","growth_1",559.7,825.2,1367.3,1694.8],
    ["Control","growth_2",547.8,905.9,1493.1,1888.8],
    ["Control","growth_3",559.8,868.6,1454,1702.6]]

```
urea_control:
     medium     sample   day_0   day_7   day_14   day_21
0   Control    growth_1   559.7   825.2   1367.3   1694.8
1   Control    growth_2   547.8   905.9   1493.1   1888.8
2   Control    growth_3   559.8   868.6   1454.0   1702.6
```
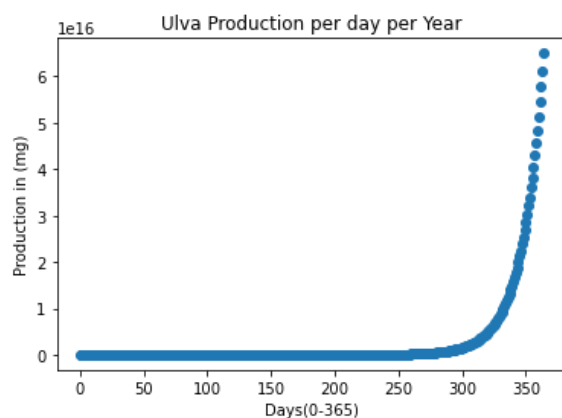
Production at the end of the year: 6.50×10^{16} mg
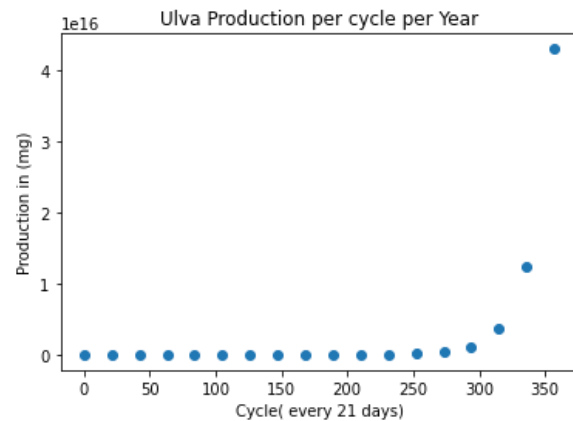

Figure 1

Figure 2

From Figure 1, it can be clearly found out that, final prediction is 6.50×10^{16} mg at the end of the year, as per plotting exponential curve equation. The same predicted data can be used to plot for every 21 days.

In particular, the Figure 2 is scatter graph is plotted for every 21 day /year.

For an instance, a plot for 50 days is shown below. At the end of 49 days, as we can see, the output will be 50.313×10^7 mg or 749.49 Kg of Ulva per 20000L of Solution.
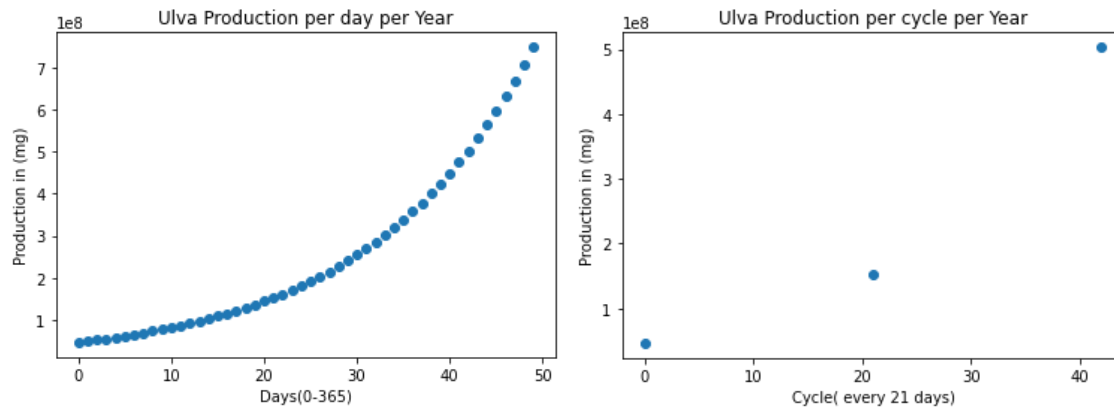


```
Figure plots(For Cycle):

Days: [0, 7, 14, 21, 28, 35, 42, 49]
Growth: [46363321.27292781, 68931210.20603095, 102516314.8659061,
152513168.4894424, 226965821.21501386, 337873206.4918482,
503139664.0014758, 749490486.6377397]
```
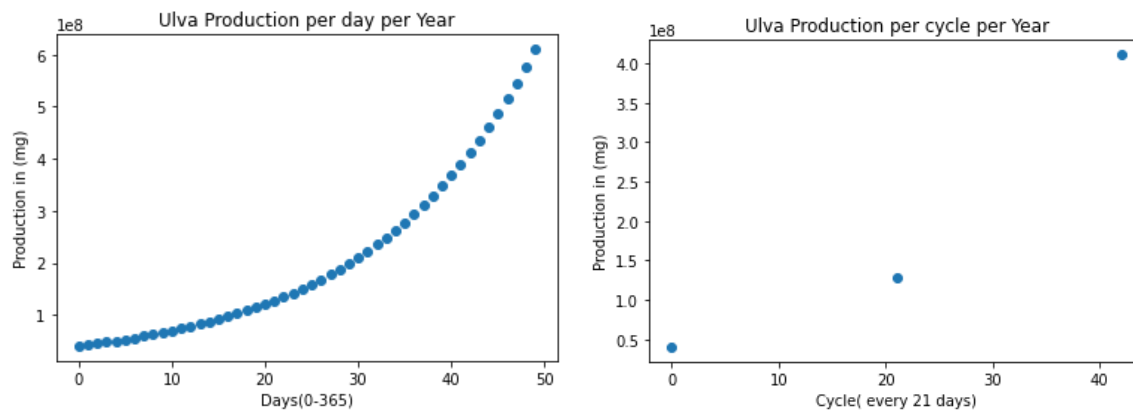
1.2 Urea with Lower concentration

Data provided:

header = ["medium","sample","day_0","day_7","day_14","day_21"]
data = [['Lower','growth_1',460.3,709.5,994.5,1416.3],
    ['Lower','growth_2',496.5,700.5,976.5,1318],
    ['Lower','growth_3',475.1,974.5,1376.1,1830.3]]

```
urea_lower:
   medium    sample   day_0   day_7   day_14   day_21
0  Lower    growth_1   460.3   709.5    994.5   1416.3
1  Lower    growth_2   496.5   700.5    976.5   1318.0
2  Lower    growth_3   475.1   974.5   1376.1   1830.3
```

Production at the end of the year: 1.22×10^{17} mg

The plot for 50 days is shown below. At the end of <mark>49 days</mark>, as we can see, the output will be 6.1017 x10^8 mg or <mark>610.17 Kg</mark> of Ulva per 20000L of Solution.

```
Figure plots(For Cycle):

Days: [0, 7, 14, 21, 28, 35, 42, 49]
Growth: [40304827.12208724, 59022305.876314424, 86626627.67806081,
127428288.17229602, 187870675.44839975, 277604667.8877746,
411113297.5095741, 610171909.116323]
```
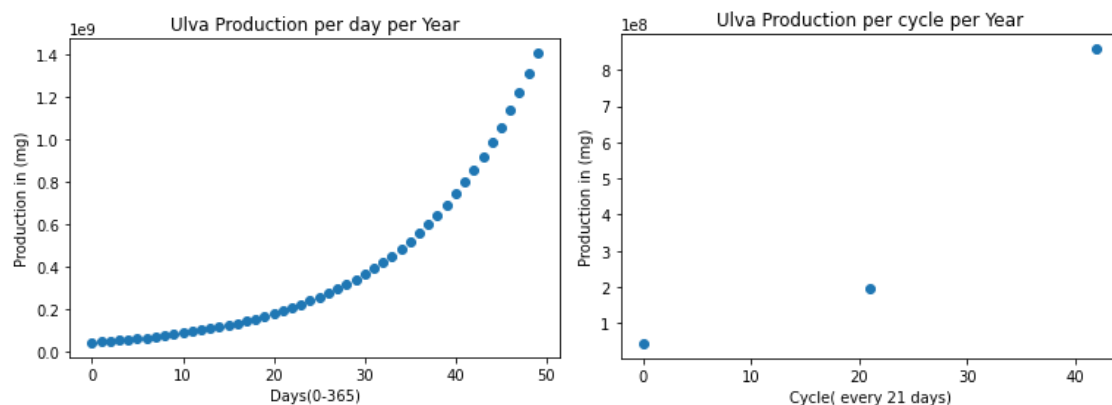
1.3 Urea with Actual concentration

Data provided:

header = ["medium","sample","day_0","day_7","day_14","day_21"]
data = [['Actual','growth_1',593.6,915.8,1518.3,2303.3],
    ['Actual','growth_2',483,910.5,1644.2,2222],
    ['Actual','growth_3',544.3,926.4,1632.4,2413.3]]

```
urea_actual:
    medium    sample  day_0  day_7  day_14  day_21
0  Actual  growth_1  593.6  915.8  1518.3  2303.3
1  Actual  growth_2  483.0  910.5  1644.2  2222.0
2  Actual  growth_3  544.3  926.4  1632.4  2413.3

Production at the end of the year: 1.03x10¹⁹ mg
```

Production at the end of the year: 1.03×10^{19} mg

The plot for 50 days is shown below. At the end of <mark>49 days</mark>, as we can see, the output will be 1.40748 x10^9 mg or <mark>1407.48 Kg</mark> of Ulva per 20000L of Solution.

```
Figure plots(For Cycle):

Days: [0, 7, 14, 21, 28, 35, 42, 49]
Growth: [44472351.155648604, 72710024.43109639, 118955016.92919876,
194738393.73734304, 319004315.7601303, 522893504.3171705,
857624103.5609406, 1407482087.5988483]
```

1.4 Urea with higher concentration

Data provided:

header = ["medium","sample","day_0","day_7","day_14","day_21"]
data = [['Higher','growth_1',596.5,794.4,1231.1,1728],
    ['Higher','growth_2',576.6,729.9,1236.5,1679.6],
    ['Higher','growth_3',525.6,928.2,1499.8,1986.7]]

```
urea_higher:
    medium     sample  day_0  day_7  day_14  day_21
0  Higher  growth_1  596.5  794.4  1231.1  1728.0
1  Higher  growth_2  576.6  729.9  1236.5  1679.6
2  Higher  growth_3  525.6  928.2  1499.8  1986.7
```

Production at the end of the year: 1.92×10^{17} mg
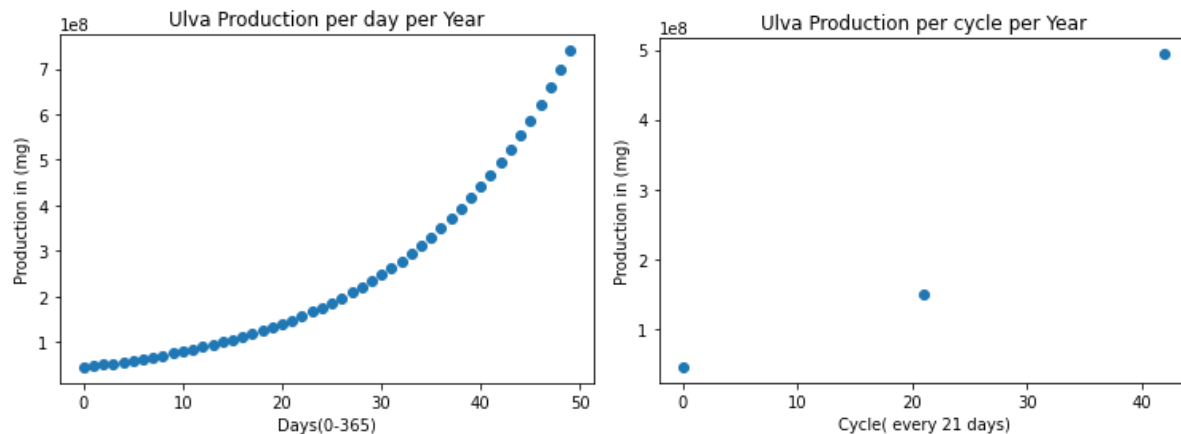
The plot for 50 days is shown below. At the end of 49 days, as we can see, the output will be 7.3974×10^8 mg or 739.74 Kg of Ulva per 20000L of Solution.

```
Figure plots(For Cycle):

Days: [0, 7, 14, 21, 28, 35, 42, 49]
Growth: [45207152.63822196, 67096210.21623822, 99726270.87228611,
148441425.71209005, 221282077.90762103, 330364139.107615,
493973020.8111123, 739747436.3892164]
```

Final conclusion by using urea in medium:
(Approx. values in Kg per 20000L Solution)

	Day 0	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42	Day 49
Control	46 Kg	68 Kg	102 Kg	152 Kg	226 Kg	337 Kg	503 Kg	749 Kg
Lower	40 Kg	59 Kg	86 Kg	127 Kg	187 Kg	277 Kg	411 Kg	610 Kg
Actual	44 Kg	72 Kg	118 Kg	184 Kg	319 Kg	522 Kg	857 Kg	1407 Kg
Higher	45 Kg	67 Kg	99 Kg	148 Kg	221 Kg	330 Kg	493 Kg	739 Kg

2) DAP under consideration

```
      medium      sample   day_0   day_7   day_14   day_21
0    Control   growth_1   559.7   825.2   1367.3   1694.8
1    Control   growth_2   547.8   905.9   1493.1   1888.8
2    Control   growth_3   559.8   868.6   1454.0   1702.6
3      Lower   growth_1   529.9   760.3   1350.9   1558.2
4      Lower   growth_2   523.0   685.0   1133.4   1554.4
5      Lower   growth_3   383.3   480.8    660.9    903.8
6     Actual   growth_1   525.7   628.8   1010.2   1302.0
7     Actual   growth_2   488.2   653.8   1017.1   1370.4
8     Actual   growth_3   540.2   777.2   1226.2   1408.0
9     Higher   growth_1   435.9   468.4    807.0   1246.5
10    Higher   growth_2   387.8   446.2    753.4   1013.7
11    Higher   growth_3   438.2   463.6    815.2   1079.6
```

2.1 DAP with Controlled concentration

Data provided:
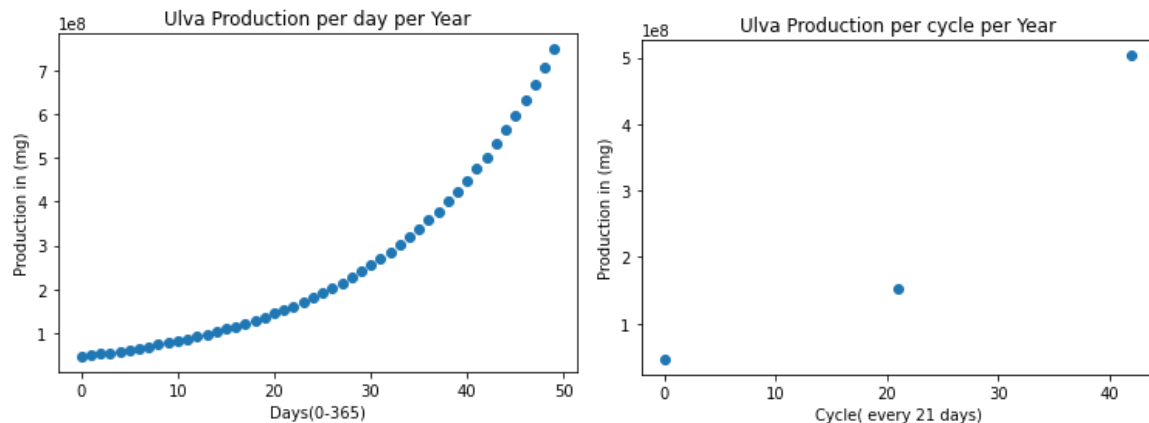header = ["medium","sample","day_0","day_7","day_14","day_21"]
data = [['Control','growth_1',559.7,825.2,1367.3,1694.8],
    ['Control','growth_2',547.8,905.9,1493.1,1888.8],
    ['Control','growth_3',559.8,868.6,1454,1702.6]]

```
DAP_control:
      medium      sample   day_0   day_7   day_14   day_21
0    Control   growth_1   559.7   825.2   1367.3   1694.8
1    Control   growth_2   547.8   905.9   1493.1   1888.8
2    Control   growth_3   559.8   868.6   1454.0   1702.6
```

Production at the end of the year: 6.50×10^{16} mg

For an instance, a plot for 50 days is shown above. At the end of 49 days, as we can see, the output will be 50.313×10^{7} mg or 749.49 Kg of Ulva per 20000L of Solution.

```
Figure plots(For Cycle):

Days: [0, 7, 14, 21, 28, 35, 42, 49]
```

```
Growth: [46363321.27292781, 68931210.20603095, 102516314.8659061,
152513168.4894424, 226965821.21501386, 337873206.4918482,
503139664.0014758, 749490486.6377397]
```
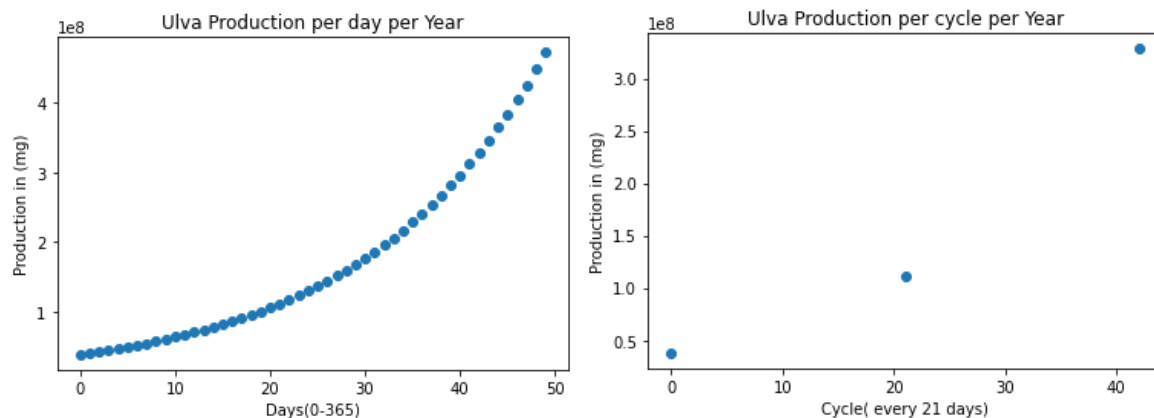
2.2 DAP with Lower concentration

Data provided:

header = ["medium","sample","day_0","day_7","day_14","day_21"]
data = [['Lower','growth_1',529.9,760.3,1350.9,1558.2],
    ['Lower','growth_2',523,685,1133.4,1554.4],
    ['Lower','growth_3',383.3,480.8,660.9,903.8]]

```
DAP_lower:
   medium    sample  day_0  day_7  day_14  day_21
0  Lower   growth_1  529.9  760.3  1350.9  1558.2
1  Lower   growth_2  523.0  685.0  1133.4  1554.4
2  Lower   growth_3  383.3  480.8   660.9   903.8
```

Production at the end of the year: 1.03×10^{16}mg

The plot for 50 days is shown below. At the end of <mark>49 days</mark>, as we can see, the output will be 4.726 x10^8 mg or <mark>472.61 Kg</mark> of Ulva per 20000L of Solution.

```
Figure plots(For Cycle):

Days: [0, 7, 14, 21, 28, 35, 42, 49]
Growth: [37903336.821170196, 54127260.78427142, 77411920.20993765,
110872237.4068506, 159012271.72337952, 228349969.49546242,
328324711.1599998, 472616293.4310026]
```

2.3 DAP with Actual concentration

Data provided:

header = ["medium","sample","day_0","day_7","day_14","day_21"]
data = [['Actual','growth_1',525.7,628.8,1010.2,1302],
    ['Actual','growth_2',488.2,653.8,1017.1,1370.4],
    ['Actual','growth_3',540.2,777.2,1226.2,1408]]

```
DAP_actual:
    medium    sample  day_0  day_7  day_14  day_21
0  Actual  growth_1  525.7  628.8  1010.2  1302.0
1  Actual  growth_2  488.2  653.8  1017.1  1370.4
2  Actual  growth_3  540.2  777.2  1226.2  1408.0
```

Production at the end of the year: 1.97×10^{15} mg
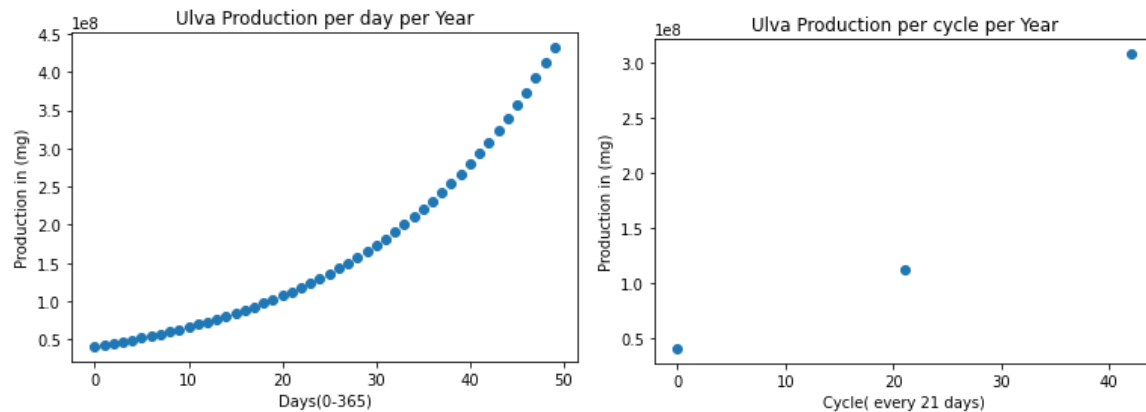
The plot for 50 days is shown below. At the end of <mark>49 days</mark>, as we can see, the output will be 4.315×10^8 mg or <mark>413.5 Kg</mark> of Ulva per 20000L of Solution.

```
Figure plots(For Cycle):

Days: [0, 7, 14, 21, 28, 35, 42, 49]
Growth: [41150457.315406196, 57535885.189654686, 80461087.86626293,
112542430.20431502, 157445503.6345727, 220306897.33244547,
308325918.35009766, 431594902.35368687]
```

2.4 DAP with higher concentration

Data provided:

header = ["medium","sample","day_0","day_7","day_14","day_21"]
data = [['Higher','growth_1',435.9,468.4,807,1246.5],
    ['Higher','growth_2',387.8,446.2,753.4,1013.7],
    ['Higher','growth_3',438.2,463.6,815.2,1079.6]]

```
DAP_higher:
    medium    sample  day_0  day_7  day_14  day_21
0  Higher  growth_1  435.9  468.4   807.0  1246.5
1  Higher  growth_2  387.8  446.2   753.4  1013.7
2  Higher  growth_3  438.2  463.6   815.2  1079.6
```

Production at the end of the year: 6.88×10^{15} mg

Ulva Production per day per Year

Ulva Production per cycle per Year
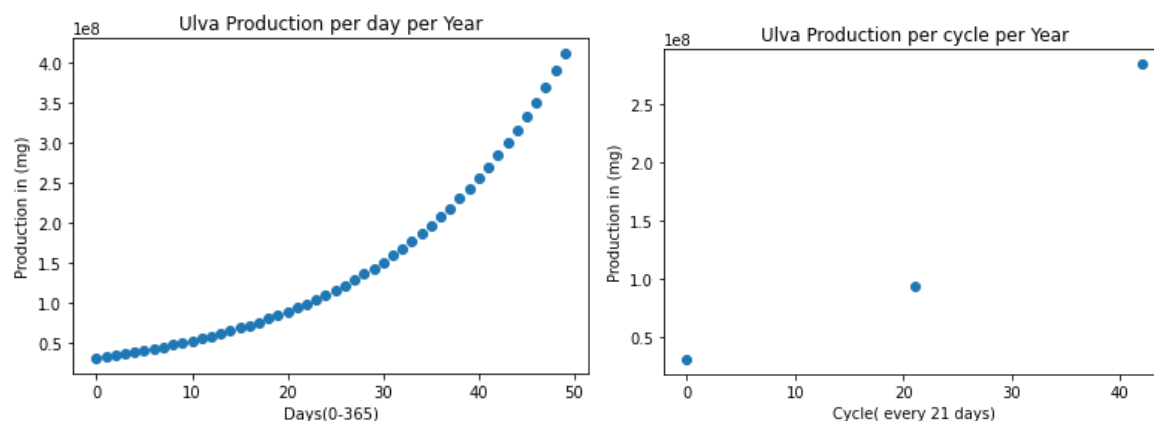
The plot for 50 days is shown below. At the end of 49 days, as we can see, the output will be 4.1122×10^8 mg or 411.22 Kg of Ulva per 20000L of Solution.

```
Cannot forecast due to negative extrapolation. Poor performance.
```

As per observation also, when comparing initial growth from day0 to day7(i.e 435.9 mg to 468.4 mg), there is no much growth of Ulva, thus gives inaccurate final prediction. This sample is unambiguous and we cannot determine the growth exactly.

```
Figure plots(For Cycle):

Days: [0, 7, 14, 21, 28, 35, 42, 49]
Growth: [30935450.636630047, 44768622.92302154, 64787470.59370533,
93757995.48598078, 135683051.63009822, 196355419.121654, 284158191.8687312,
411223068.6950367]
```

Final conclusion by using DAP in medium:
(Approx. values in Kg per 20000L Solution)

	Day 0	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42	Day 49
Control	46 Kg	68 Kg	102 Kg	152 Kg	226 Kg	337 Kg	503 Kg	749 Kg
Lower	37 Kg	54 Kg	77 Kg	110 Kg	159 Kg	228 Kg	328 Kg	472 Kg
Actual	41 Kg	57 Kg	80 Kg	112 Kg	157 Kg	220 Kg	308 Kg	431 Kg
Higher*	30 Kg	44 Kg	64 Kg	93 Kg	135 Kg	196 Kg	284 Kg	411 Kg

Where * denotes poor growth in initial days.

3) Both Urea and DAP under consideration

```
     medium     sample   day_0   day_7   day_14   day_21
0    Control   growth_1   349.2   528.7   1080.0   3849.0
1    Control   growth_2   382.6   747.2   1334.1   4167.0
2    Control   growth_3   349.1   754.9   1260.5   2090.5
3     Lower    growth_1   353.9   499.8    743.7   1055.1
4     Lower    growth_2   326.7   498.5    938.3   1353.6
5     Lower    growth_3   381.0   501.6    884.0   1467.5
6    Actual    growth_1   359.2   968.0   1368.9   2029.0
7    Actual    growth_2   439.6   811.6   1217.5   2121.0
8    Actual    growth_3   286.8   547.5    796.6   1181.9
9    Higher    growth_1   314.7   412.7    664.9    950.4
10   Higher    growth_2   241.4   322.1    685.2    801.5
11   Higher    growth_3   257.5   278.0    610.3    712.7
```

3.1 Both with Controlled concentration

Data provided:
header = ["medium","sample","day_0","day_7","day_14","day_21"]
data = [['Control','growth_1',349.2,528.7,1080,3849],
    ['Control','growth_2',382.6,747.2,1334.1,4167],
    ['Control','growth_3',349.1,754.9,1260.5,2090.5]]

```
both_control:
     medium     sample   day_0   day_7   day_14   day_21
0    Control   growth_1   349.2   528.7   1080.0   3849.0
1    Control   growth_2   382.6   747.2   1334.1   4167.0
2    Control   growth_3   349.1   754.9   1260.5   2090.5
```

```
Production at the end of the year: 1.70x10²⁵ mg
```

Production at the end of the year: 1.70×10^{25} mg
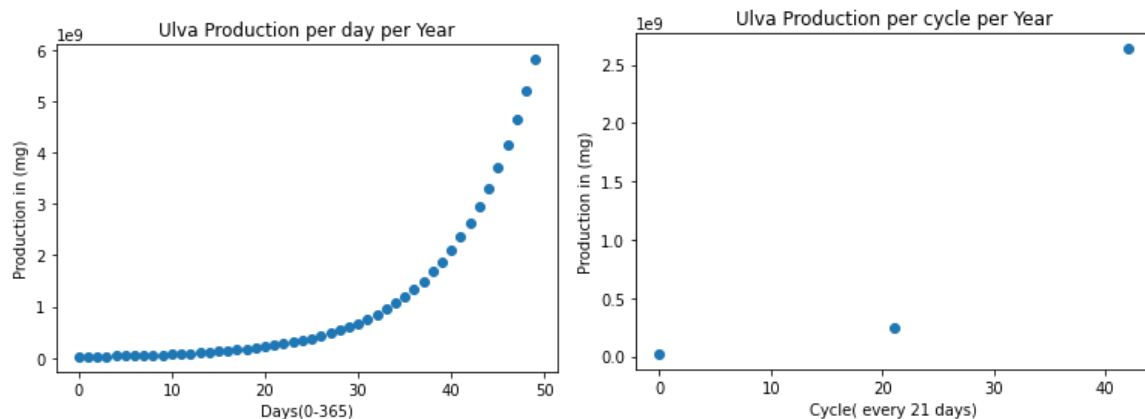
For an instance, a plot for 50 days is shown above. At the end of 49 days, as we can see, the output will be 5.81732×10^{9} mg or 5817.32 Kg of Ulva per 20000L of Solution.

```
Figure plots(For Cycle):

Days: [0, 7, 14, 21, 28, 35, 42, 49]
```

```
Growth: [22845384.34988815, 50408295.944352366, 111225806.53915995,
245419524.87232757, 541517702.2551255, 1194857752.2844656,
2636451296.5111923, 5817324635.996259]
```
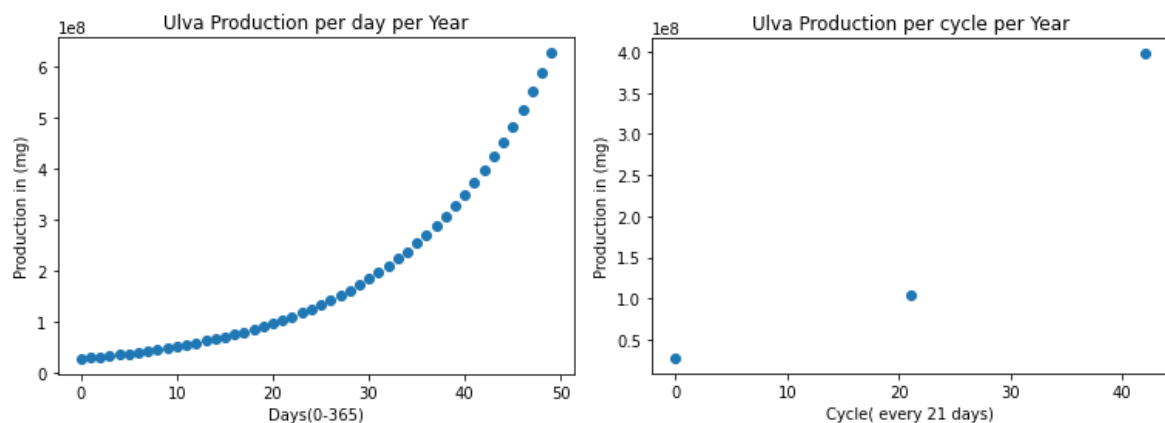
3.2 Both with Lower concentration

Data provided:

header = ["medium","sample","day_0","day_7","day_14","day_21"]
data = [['Lower','growth_1',353.9,499.8,743.7,1055.1],
    ['Lower','growth_2',326.7,498.5,938.3,1353.6],
    ['Lower','growth_3',381,501.6,884,1467.5]]

```
both_lower:
   medium    sample  day_0  day_7  day_14  day_21
0  Lower   growth_1  353.9  499.8   743.7  1055.1
1  Lower   growth_2  326.7  498.5   938.3  1353.6
2  Lower   growth_3  381.0  501.6   884.0  1467.5
```

Production at the end of the year: 1.24×10^{18} mg

The plot for 50 days is shown below. At the end of <mark>49 days</mark>, as we can see, the output will be 6.2643 $\times 10^8$ mg or <mark>626.43 Kg</mark> of Ulva per 20000L of Solution.

```
Figure plots(For Cycle):
```

```
Days: [0, 7, 14, 21, 28, 35, 42, 49]
Growth: [27427738.359533235, 42564322.716822386, 66229495.413838886,
103316277.29465032, 161568118.60321537, 253260472.48510006,
397884579.79039615, 626435697.0420486]
```
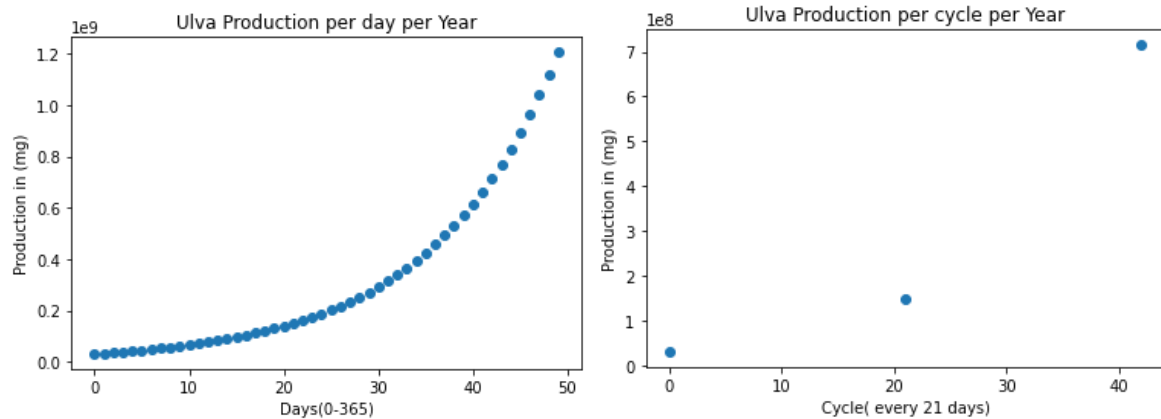
3.3 Both with Actual concentration

Data provided:

header = ["medium","sample","day_0","day_7","day_14","day_21"]
data = [['Actual','growth_1',359.2,968,1368.9,2029],
    ['Actual','growth_2',439.6,811.6,1217.5,2121],
    ['Actual','growth_3',286.8,547.5,796.6,1181.9]]

```
both_actual:
     medium    sample   day_0   day_7   day_14   day_21
0   Actual   growth_1   359.2   968.0   1368.9   2029.0
1   Actual   growth_2   439.6   811.6   1217.5   2121.0
2   Actual   growth_3   286.8   547.5    796.6   1181.9
```

```
Production at the end of the year: 4.23x10¹⁹ mg
```


The plot for 50 days is shown below. At the end of <mark>49 days</mark>, as we can see, the output will be 1.20522 x10^9 mg or <mark>1205.22 Kg</mark> of Ulva per 20000L of Solution.

```
[0, 7, 14, 21, 28, 35, 42, 49]
[31887439.903974812, 53379494.90822456, 89469489.33046779,
150145903.35882518, 252279297.0175578, 424394932.5988389,
714775129.0581511, 1205227349.0670145]
```

3.4 Both with higher concentration

Data provided:

header = ["medium","sample","day_0","day_7","day_14","day_21"]
data = [['Higher','growth_1',314.7,412.7,664.9,950.4],
        ['Higher','growth_2',241.4,322.1,685.2,801.5],
        ['Higher','growth_3',257.5,278,610.3,712.7]]
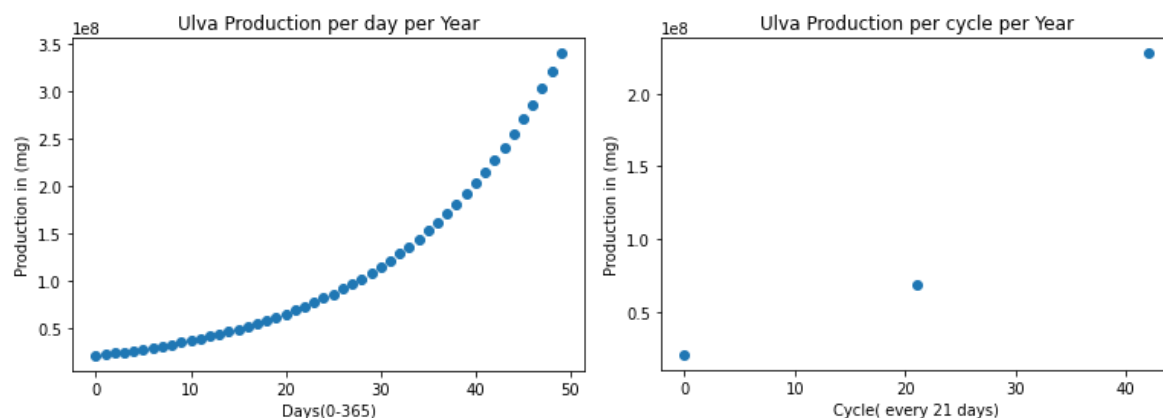
```
both_higher:
     medium    sample   day_0   day_7   day_14   day_21
0   Higher   growth_1   314.7   412.7    664.9    950.4
1   Higher   growth_2   241.4   322.1    685.2    801.5
2   Higher   growth_3   257.5   278.0    610.3    712.7
```

```
Production at the end of the year: 4.91x10¹⁶ mg
```

The plot for 50 days is shown below. At the end of <mark>49 days</mark>, as we can see, the output will be 4.1122 x10^8 mg or 411.22 <mark>Kg</mark> of Ulva per 20000L of Solution.

```
Cannot forecast due to negative extrapolation. Poor performance.
```

As per observation also, when comparing initial growth from day0 to day7(i.e 257.5 mg to 278.0 mg), there is no much growth of Ulva during this week, thus gives inaccurate final prediction. This sample is unambiguous and we cannot determine the growth exactly.

```
Figure plots(For Cycle):

Days: [0, 7, 14, 21, 28, 35, 42, 49]
Growth: [20685044.66916676, 30802464.154532682, 45897746.96095697,
68435183.53229184, 102106796.95424327, 152447992.00512758,
227763945.62028185, 340524603.1247054]
```

Final conclusion by using DAP in medium:
(Approx. values in Kg per 20000L Solution)

	Day 0	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42	Day 49
Control	<mark>27 Kg</mark>	<mark>55 Kg</mark>	<mark>113 Kg</mark>	<mark>236 Kg</mark>	<mark>493 Kg</mark>	<mark>1039 Kg</mark>	<mark>2198 Kg</mark>	<mark>4675 Kg</mark>
Lower	27 Kg	42 Kg	66 Kg	103 Kg	161 Kg	253 Kg	397 Kg	626 Kg
Actual	31 Kg	53 Kg	894 Kg	150 Kg	252 Kg	424 Kg	714 Kg	1205 Kg
Higher*	20 Kg	30 Kg	45 Kg	68 Kg	102 Kg	152 Kg	227 Kg	340 Kg

Where * denotes poor growth in initial days.

Conclusion (By observing best 50 days growth of each sample):

	Day 0	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42	Day 49
Urea	44 Kg	72 Kg	118 Kg	184 Kg	319 Kg	522 Kg	857 Kg	1407 Kg
DAP	46 Kg	68 Kg	102 Kg	152 Kg	226 Kg	337 Kg	503 Kg	749 Kg
Both	27 Kg	55 Kg	113 Kg	236 Kg	493 Kg	1039 Kg	2198 Kg	4675 Kg

Both urea and DAP under controlled concentration gives better result.