UNIVERSITAT POLITÈCNICA DE VALÈNCIA

ESCOLA POLITÈCNICA SUPERIOR DE GANDIA

Grau en Ciències Ambientals

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

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"Study of the effects of an artificial cut on the invasive plant S. Ineaquidens"

TREBALL FINAL DE GRAU

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I Abstract

Biological invasions are one of the most important factors affecting to biodiversity. It is a recurrent topic of ecological research because the processes and their impact on native ecosystems are complex and difficult to understand. The origin of most of the introductions is anthropogenic, intentionally or not, without considering risks and consequences to the native ecosystem.

The present study is about the invasive plant *Senecio inaequidens* (*Asteraceae*). It appeared in several areas of Europe mainly by transportation of sheep wool from South Africa to Europe from 1889 onwards.

The aim of the present study is to investigate how an artificial cut affects to the growth and flower production of *S. ineaquidens*. Our main questions are the following:

- How an artificial cut affects to the growth of the invasive *S. ineaquidens*?
- How an artificial cut affects to the flower production of the invasive *S. ineaquidens*?

Therefore, we chose a population of *S. ineaquidens* in a ruderal with high level of disturbance and we distributed the area in three groups of plots with different highs of cuts and one pilot plot.

The treatment process was the following: (1) Overview of the plot for know the ground cover and discuss the average of vascular plants cover, mosses cover and ground cover. (2) Measurement of all the individuals in the plot and write their high in the field book. (3) Cut all the individuals according to the treatment for each group and after two moth measure the length and the number of flowers.

The consequences on the growth are lower growth and less shoots. There is a relation treatment-shoots but there is any relation treatment-growth. The higher the cut is the more the shoots are and the growth is the same for any cut. Moreover, this has consequences on the flower production. The more shoots the plants have the more heads flower produce.

1 Introduction

Biological invasions are one of the most important factors affecting to biodiversity (IUCN). It is a recurrent topic of ecological research because the processes and their impact on native ecosystems are complex and difficult to understand (Manchester & Bullock 2000, Ehrenfeld 2010, Kowarik 2010). The origin of most of the introductions is anthropogenic, intentionally or not, without considering risks and consequences to the native ecosystem (EFFERTZ 2014). The “conceptual model of invasion steps and stages” (INVASS model, HEGER 2004) shows how takes the spread of an invasive species in a new area (fig.1, HEGER and JÜRGEN BÖHMER 2005).

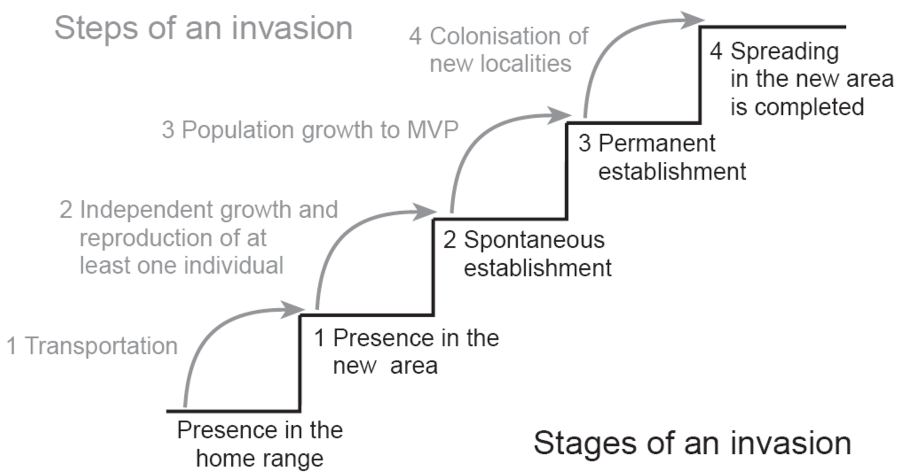

Figure 1: The invasion steps are designed in a way to encompass the main problems that may arise for a plant continuing in an invasion process (HEGER 2001 and HEGER and JÜRGEN BÖHMER 2005).

The present study is about *Senecio inaequidens* (*Asteraceae*). This is a perennial shrubby herb about 60–80 cm tall with a rapid growth in suitable habitats, associated with quick production of aerial and subterranean biomass (LÓPEZ-GARCÍA and MAILLET 2004). It’s a late flowering plant (june-july) with lemon-yellow flower heads with 80 to 100 flowers (GUILLERM et al. 1990), which produces up to 29,000 seeds per plant (ERNST 1998). The species is native to South Africa occurring within grassland and savannah biomes (LOW a. REBELO 1996). *S. inaequidens* appeared in several areas of Europe by transportation of sheep wool from South Africa to Europe from 1889 onwards (LÓPEZ-GARCÍA and MAILLET 2004). Other modes of transportation are also conceivable, but every one of the reported five primary centres of origin are connected to the wool processing industry (i.e. Mazamet, France; Calais, France; Verona, Italy; Liège, Belgium and Bremen, Germany; WERNER et al. 1991), which supports this assumption (HEGER and JÜRGEN BÖHMER 2005). The rapid dispersal of S. inaequidens has been facilitated by modern transportation, especially along railways (Ernst 1998 and LÓPEZ-GARCÍA and MAILLET 2004). S. inaequidens it's a ruderal (photos 1 and 2) perennial species and is associated with high levels of temporal and spatial disturbance. It has a broad ecological tolerance and also a potential for self-compatibility and a prolonged period of reproduction. These characteristics facilitate the invasive ability of the species in disturbed environments (LÓPEZ-GARCÍA and MAILLET 2004).

Photo 1 & 2: Two individuals in urban areas. Left Amsterdam harbour, right a street in Amsterdam.

Another important treat of *S. ineaquidens* is its toxicity. Certain *S.* species contain toxic pyrrolizidine alkaloids (Pas) and one population analysed in Frankfort (Free State Province, South Africa), where an outbreak of hepatotoxicity in cattle occurred, contained known hepatotoxic Pas (DIMANDE et al. 2007). The article of DIMANDE et al. wrote in 2007 concludes that S. inaequidens was most probably responsible for the cattle mortalities in the area of Frankfort.

The aim of the present study is to investigate how an artificial cut affects to the growth and flower production of *S. ineaquidens*. Our main questions are the following:

- How an artificial cut affects to the growth of the invasive *S. ineaquidens*?
- How an artificial cut affects to the flower production of the invasive *S. ineaquidens*?

Therefore, we chose a population of *S. ineaquidens* in a ruderal with high level of disturbance and we distributed the area in 3 groups of plots with different highs of cuts and 1 pilot plot.

2 Material and methods

2.1 Study site and plant sampling

The study was carried on the spring-summer 2016 in the surroundings of the University of Bremen. We focused in high-disturbed areas in the University City as ruderals (Fig. 2).

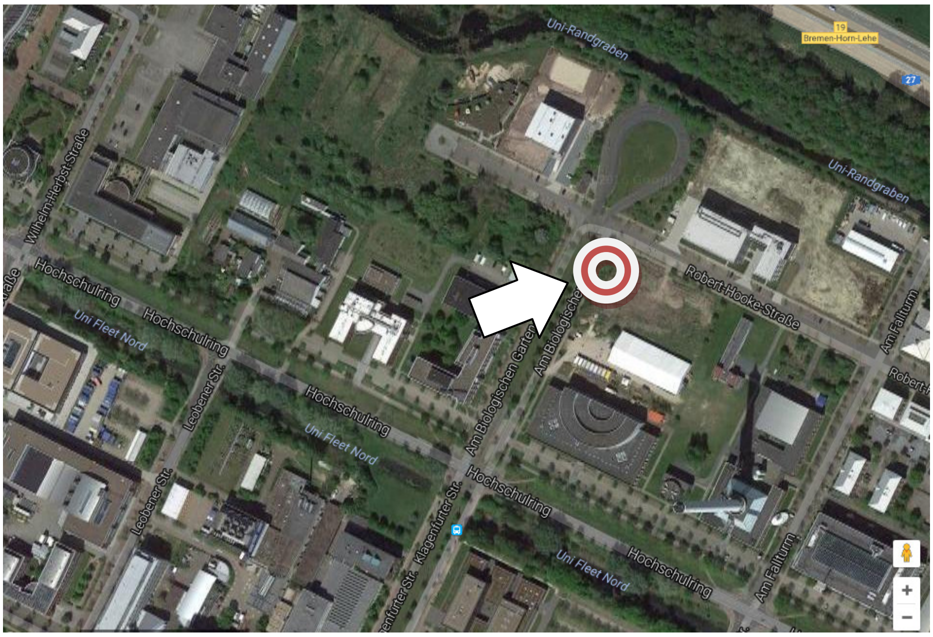

Figure 2: Adress: Robert-Hooke-Straße, 21, 28359, Bremen, Germany. Coordinates: 53.111928, 8.856702

40 plots of 4 m^2 (photo 3) were sampled in groups of 10 according to different treatments and a group of pilot plots for compare the effects (table 1 appendix). The different treatments were different highs of cut.

Photo 3: Example of a plot before the treatment (the lines mark the borders of the plot).

The first group of plots (number 1 to 10) was for the lower cut, at 2 cm from the ground. The second group of plots (number 11 to 20) was for the middle high cut, at 15 cm from the ground. The third group of plots (number 21 to 30) was the highs cut, just under the flower (in the time of cutting under the cocoons). The last group of plots (number 31 to 40) was the one without treatment for compare the effects on the growth and flower production. The plots were marked with a tape and wood sticks (photo 4) to locate them for the different treatment seasons.

Photo 4: Materials and tools for the field work.

2.2 Plant treatment and analysis

We started to cut June the 18th when the studied population started the flowering time. The treatment process was the following: (1) Overview of the plot for know the ground cover and discuss the average of vascular plants cover, mosses cover and ground cover. (2) Measurement of all the individuals in the plot and write their high in the field book. (3) Cut all the individuals according to the treatment for each group (table 2 appendix).

After the treatment we made a periodic supervision of the growth each week and after two months we proceed to made again an overview to know the ground cover, measure again all the individuals and count the flowers (tables 3 & 4 appendix). We were able to know which individuals were cut because cut was easily visible.

After the treatment and the data collection (photo 5), all the data was introduced in an excel sheet and grouped per plot thus, for the statical analysis we had a population (n) of 40 plots with an average of ground cover, the number of individual, the number of shoots and the average of shoots growth per plot before and after the treatment and 40 plots (n) with the number of flower per plot after the treatment (table appendix…).

Photo 5: Field book and field tools.

2.3 Statistical analysis

To determine the effects on growth and flower production we compared the data after treatment. We distinguished the data in four groups according the treatment and the control samples. Then we analysed the differences between them with box-whisker plots and Kruskal-Wallis test. We had chosen the Kruskal-Wallis test because any of our data follow a normal distribution according to the skewness and kurtosis calculations for each variable (tables 5 to 10 appendix). We calculate all the tests and draw the graphs with *Matlab R2015b*

3 Results

3.1 Consequences of cut on individual survival of *S. ineaquidens*

In total, we measured 738 individuals with 2486 shoots before the treatment and 629 individuals with 7976 shoots after the treatment. In consequence, there were 108 deaths after the low cut and one death after the middle cut. We appreciate these differences also with the box-whisker plots (fig. 3 & 4).

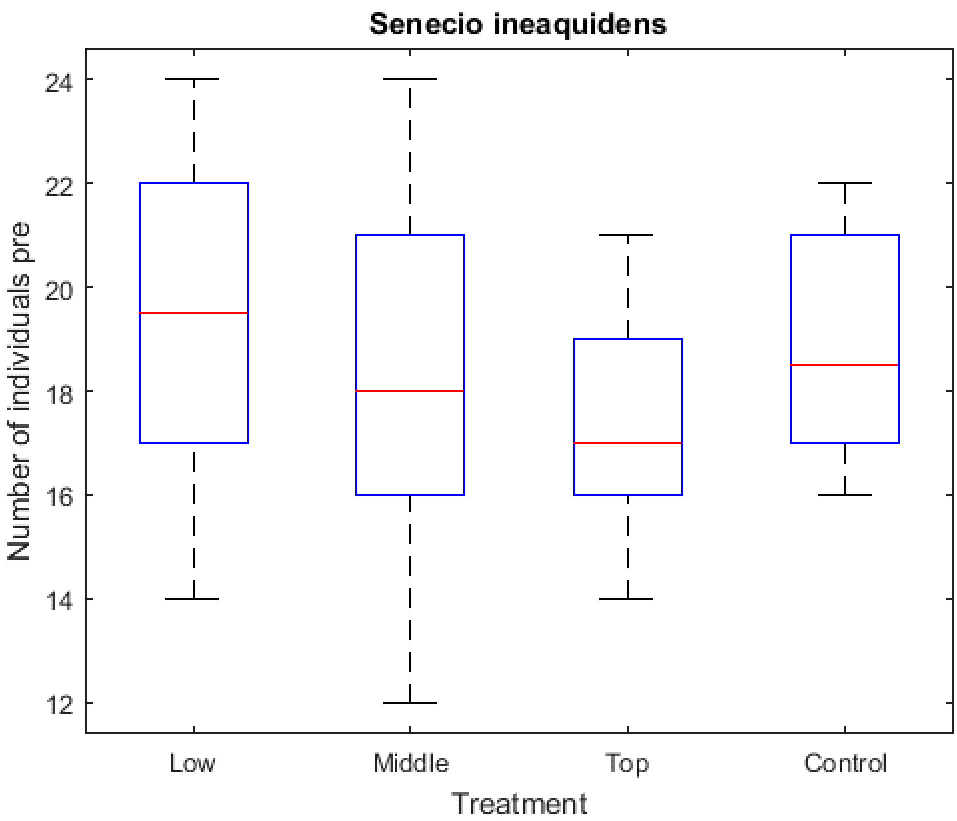

Figure 3: Number of individuals before the treatment.

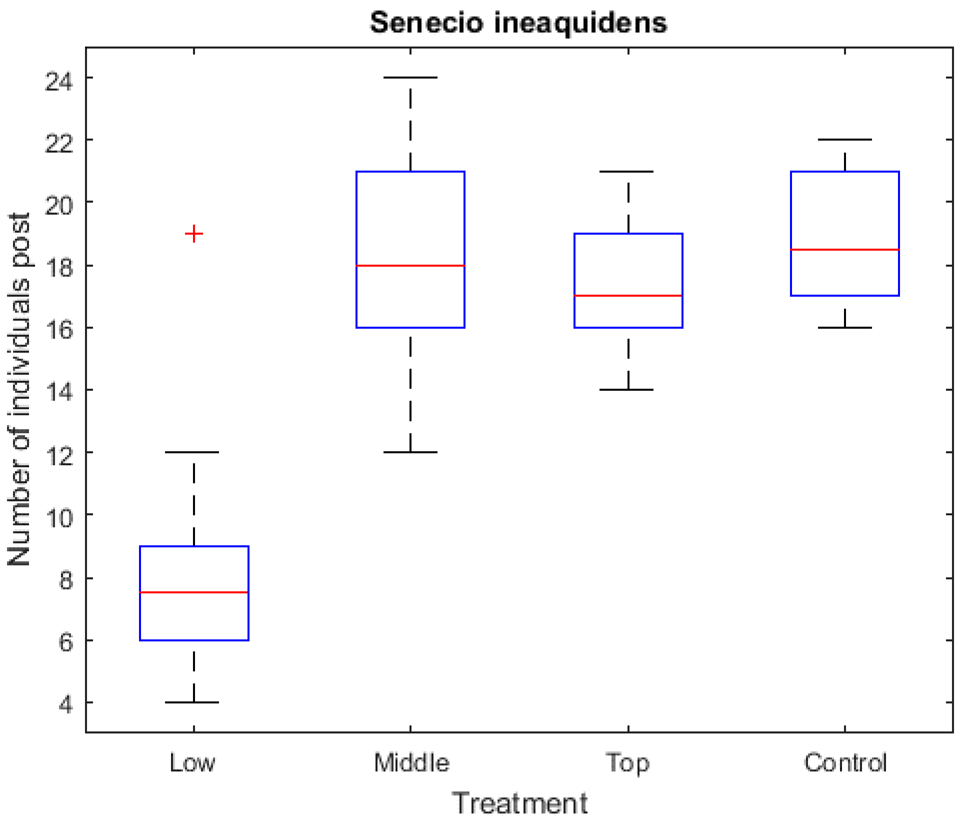

Figure 4: Number of individuals after the treatment.

Also with the Kruskal-Wallis test (fig. 5) we can assert that the variables compared come from different populations.

Kruskal-Wallis ANOVA Table

Source	SS	df	MS	Chi-sq	Prob>Chi-sq
Columns	2417.8	3	805.933	17.83	0.0005
Error	2870.2	36	79.728		
Total	5288	39			

Figure 5: Kruskal-Wallis test made with Matlab. Prob>Chi-sq < 0.05 so we rejected the null hypothesis.

3.2 Consequences of cut on growth of *S. ineaquidens*

We had measured the length of the shoots for each individual so it's interesting to see the variation on the number of shoots per treatment and also their length. We had drawn the number of shoots and their length before and after the treatment (fig. 6, 7, 8 & 9).

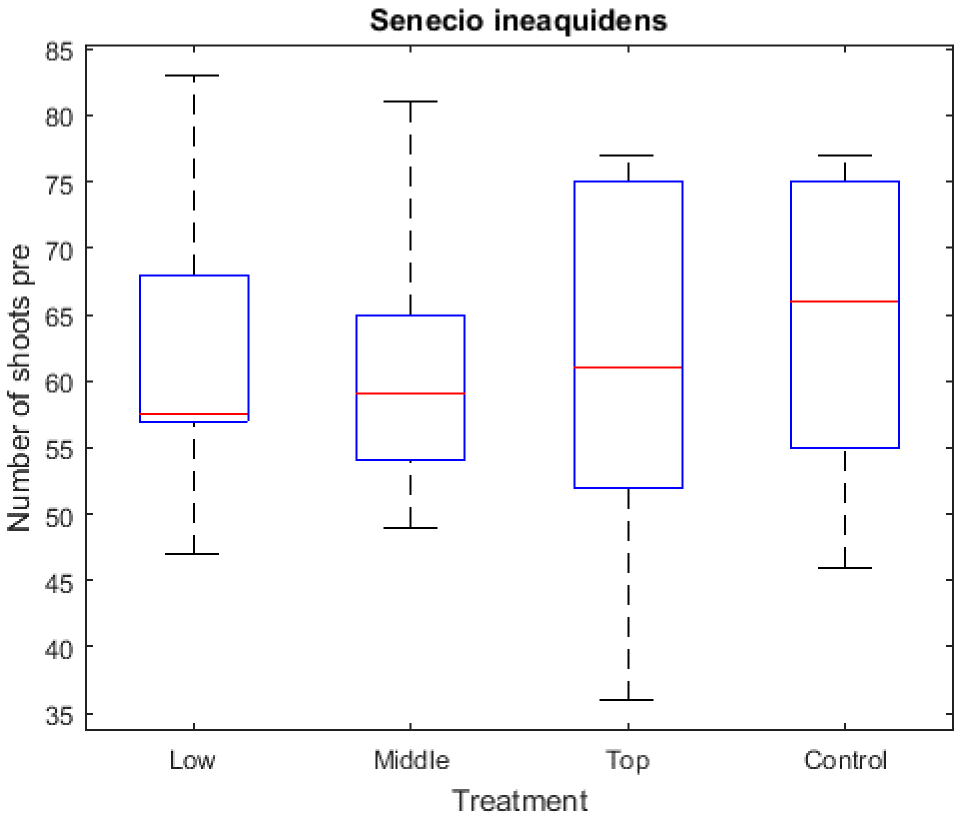

Figure 6: Number of shoots measured before the treatment.

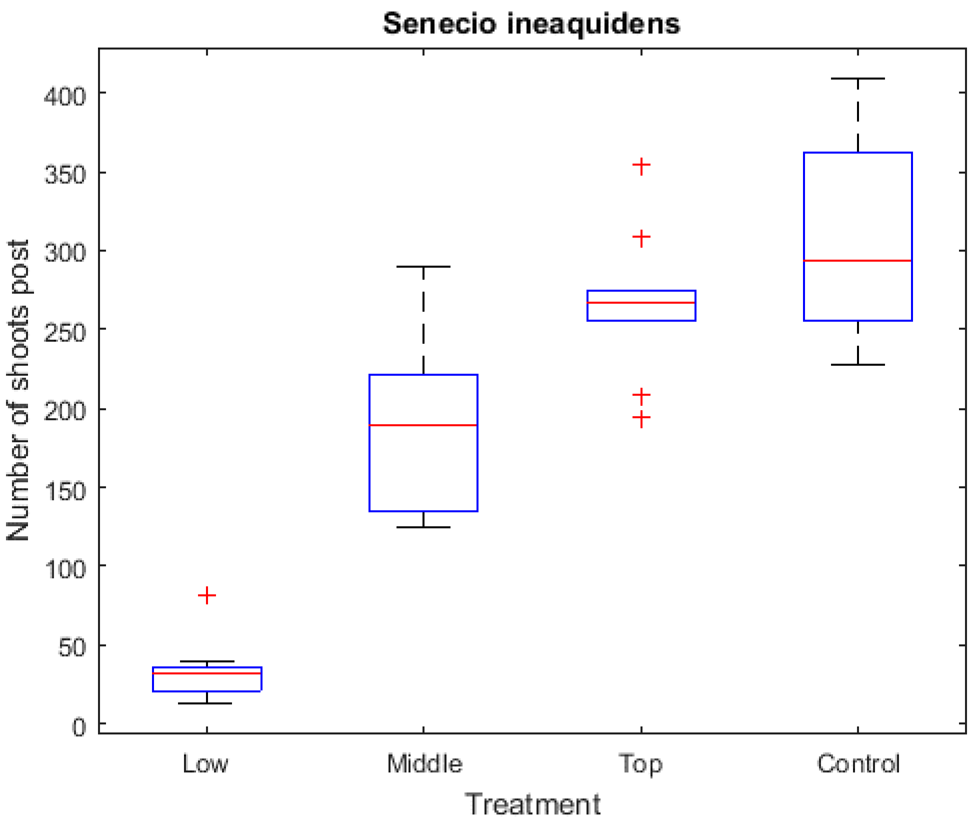

Figure 7: Number of shoots measured after the treatment.

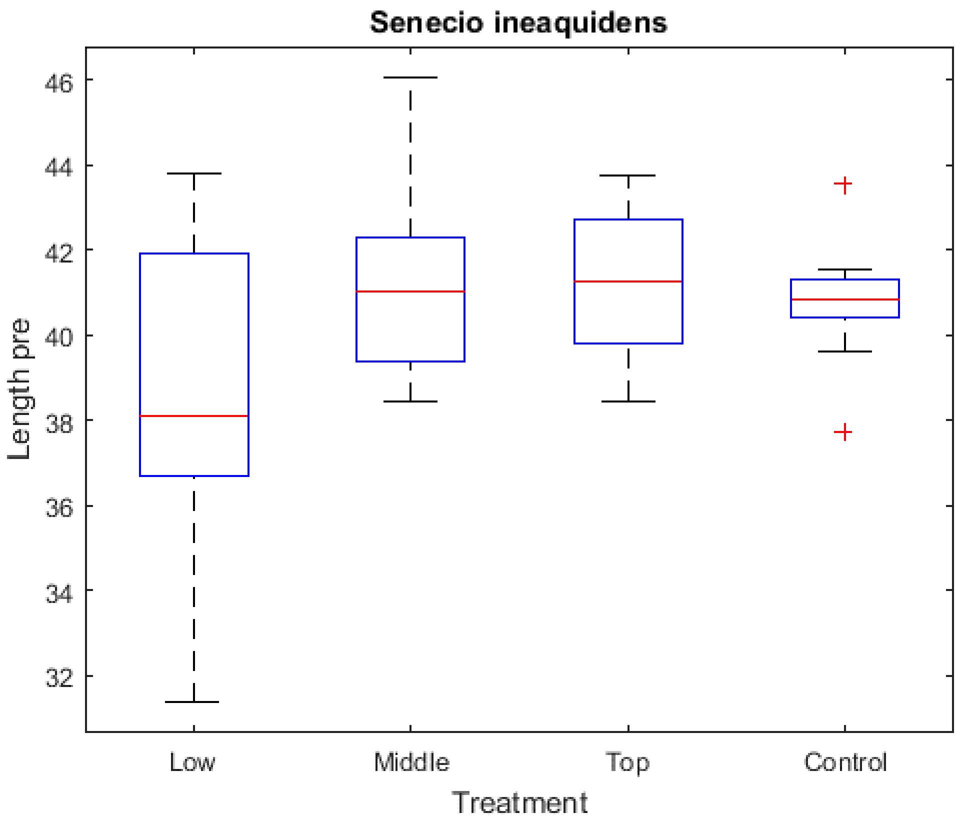

Figure 8: Length before the treatment measured in centimetres.

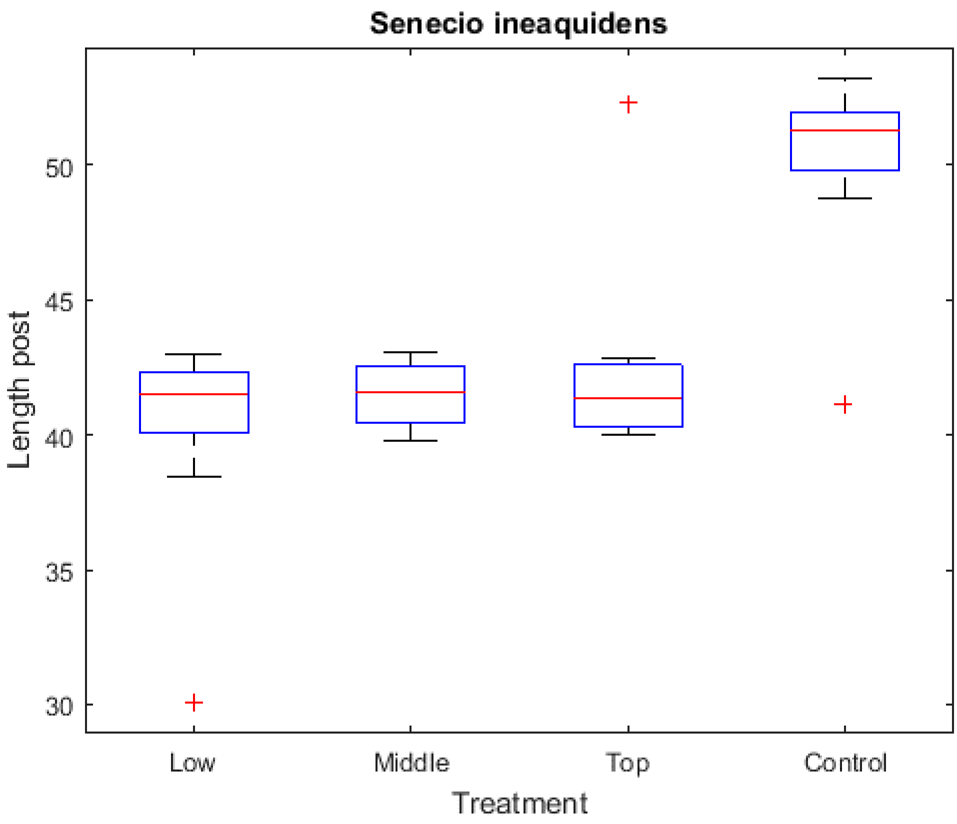

Figure 9: Length after the treatment measured in centimetres.

In addition, we made the Kruskal-Wallis test for the data after treatment (fig. 10) for see numerically if the data come from different populations, in this case if the differences between the treatments and the control samples are significant.

Kruskal-Wallis ANOVA Table

Source	SS	df	MS	Chi-sq	Prob>Chi-sq
Columns	2047.4	3	682.467	14.98	0.0018
Error	3282.6	36	91.183		
Total	5330	39			

Figure 10: Kruskal-Wallis test made with Matlab. Prob>Chi-sq < 0.05 so we rejected the null hypothesis, which is that the means are the same.

Finally, we analysed the growth differences by subtract the growth before treatment to the growth after treatment and we drew the data with a box-whisker plot (fig. 11). Then, numerically by the Kruskal-Wallis test (fig.12).

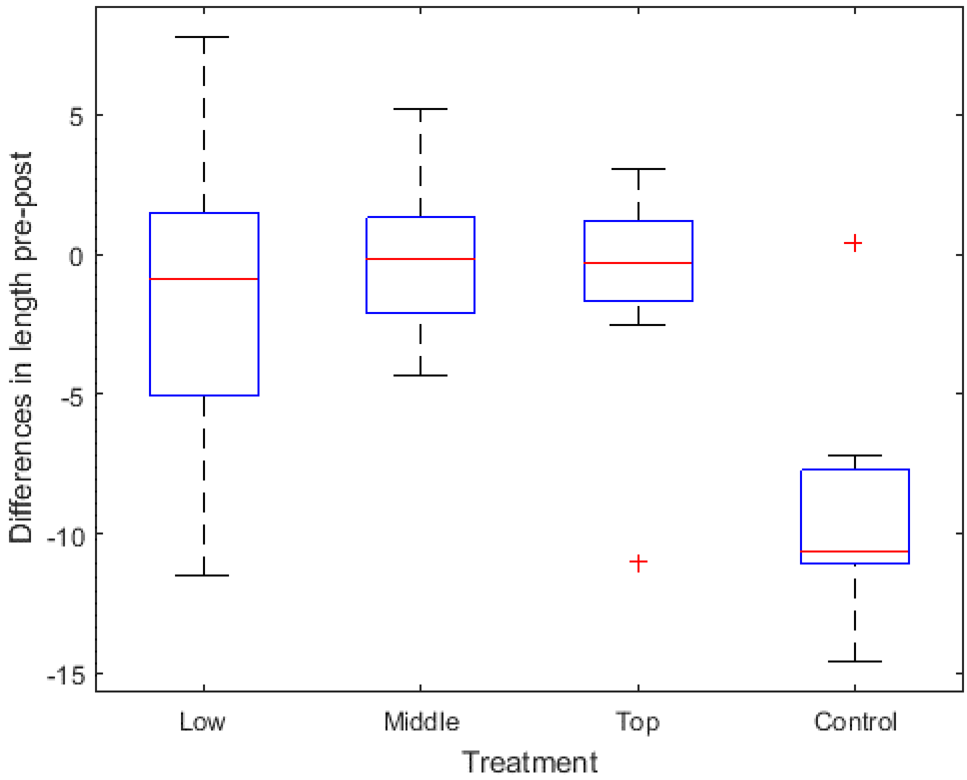

Figure 11: Differences in growth after-before the treatment measured in centimeters.

Kruskal-Wallis ANOVA Table

Source	SS	df	MS	Chi-sq	Prob>Chi-sq
Columns	1849.4	3	616.467	13.53	0.0036
Error	3480.6	36	96.683		
Total	5330	39			

Figure 12: Kruskal-Wallis test made with Matlab. Prob>Chi-sq < 0.05 so we rejected the null hypothesis, which is that the means are the same.

3.3 Consequences of cut on flower production of *S. ineaquidens*

We distinguished two different variables for the flower production analysis the shoots with flowers and the number of flower heads after the treatment and we drew them in box-whisker plots (fig. 13 & 14).

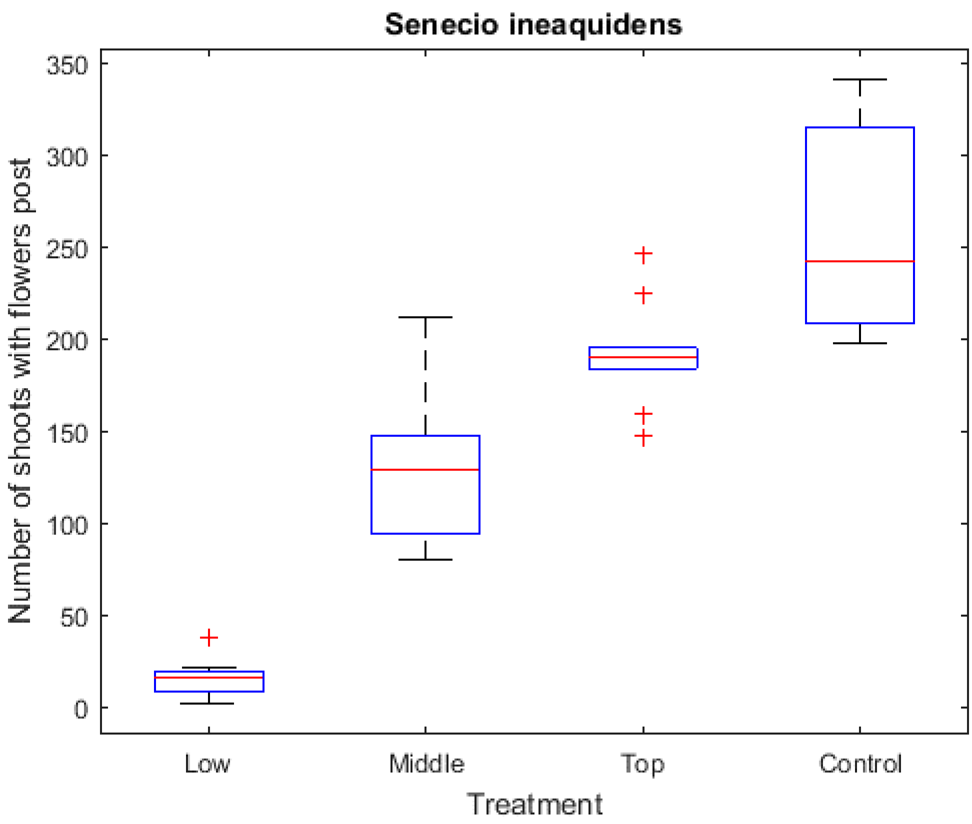

Figure 13: Number of shoots with flowers after the treatment.

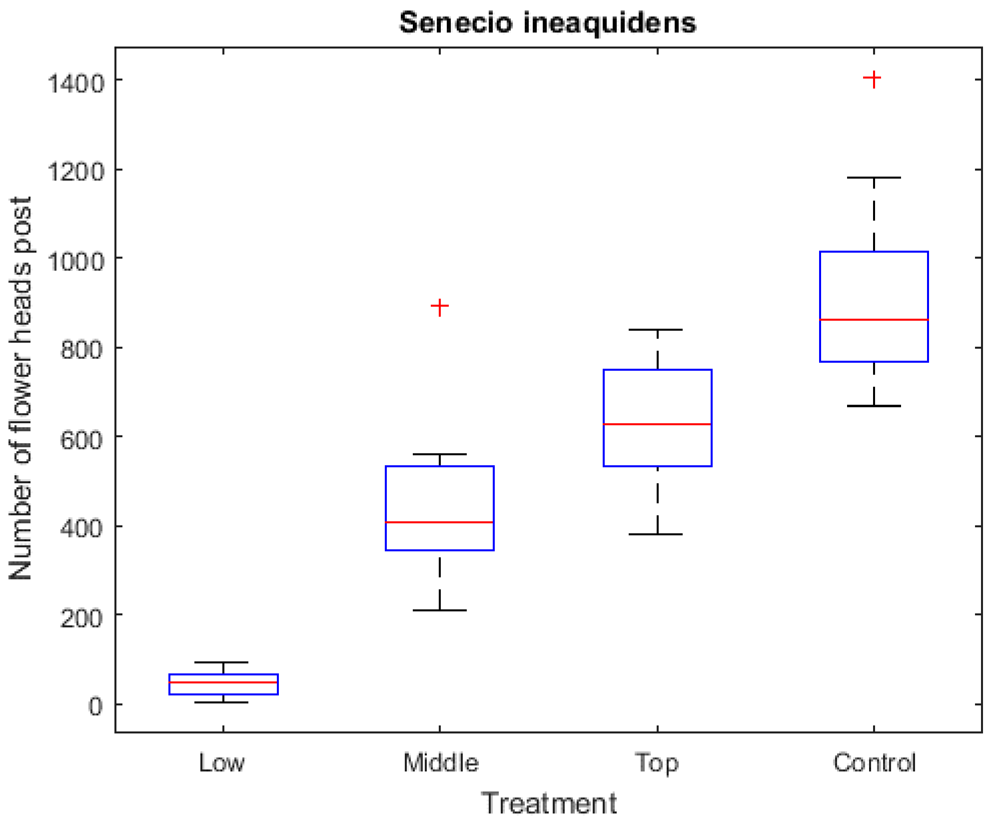

Figure 14: Number of flower heads after the treatment.

Again, the data were analyses with the Kruskal-Wallis test (fig. 15 & 16)

Kruskal-Wallis ANOVA Table

Source	SS	df	MS	Chi-sq	Prob>Chi-sq
Columns	4557.95	3	1519.32	33.36	2.70363e-07
Error	770.55	36	21.4		
Total	5328.5	39			

Figure 15: Kruskal-Wallis test made with Matlab. Prob>Chi-sq < 0.05 so we rejected the null hypothesis, which is that the means are the same.

Kruskal-Wallis ANOVA Table

Source	SS	df	MS	Chi-sq	Prob>Chi-sq
Columns	4303.4	3	1434.47	31.49	6.70821e-07
Error	1026.6	36	28.52		
Total	5330	39			

Figure 16: Kruskal-Wallis test made with Matlab. Prob>Chi-sq < 0.05 so we rejected the null hypothesis, which is that the means are the same.

4 Discussion

4.1 Methodology

The main aim of the work is to analyse the effects of an artificial cut on the invasive *S. ineaquidens* and at the beginning we focused on the effects related to growth and flower production but we have more effects after have a look at the result. This other effect is related to the survival.

4.2 Consequences of cut on individual survival of *S. ineaquidens*

We can affirm that we have a collateral effect and this is the effect of the cut on the survival. We can attribute this effect to competition and there are evidences about it (fig. 17) if we analyse the relation between the cover of vascular plants, which are the main competitors with the studied plant. Under this point of view, we had taken the data of the bottom cut sample, which is the unique with deaths (except one death in the middle high cut treatment, which is irrelevant).

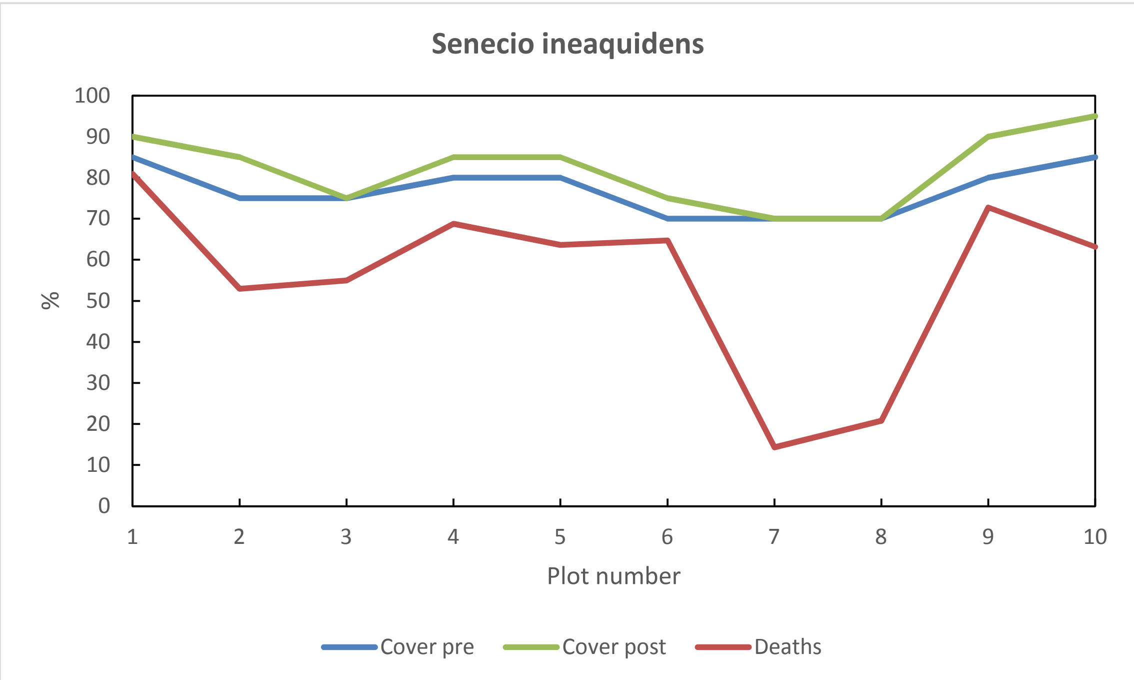

Figure 15: Relation between vascular plants cover and deaths for bottom cut samples, in percent.

The graphic presents a correlation between each variables so we suggest that there is a relation between the survivals, the ground cover and the lower cut because the other samples do not have this effect. In this case would be interesting to test the cut for isolated individuals for further investigations.

4.3 Consequences of cut on growth of *S. ineaquidens*

The effects on growth are the same for each treatment because we can see the differences in growth near zero for all the treatment (fig. 11) and more than 10 centimetres of average between the treated samples and the control population. The difference between the treated samples is the number of shoots grown, the higher the cut is the more the shoots are. We observed that the shoots cut have not any additional growth after the cut but under the cut there were able to grow more shoots.

4.4 Consequences of cut on flower production of *S. ineaquidens*

The effects on flower production are that after the treatment we have more flower heads for higher cuts. This is because the samples with higher cuts are able to grow more shoots and this new shoots produce the same head flowers (fig. 16). The ratio mean showed in the figure has a difference 0.7 flower heads per shoot between the lowest ratio (lower cut) and the higher ratio (control).

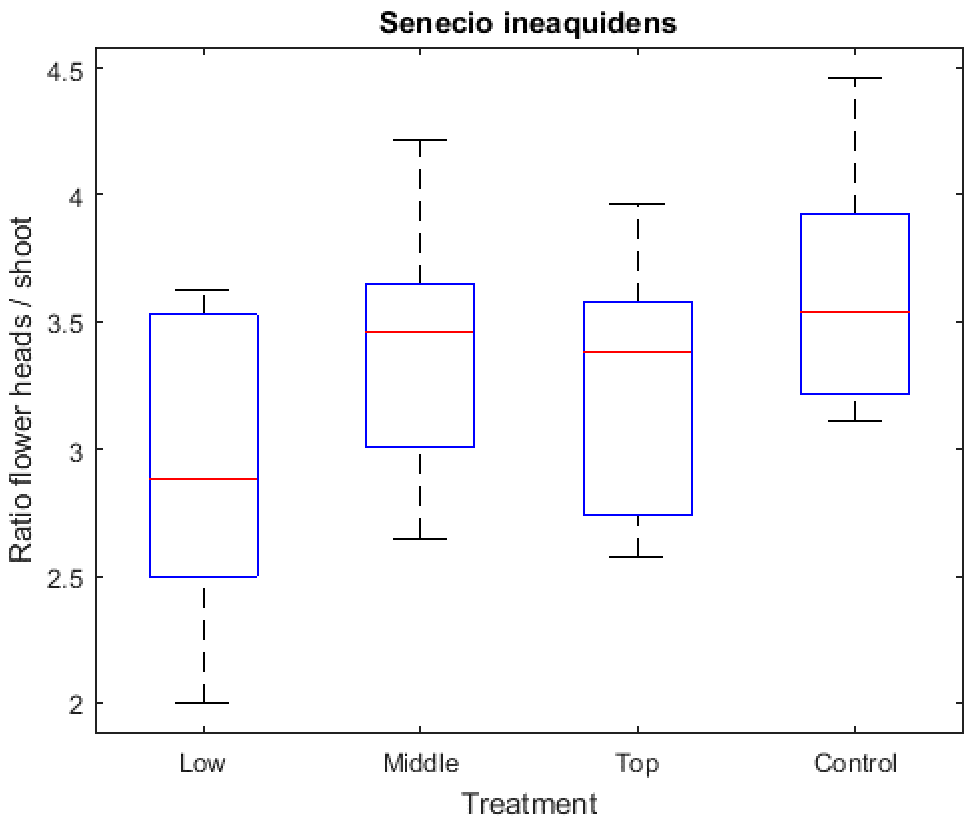

Figure 16: Ratio flower heads per shoots after treatment.

We considered that this difference is not significant also because there is any correlation length cut - ratio because the tot treatment has lower ratio than the middle and the control.

5 Conclusion and outlook

According to the main questions asked at the beginning, we have enough data to affirm that an artificial cut affect to the growth and to the flower production of the invasive *S. ineaquidens*.

The consequences of this treatment on the growth are lower growth and less shoots. There is a relation treatment-shoot but there is any relation treatment-growth. The higher the cut is the more the shoots are and the growth is the same for any cut. Moreover, this has consequences on the flower production. The more shoots the plants have the more heads flower produce.

For further investigations, we suggest to repeat the experiment in isolated populations for study the consequences of cut without competition of other plants. Also would be interesting to repeat the study with longer time. It will determine if a cut treatment is useful to control the population of this invasive plant.

6 Acknowledgements

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Thanks also to David Zele for the suggestion of study this topic.

Of course, thanks to my parents for giving this opportunity to study abroad and thanks to my friends in Germany, without them it would be impossible.

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8 Appendix

Table 1: Field sheet used for the fieldwork.

<table>
<tr><td colspan="12">FIELD SHEET</td></tr>
<tr><td colspan="4" rowspan="2">Plot no.:</td><td colspan="8">Location:</td></tr>
<tr><td colspan="8">GPS coord.:</td></tr>
<tr><td colspan="12">Habitat:</td></tr>
<tr><td colspan="12">Cover (%)</td></tr>
<tr><td colspan="4">Bascular plants</td><td colspan="4">Mosses</td><td colspan="4">Ground</td></tr>
<tr><td colspan="4"></td><td colspan="4"></td><td colspan="4"></td></tr>
<tr><td colspan="12">Treatment (Cut)</td></tr>
<tr><td colspan="3">None</td><td colspan="3">Bottom</td><td colspan="3">Middle</td><td colspan="3">Top</td></tr>
<tr><td colspan="3"></td><td colspan="3"></td><td colspan="3"></td><td colspan="3"></td></tr>
<tr><td colspan="12">Data</td></tr>
<tr><td colspan="3">Observation date:</td><td colspan="3">No. of individual</td><td colspan="3">No. of shoots</td><td colspan="3">Length of shoot (cm)</td></tr>
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Table 2: Resume of the data beafore the treatment

		Before treatment					
		Ground cover (%)			Measurements		
Polot num.	Treatment	V. plants	Mosses	Ground	Population	Shoots	Lenght
1	low	85	5	10	21	76	37,86
2	low	75	5	20	17	47	31,37
3	low	75	5	20	20	57	35,74
4	low	80	5	15	16	57	36,70
5	low	80	5	15	22	65	42,68
6	low	70	5	25	17	50	37,94
7	low	70	5	25	14	57	43,79
8	low	70	5	25	24	83	41,43
9	low	80	5	15	22	68	41,91
10	low	85	5	10	19	58	38,31
11	middle	85	5	10	24	81	38,72
12	middle	80	5	15	21	63	42,29
13	middle	80	5	15	16	54	43,57
14	middle	70	5	25	15	50	41,52
15	middle	70	5	25	17	54	38,44
16	middle	75	5	20	19	62	46,07
17	middle	70	5	25	20	49	40,55
18	middle	80	5	15	12	56	40,09
19	middle	85	5	10	23	77	39,38
20	middle	85	5	10	17	65	41,66
21	top	90	5	5	16	47	39,04
22	top	85	5	10	18	52	42,49
23	top	75	5	20	15	36	43,31
24	top	70	5	25	14	60	38,45
25	top	70	5	25	16	62	41,19
26	top	85	5	10	18	69	43,75
27	top	85	5	10	21	75	42,73
28	top	70	5	25	20	77	41,04
29	top	70	5	25	16	59	39,78
30	top	80	5	15	19	75	41,35
31	control	80	5	15	18	55	40,62
32	control	85	5	10	22	77	40,40
33	control	85	5	10	22	75	43,57
34	control	80	5	15	17	61	41,31
35	control	75	5	20	18	48	37,72
36	control	70	5	25	19	71	41,56
37	control	80	5	15	16	60	41,00
38	control	85	5	10	17	46	40,72
39	control	90	5	5	19	77	39,61
40	control	85	5	10	21	75	41,08
TOTAL					738	2486	

Table 3: Resume of the data after the treatment

		After treatment					
		Ground cover (%)			Measurements		
Polot num.	Treatment	V. plants	Mosses	Ground	Population	Shoots	Lenght
1	low	90	5	5	4	13	30,08
2	low	85	5	10	8	34	42,85
3	low	75	5	20	9	36	41,44
4	low	85	5	10	5	26	38,42
5	low	85	5	10	8	31	41,29
6	low	75	5	20	6	15	43,00
7	low	70	5	25	12	40	42,30
8	low	70	5	25	19	81	41,49
9	low	90	5	5	6	21	40,10
10	low	95	5	0	7	33	41,52
11	middle	95	5	0	24	240	43,06
12	middle	90	5	5	21	195	42,67
13	middle	85	5	10	16	183	41,85
14	middle	80	5	15	15	135	42,56
15	middle	75	5	20	17	133	41,69
16	middle	80	5	15	19	221	40,85
17	middle	80	5	15	19	185	40,48
18	middle	85	5	10	12	125	39,79
19	middle	95	5	0	23	290	41,50
20	middle	95	5	0	17	194	40,35
21	top	95	5	0	16	275	39,98
22	top	95	5	0	18	259	42,58
23	top	85	5	10	15	209	40,28
24	top	70	5	25	14	255	41,00
25	top	80	5	15	16	194	42,86
26	top	85	5	10	18	267	41,77
27	top	85	5	10	21	355	41,53
28	top	85	5	10	20	309	41,20
29	top	80	5	15	16	269	40,29
30	top	85	5	10	19	266	52,33
31	control	90	5	5	18	255	51,29
32	control	95	5	0	22	403	51,50
33	control	90	5	5	22	409	50,74
34	control	80	5	15	17	277	51,96
35	control	80	5	15	18	227	52,29
36	control	85	5	10	19	317	41,15
37	control	85	5	10	16	250	53,22
38	control	90	5	5	17	308	51,32
39	control	95	5	0	19	279	49,79
40	control	90	5	5	21	362	48,81
					629	7976	

Table 4: Resume of the data after the treatment. Head flowers.

		Flowers after treatment		
Polot num.	Treatment	Shoots without flowers	Flowers heads	Shoots with flowers
1	low	11	4	2
2	low	19	44	15
3	low	17	67	19
4	low	16	28	10
5	low	15	58	16
6	low	9	17	6
7	low	24	51	16
8	low	43	94	38
9	low	13	20	8
10	low	11	78	22
11	middle	89	560	151
12	middle	68	364	127
13	middle	63	375	120
14	middle	41	343	94
15	middle	46	262	87
16	middle	73	536	148
17	middle	51	442	134
18	middle	45	212	80
19	middle	78	894	212
20	middle	63	474	131
21	top	84	657	191
22	top	69	749	190
23	top	50	630	159
24	top	65	623	190
25	top	46	381	148
26	top	75	507	192
27	top	109	839	246
28	top	84	805	225
29	top	85	617	184
30	top	71	534	195
31	control	47	668	208
32	control	77	1015	326
33	control	68	1183	341
34	control	47	985	230
35	control	29	777	198
36	control	63	806	254
37	control	43	746	207
38	control	55	920	253
39	control	47	769	232
40	control	47	1405	315

Distribution form analysis by calculating Skewness and Kurtosis with *Matlab R2015b* for the different variables.

Table 5: Variable: Number of individuals after treatment. The distribution for the low and middle treatment is not normal (kurtosis > 2), we can't make an ANOVA analysis.

Treatment	Frequency	Skewness	Kurtosis
Low	10	1.5395	4.6052
Middle	10	0.0160	2.2301
High	10	0.2146	1.9045
Control	10	0.3540	1.8069
Total	40	0.7638	2.5882

Table 6: Variable: Number of shoots after treatment. The distribution for the low, middle and high treatment is not normal (kurtosis > 2), we can't make an ANOVA analysis.

Treatment	Frequency	Skewness	Kurtosis
Low	10	1.5972	5.1917
Middle	10	0.4411	2.4935
High	10	0.2977	3.0448
Control	10	0.4663	1.8868
Total	40	-0.2466	2.0277

Table 7: Variable: Length of shoots after treatment. The distribution for the low, high treatment and control is not normal (kurtosis > 2 and skewness is not between -2 and 2), we can't make an ANOVA analysis.

Treatment	Frequency	Skewness	Kurtosis
Low	10	-2.1180	6.3161
Middle	10	-0.0523	1.7636
High	10	2.3308	7.0662
Control	10	-2.0538	6.2088
Total	40	0.4082	3.2217

Table 8: Variable: Difference of length of shoots post-pre-treatment. The variables for all the treatments don't follow a normal distribution (kurtosis >2), we can't make an ANOVA analysis.

Treatment	Frequency	Skewness	Kurtosis
Low	10	-0.1992	2.9133
Middle	10	0.4274	2.9201
High	10	-1.7647	5.5890
Control	10	1.4377	5.5890
Total	40	-0.4487	4.7502

Table 9: Variable: Shoots with flowers after treatment. The variables for all the treatments don't follow a normal distribution (kurtosis >2 for low, middle and high treatment), we can't make an ANOVA analysis.

Treatment	Frequency	Skewness	Kurtosis
Low	10	0.9786	3.7074
Middle	10	0.7849	3.3734
High	10	0.3784	2.8919
Control	10	0.5442	1.7751
Total	40	-0.0250	2.1082

Table 10: Variable: Number of flower heads after treatment. The variables for all the treatments don't follow a normal distribution (kurtosis >2), we can't make an ANOVA analysis.

Treatment	Frequency	Skewness	Kurtosis
Low	10	0.1462	1.9210
Middle	10	1.1637	4.0248
High	10	-0.1808	2.3539
Control	10	0.9302	2.9027
Total	40	0.2376	2.3897

9 Declaration

I hereby certify that I have written this thesis independently and that no part of this thesis has been published or submitted for publication. I confirm that, to the best of my knowledge, my thesis does not infringe upon anyone's copyright nor violate any proprietary rights and that any ideas, techniques, quotations, or any other material from the work of other people included in my thesis are fully acknowledged in accordance with the standard referencing practices. Furthermore, I declare that I did not submit this thesis to a different examination procedure.

(Place and date) (Signature)