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Department of Crop Production Ecology
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Contents

1. Abstract

Couch grass (*Elytrigia repens*) is a problematic weed, native to Europe and commonly found in grassland and agricultural land, causing a decrease in yield in many agricultural crops. Two climate chamber experiments were conducted to investigate how competition from cover crops like red clover (*Trifolium pretense* var. Titus) and rye-grass (*Lolium perenne* var. Irene) changes the biomass allocation and morphology of couch grass. In the first experiment, couch grass was grown in different combinations (low, medium and high competition) with rye-grass. In the second experiment it was grown with rye-grass, red clover and with both together. The results showed a decrease of above ground biomass allocation of couch grass, and also distinctive features in morphology in nodes, branching points, leaf area and leaf density from control. In experiments with rye-grass, got significant results in number of shoots per pots and above ground biomass of couch grass, pointing towards decrease in the above ground parts of couch grass due to competition from cover crop and a trend in the case of branching points and number nodes. The results of rhizome weight found to be insignificant in both experiments. It was found that competition from cover crop especially rye-grass affected biomass allocation and morphology of couch grass in a simulated environment after harvest and thereby effective in control couch grass in the following season

Popular Summary

Couch grass (*Elytrigia repens*) is one of the important unwanted plant in agricultural fields mainly found the cold regions of the world such as America, Europe, Africa, Asia, Australia etc. It is considered as one of the worst weed and causes production loss in agriculture. Two laboratory experiments were conducted by using rye-grass (*Lolium perenne* var. Irene) and red clover(*Trifolium pretense* var. Titus) to control couch grass. In the experiment, tried to find out how competition from red clover and rye-grass affecting the growth and development of couch grass. In the first experiment, couch grass was grown in different combinations such as low, medium and high competition with rye-grass. In the second experiment it was grown with rye-grass, red clover and with both together. The results showed a decrease in total quantity of above ground parts of couch grass and also decreasing trend in leaf area, leaf density, branching points and nodes. The experiment with rye-grass showed significant results in number shoots per pots and also in the total quantity of above ground parts of couch grass. The results of rhizome weight of couch grass was found to be insignificant in both experiments. Competition from rye-grass and red clover found to be affected distribution of couch grass to above or below ground and also made changes in the external features of couch grass

2. Introduction

Couch grass, a perennial weed growing in many parts of the world, is mainly a problematic weed in Northern temperate regions of the world. It belongs to the family *Poaceae* and is known by many different scientific names, such as *Elytrigia repens, Elymus repens, Triticum repens* and *Agropyron repens*. It has also several common names, such as common couch, quack grass twitch grass (Palmer & Sagar 1963). The current distribution of couch grass is circumpolar (Hulten 1962). It is found throughout Europe, Australia, New Zealand and temperate zones of Asia and North and South America (Werner *et al* 1977). It is common in agricultural areas, waste-land, road and river margins etc. (Hulten 1950). It thrives in cooler climates and is one of the most serious weeds in the Northern temperate zone, but is absent from the tropics (Palmer & Sagar 1963). It grows in areas where pH ranges from 4.5 to 8.0 (Doyon 1965; 1968; Rousseau 1968). As a C3 plant, in terms of photosynthetic pathways, couch is not well adapted to hot dry climates (Håkansson 2003). At higher temperatures, biomass production is lowered and the allocation of photosynthesis to underground organs decreases (Holm *et al* 1977) and temperatures above 35°C depresses all growth (Bond *et al* 2007).

Couch grass spreads mainly by rhizomes, and seeds to a lower degree. Rhizomes are up to 1 m long, slender (1.5 mm), smooth, whitish and scaly. Leaves are 6-20 cm long, green in color with finely pointed tips. Leaf sheaths are present with overlapping hyaline margins. Couch grass seeds germinate in the early spring season. When the plant reaches 6-8 leaf stage, it will start producing tillers (Palmer & Sagar 1963). Couch grass can develop dense stand with a tall leaf canopy and also an extensive underground system consisting of numerous rhizomes. When these rhizomes are disturbed by any physical methods, new plants will regenerate from fragments of rhizomes (Håkansson 1967; Grime *et al* 1986).

Couch grass causes reduction in quality and yield of agricultural crops (Westra & Wyse 1981). Presence of couch has been found to reduce the yield of crops such as corn, wheat, oats, barley, soya bean and potatoes. Delay in couch grass removal from the agricultural field shows greater reductions in yield. Delaying removal of couch grass for 2 weeks after crop emergence caused a 21% total tuber yield reduction (Rioux 1973). Therefore it is of prime importance to control couch grass effectively.

Early control of couch grass used different physical methods such as various forms of tillage. In addition, herbicides such as glyphosate and pronamide have been used effectively in several decades (Marshall 1989). All these methods might have negative effects on environment such as killing beneficial organisms and accumulation of harmful chemicals in ecosystem, and nutrient leaching. The repeated application of a particular group of chemicals cause changes in genetic composition of weeds that leads to increased frequency of resistance alleles and resistant individuals, makes weed populations become adapted to herbicides (Marie *et al* 1996). Therefore it is important to develop an alternative method to control couch effectively without causing any harm to the environment. One such method could be undersowing, where undersowing spring cereals with cover crops can appreciably retard the spread of couch grass after harvest. This method might be especially useful if cultivation or spraying is delayed (Dyke *et al* 1976). This can work on couch grass, since a competitive crop can delay and reduce the growth of rhizomes. Shading and competition for water delays couch grass growth until after harvest and forces the plant to concentrate on above ground parts rather than below ground parts (Cussans 1968; Håkansson 1967; Williams 1970; Håkansson 1974). So by maintaining the competition pressure throughout the year, even when the crop is no longer in the field it would be theoretically possible to control couch grass growth.

The aim of the current experiment was to determine the morphological response and allocation changes in couch grass due to competition from perennial rye-grass (*Lolium perenne* var. Irene) and red clover (*Trifolium pretense* var. Titus), and therefore its potential as a control mechanism. Rye-grass, since it is an aggressive competitor for nitrogen, and red clover, since it acts as a competitor for light and water to couch grass (its ability to fix nitrogen could also make it a valuable cover crop for other reason than control). Cussan (1968) proposed that the effectiveness of a crop to compete with the crouch grass depends on its ability to grow fast and to have an efficient growth with respect to light. The competition for resources forces the couch grass to respond by making changes in its morphology and allocate resources to above or below-ground to compete with its neighbouring plants. Cody (1966) and Harper (1967) noticed the ecological importance of the allocation of energy during the development of an organism. For perennial grasses, below-ground growth is more important as they mainly use rhizomes for propagation in the following year. To limit the growth of a plant, it is important to know how it is using its energy for different types of activities, as some species use it for penetrating organs such as rhizomes, roots, vegetative parts etc. while others use it for maintaining competition with neighbouring plants.

3. Hypotheses

- Competition from the chosen cover crops will affect the morphology of couch grass
- Competition will result in fewer, but larger aerial shoots instead of more and smaller shoots and/or tillers
- Competition will result in shorter rhizomes, which have fewer nodes and fewer branching points
- Competition changes the way couch grass allocate its resources?
- The focus will be on above-ground biomass at a cost of below-ground biomass

4. Materials and Methods

Two climate chamber experiments were conducted in 2012 to analyze morphological changes in couch grass by using the following data. The length and width of the leaf were measured for morphological features and the rhizome length was measured to get the morphological value for the size of the rhizomes, while dry weight represents allocation priority of couch grass.

A total of 12 climate chambers were used (30x30 cm), 6 for each experiment with 4 pots in each chamber. The rhizomes of couch grass for the first experiment had been stored in a cold room over the winter and the rhizomes for the second experiment were collected from outside Uppsala one week before the start of experiment. The soil used for the experiments included the following compositions - light peat 60%, black peat 25%, sand 0,5-4 mm 15% and PG-/Multimix 14-7-15 1,30 kg/cm, FTE 36/Multispor 0,050 kg/cm, Limestone 4,5 kg/cm, Dolomite 2,9 kg/cm. The pots were about 18 cm in diameter and 23 cm high.

Couch grass rhizomes were first washed to remove dirt and then cut into pieces with 4 nodes on each piece. The rhizomes were divided into four weight classes of which each pot was allocated one from each weight class. The weight of the rhizomes ranged from 0.20 g to 0.90 g and the average length was 15 cm. At the bottom of each pot a mesh was placed to prevent soil escaping. Approximately half of the pot (around 1200g) was filled with soil. Four rhizome pieces were planted with as even spacing as possible on the soil. The rhizomes were then covered by an additional 400 g of soil. The rye-grass and red clover seeds for the different treatments were then sown according to details in Table 1 & 2. To cover the seeds another 150 g of soil was placed on top, and subsequently150 ml of water was added, making the total weight of the pot 2250 g. The temperature and light of growth chambers (18°C for 16 hours day^{-1} and 8°C the other 8 hours, and approximately 500 µ mol of light during the warm period) were set in such a manner, which emulated the time after harvest, approximately July-August. The plants were watered twice in a week to the initial weight 2250 g. At the same time they were rotated in a clockwise manner so that there would be no bias from the placement within the cabinet. Emergence was registered three days a week. Shoots from cover crops and couch grass started to emerge 8 days after planting and within one week most of them had emerged and started to grow.

After three weeks of planting, all plants were cut 5 cm above the soil with scissors to reduce any emergence advantage for couch grass. The number of leaves was counted (couch averaging on three-four leaves and rye-grass generally at two). It was observed that after the cutting couch grass and rye-grass started re-growth very quickly. And also, interestingly many plants started branching growth from base itself. Tufted or cluster like growth was found. The final harvest was done 9 weeks after planting and measurements were taken. Then the aboveground biomass and rhizomes were dried in oven for 24 hours at 105°C and then weighed.

Statistical analyses were performed using Minitab 16.0. The design of the experiment was randomized complete blocks and thus the analysis was done using an ANOVA model with block as a random factor.

4.1 Experiment I - Increasing levels of competition from Rye-grass

The first experiment was started on March 2012 and the competitive crop used in this experiment was perennial rye-grass (*Lolium perenne* var. Irene). Six cabinets were used with 4 different treatments and thus the total number of pots was 24. The treatment in each pot and different levels of competition are shown in Table 1. The number of rye-grass seeds was converted from weight ha^{-1} by calculating the weight that was appropriate for a pot of 18 x 18 cm and then seeing on average how many seeds that weight equated to.

Table 1: Treatments and level of competition in experiments with perennial rye-grass (*Lolium perenne* var. Irene)

Treatment	**Rhizome/seeds**	**Level of competition**
B	4 couch grass rhizomes with 5 kg ha^{-1} of rye-grass (9 seeds)	Low level
C	4 couch grass rhizomes with 10 kg ha^{-1} of rye-grass (18 seeds)	Medium level
D	4 couch grass rhizomes with 20 kg ha^{-1} of rye-grass (36 seeds)	High level
A	Only couch grass	Control

4.2 Experiment II - Competition from Rye-grass along with Red clover

The second experiment started on March 2012, two weeks after the first experiment following the same method but with different treatments. For the second experiment, red clover (*Trifolium pretense* var. Titus) and rye-grass (*Lolium perenne* var. Irene) were used in competition with couch grass. Nitrogen fixating bacterial solution (100 ml) was added after three weeks to all treatments to ensure natural conditions for the red clover. Six cabinets were used just like in experiment I, but one malfunctioned and rendered the plants inside unusable. The number of seeds for each treatment was calculated as in experiment I, but they were over-seeded with 60 seeds in each pot and excess were then culled after emergence. The different treatments used in experiments II are shown in *Table 2*.

Table 2: Treatments and level of competition in experiments with rye-grass (*Lolium perenne* var. Irene) and red clover (*Trifolium pretense* var. Titus)

Treatment	**Rhizome/seeds**	**Level of competition**
B	4 couch grass rhizomes with 5kg/ha of red clover(3 rows with 5 seeds in each row)	Low level
C	4 couch grass rhizomes with 10kg/ha of rye-grass (3 rows with 6 seeds in each row)	Medium level
D	4 couch grass rhizomes with 5kg/ha of red clover and 10kg/ha of rye-grass (3 rows of rye-grass and red clover with 6 and 5 seeds respectively)	High level
A	Only couch grass	Control

5. Results

The result from the statistical analysis showed a great variation from significant to trends, while some results were just insignificant. Compared to second experiment (competition from red clover and rye-grass) the first experiment (increasing competition from rye-grass) revealed more significant results. Tu key tests were conducted on significant results for further analysis.

5.1 Mean shoot length

The shoot length was measured from the base of the root to the first leaf of the shoot. Results obtained for both rye-grass (Exp. I) and rye-grass with red clover (Exp. II) were insignificant (Fig. 1 & 2; p= 0,756 and p=0,310 respectively).

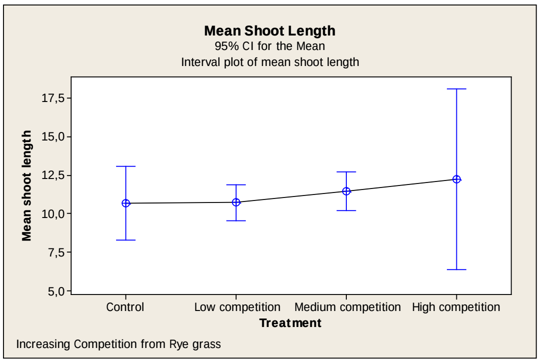


Fig. 1. Interval plot showing mean shoot length of couch grass with rye-grass (Exp. I). X-axis shows treatments and Y-axis shows mean shoot length with mean values.

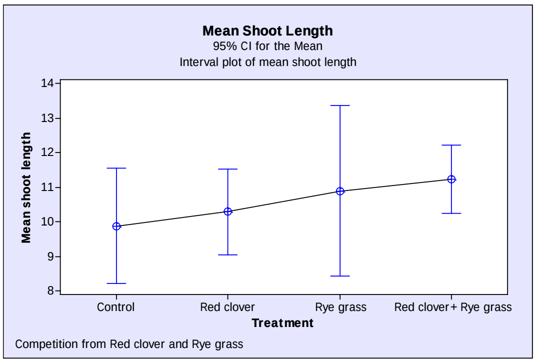


Fig. 2. Interval plot showing mean shoot length of couch grass with rye-grass and red clover (Exp. II). X-axis shows treatments and Y-axis shows mean shoot length with mean values.

5.2 Leaf length and width

The leaf length was measured with a ruler and the width using a screw gauge on the centre of the leaf. The results obtained here are insignificant (Fig. 3 & 4). The values attained for leaf length are F= 1.26 p= 0.325 and for leaf width F=2.19 p=0.132 in experiments with rye-grass (Exp. I) and F= 0.19 p= 0.900 and F=0.88 p=0.479 respectively, in the experiment with rye-grass and red clover (Exp. II).

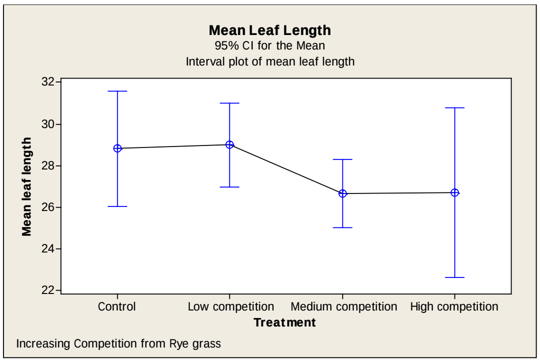


Fig. 3. Interval plot showing mean leaf length of couch grass with rye-grass (Exp.1). X-axis shows treatments and Y-axis shows mean leaf length with mean values.

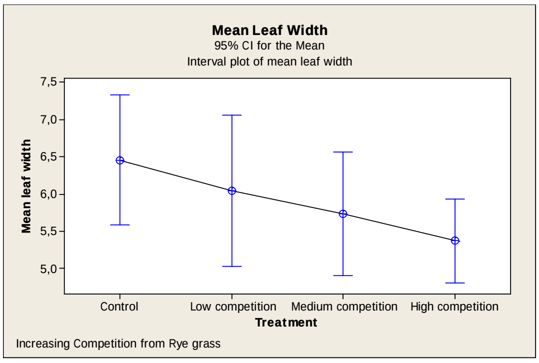


Fig. 4. Interval plot showing mean leaf width of couch grass with rye-grass (Exp.1). X-axis shows treatments and Y-axis shows mean leaf width with mean values.

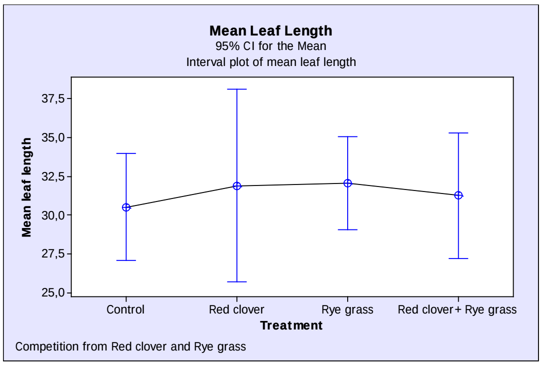


Fig. 5. Interval plot showing mean leaf length of couch grass with rye-grass and red clover (Exp. II). X-axis shows treatments and Y-axis shows mean leaf length with mean values.

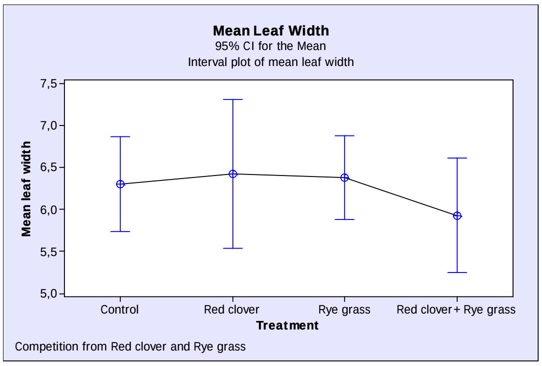


Fig. 6. Interval plot showing mean leaf width of couch grass with rye-grass and red clover(Exp. II). X-axis shows treatments and Y-axis shows mean leaf width with mean values.

5.3 Leaf area and leaf density

Leaf area was calculated by multiplying the values of leaf length and leaf width. Average leaf density was calculated by multiplying leaf area with the average weight of a leaf taken from each main shoot. Leaf area and leaf density in competition with rye-grass showed a very weak decreasing trend towards in the experiment with rye-grass (Exp. I; Fig. 7 & 8). The values attained for leaf area are F=1.77 p=0.197 and for leaf density F=1. 89 p= 0.177 in experiments with rye-grass and F=0.29 p= 0.830 and F=1.56 p= 0.249 respectively in experiments with rye-grass and red clover (Exp. II).

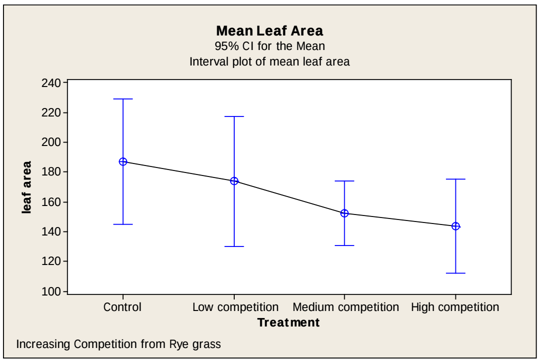


Fig. 7. Interval plot showing mean leaf area of couch grass with rye-grass (Exp.1). X-axis shows treatments and Y-axis shows mean leaf area with mean values.

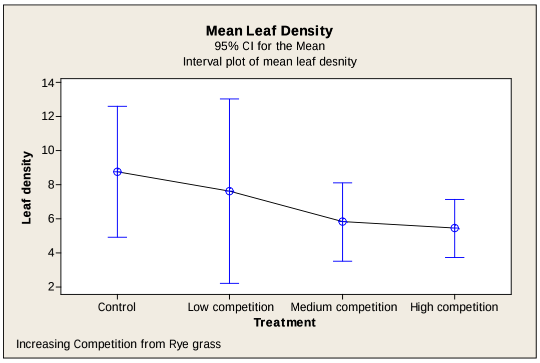
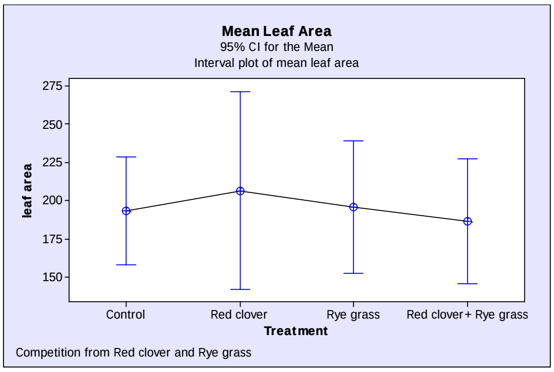


Fig. 8. Interval plot showing mean leaf density of couch grass with rye-grass (Exp.1). X-axis shows treatments and Y-axis shows mean leaf density with mean values.



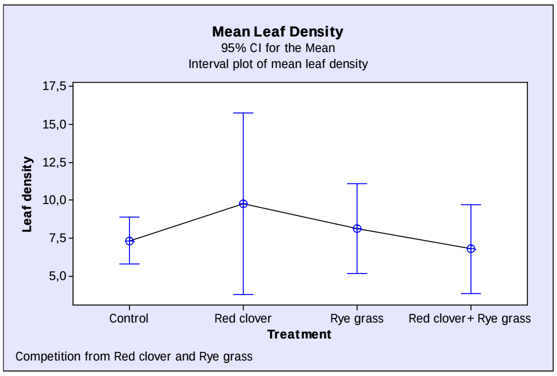
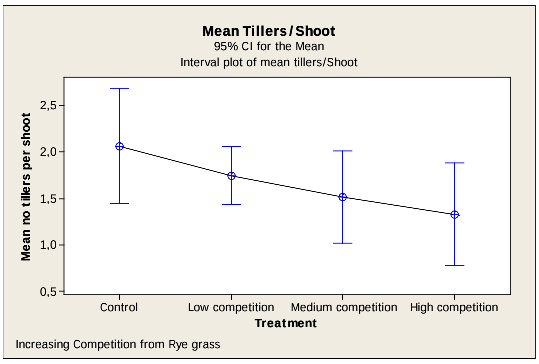


Fig. 9. Interval plot showing mean leaf area of couch grass with rye-grass and red clover (Exp. II). X-axis shows treatments and Y-axis shows mean leaf area with mean values.

Fig. 10. Interval plot showing mean leaf density of couch grass with rye-grass and red clover (Exp. II). X-axis shows treatments and Y-axis shows mean leaf density with mean values.

5.4 Mean tillers and shoots

Tillers are shoots that grow after the emergence of the main shoot from the rhizome. The number of tillers were counted in each shoot. The number of mean tillers per shoot showed a trend (F=2.72 p=0.082) with increasing competition with rye-grass (Fig.11).
In experiments with rye-grass and red clover (Exp. II) the results are insignificant (F=0. 22 p= 0.878 Fig 12).



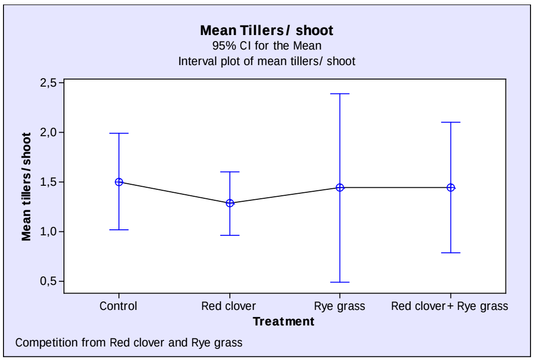


Fig. 11. Interval plot showing mean tillers per shoot of couch grass with rye-grass (Exp.1). X-axis shows treatments and Y-axis shows mean tillers per shoot with mean values.

Fig. 12. Interval plot showing mean tillers per shoot of couch grass with rye-grass and red clover (Exp. II). X-axis shows treatments and Y-axis shows mean tillers per shoot with mean values.

5.5 Number of shoots

Shoots are initial or main outgrowth from rhizomes and the number of shoots was counted separately and mean values were taken. In Exp I the mean number of shoots per pot showed a close to significant result with F value = 3.23 and p value = 0.052. Grouping information using the Tu key method revealed significant difference between ‘Control’ and ‘High competition’. In Exp. II the results were insignificant (F=0.16 and p= 0.921).

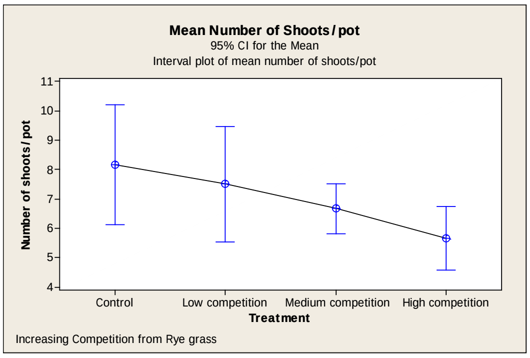


Fig. 13. Interval plot showing mean number of shoots per pot of couch grass with rye-grass (Exp.1).X-axis shows treatments and Y-axis shows number of shoots per pot with mean values.

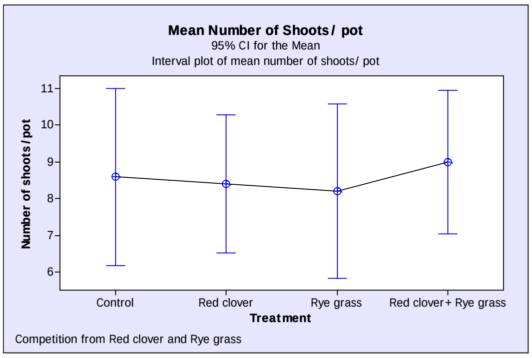


Fig. 14. Interval plot showing mean number of shoots per pot of couch grass with rye-grass and red clover (Exp. II). X-axis shows treatments and Y-axis shows mean shoot per pot with mean values.

5.6 Rhizome length

Length of main rhizome and branches were measured by using a ruler and the results are insignificant for both the experiments with values F= 2, 12 and p= 0,129 (Exp.1) and F=0.67 p= 0.584 and F= 0.37 p= 0.775 (Exp. II), but there is a slight increase in rhizome length from low competition to high competition.

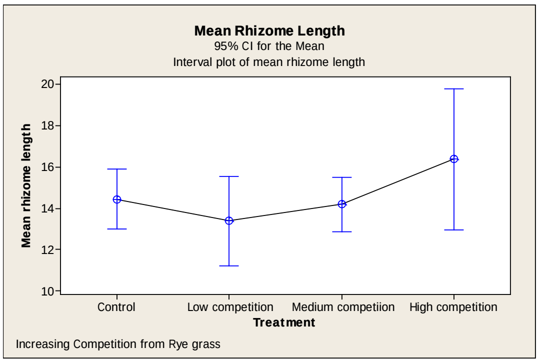


Fig. 15. Interval plot showing mean rhizome length of couch grass with rye-grass (Exp.1). X-axis shows treatments and Y-axis shows mean rhizome length with mean values.

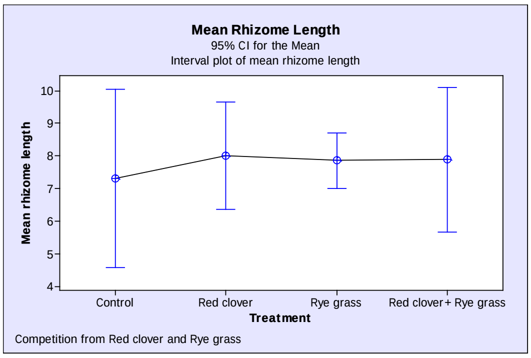


Fig. 16. Interval plot showing mean rhizome length of couch grass with rye-grass and red clover (Exp. II). X-axis shows treatments and Y-axis shows mean rhizome length with mean values.

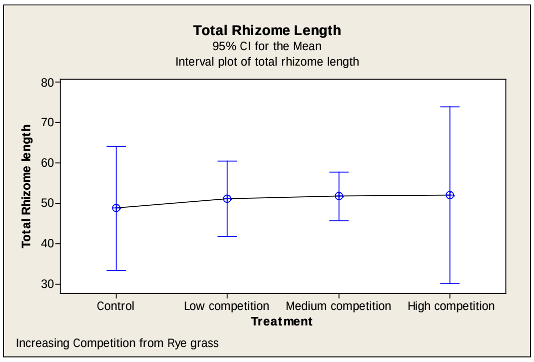


Fig. 17. Interval plot showing total rhizome length of couch grass with rye-grass (Exp.1). X-axis shows treatments and Y-axis shows total rhizome length with mean values.

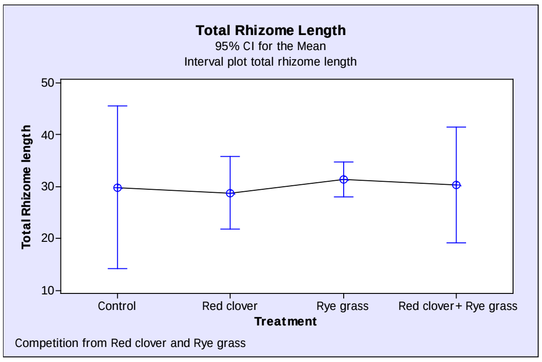


Fig. 18. Interval plot showing total rhizome length of couch grass with rye-grass and red clover (Exp. II). X-axis shows treatments and Y-axis shows total rhizome length with mean values.

5.7 Branching points

Branching points are the points on the rhizomes, from which new branches start to develop. Here, the number of branching points was counted separately for each rhizome. As can be seen from the graph there was a trend, though not significant (F=2.60 and p=0.090), towards decreasing number of branching points with increasing competition from rye-grass in experiment I. For Exp. II, although the result is non-significant (F=1.66 p=0.229), there was a trend towards reduced number of branching points in treatments with rye-grass and red clover + rye-grass.

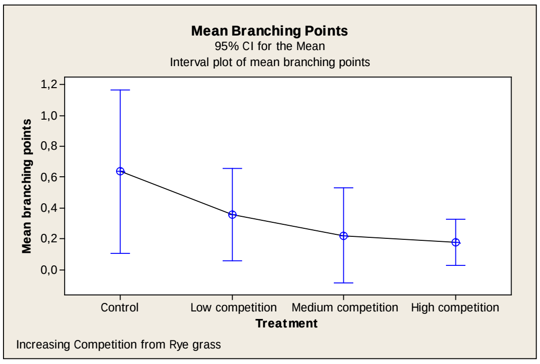


Fig. 19. Interval plot showing mean branching points of couch grass with rye-grass. (Exp.1). X-axis shows treatments and Y-axis shows mean branching points with mean values.

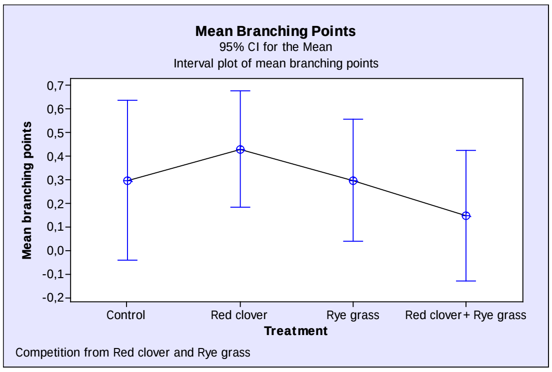


Fig. 20. Interval plot showing mean branching points of couch grass with rye-grass and red clover (Exp. II). X-axis shows treatments and Y-axis shows mean branching points with mean values.

5.8 Nodes

A node is the area of couch grass rhizome from which the shoots and roots grow, and here the number of nodes was counted on each rhizome. For mean nodes, a trend can be seen with values F= 2.52 p= 0.09 .There is a continuous decrease from 'Low competition' to 'High competition' when mean nodes are taken into account. The results were insignificant for Exp. 11 with rye-grass and red clover (F= 0.41 p= 0) .

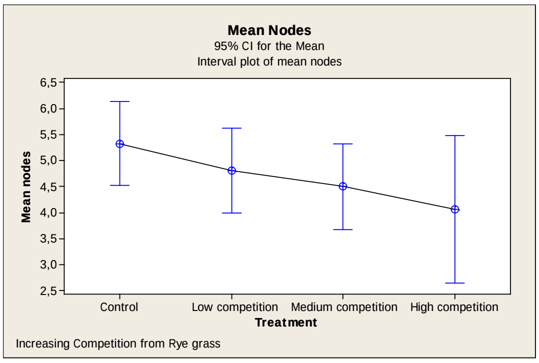


Fig. 21. Interval plot showing mean nodes of couch grass with rye-grass (Exp.1). X-axis shows treatments and Y-axis shows mean nodes with mean values.

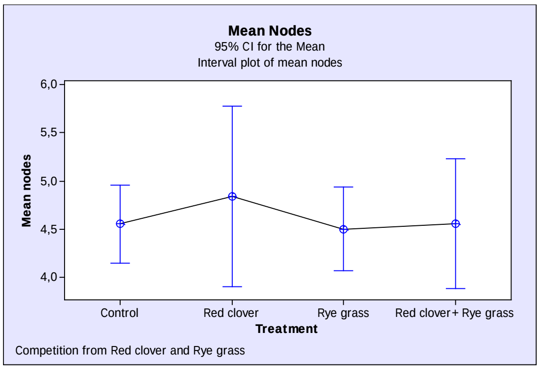


Fig. 22. Interval plot showing mean nodes of couch grass with rye-grass and red clover (Exp. II). X-axis shows treatments and Y-axis shows mean nodes with mean values.

5.9 Rhizome weight

None of the treatments significantly affected the rhizome dry weight. The values for increasing competition with rye-grass (Exp. 1) were F= 0. 55 and p= 0.658, and for competition with rye-grass and red clover (Exp. 11) F=0. 67 and p= 0.584.

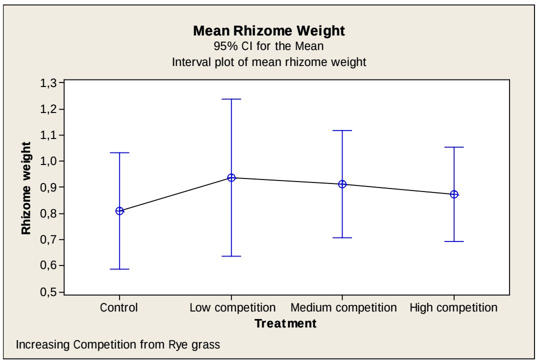


Fig. 23. Interval plot showing mean rhizome weight with rye-grass (Exp.1). X-axis shows treatments and Y-axis shows rhizome weight with mean values.

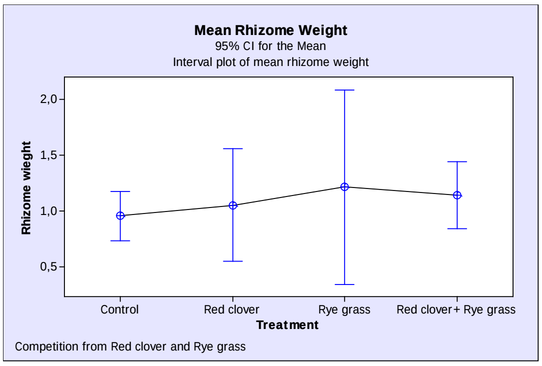


Fig. 24. Interval plot showing mean rhizome weight with rye-grass and red clover (Exp. II). X-axis shows treatments and Y-axis shows rhizome weight with mean values.

5. 10 Above ground Couch grass

Dry weight of all shoots is what is meant by aboveground biomass. Aboveground biomass of couch grass was significantly reduced by increasing competition with rye-grass in Exp. 1 (F=12. 56 and p= 0.000). However, only and a weak trend (F=2. 17 and p=0.145) was shown in competition with rye-grass and red clover.

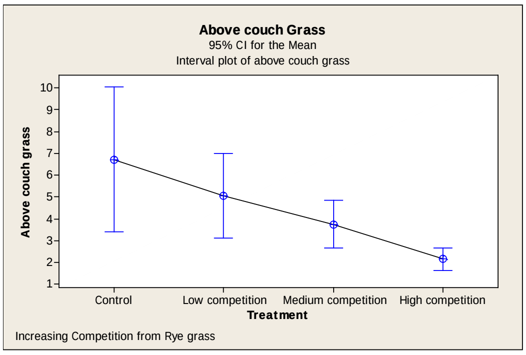


Fig. 25. Interval plot showing above couch grass with rye-grass (Exp.1). X-axis shows treatments and Y-axis shows above couch grass with mean values.

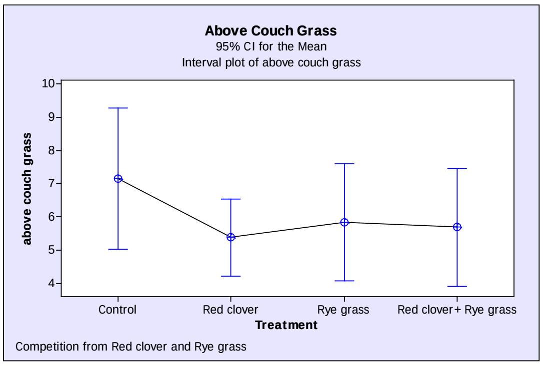


Fig. 26. Interval plot showing above couch grass with rye-grass and red clover (Exp. II). X-axis shows treatments and Y-axis shows above couch grass with mean values.

6 . Discussion

A plant's competitive ability is determined both by how well it gathers resources for itself, and also how it denies those resources for its competitors (Tilman 1988). The presence or absence of cover crops such as rye-grass and red clover affects the growth, development and further propagation of couch grass. This experiment shows that competition from cover crops can change the morphology of couch grass and also limit its biomass acquisition, in a simulated environment after harvest. For both experiments, we got significant results that throw light into how competition affects the morphology and biomass allocation of couch grass. Even though the number of replicates used were few, it is still possible to make assumptions about the changes that happened to the couch grass.

6 .1 Shoot length, leaf length and leaf width

The ability to compete for above ground resources such as carbon dioxide and light, are dependent upon morphological features like shoot length, leaf area and leaf density. Competition can shape these features and they will in turn shape the competitive ability of the plant. In the case of shoot length, the results were insignificant in the experiments presented here (Fig. 1 & 2). The insignificant results may be because of limited space availability in the growth chambers. According to Tilman (1988) light interception and nutrient uptake are proportional to leaf biomass and root biomass respectively. In the case of leaf length and leaf width, which affect leaf area, there is a decrease from control to higher competition but the results are insignificant (Fig. 3, 4, 5 & 6).The insignificant results may be because the competitive plants forces the couch grass to concentrate more on its aerial parts than below ground part (Wiliam 1970 & Håkansson 1974). The trend that the leaf width shows towards decreased width with increased competition show that there is a likely effect of competition on the morphology of the leaf. That it affected width rather than length or shoot length could be because it is sacrificing the area of the leaf to try to keep its overall growth up so that it can get above the rye-grass. It can be seen that there is a decrease in leaf area and leaf density showing a weak trend in experiment with rye-grass (Fig. 7 & 8) but insignificant in experiment with red clover and rye-grass (Fig. 9 & 10). Cussan (1968) said the efficiency of competitive plants not only depends upon biomass production but also how fast it establishes and have efficient growth in respect to light reception. Less wide leaves will mean less leaf area exposed to the light, which will mean less potential photosynthesis.

6 .2 Mean tillers and number of shoots

As mentioned in the introduction when couch grass reaches certain growth level, it starts producing tillers (Palmer & Sagar 1963). The number of tillers and the amount of new rhizomes produced is reduced by competition (Håkansson 1968). In experiments with rye-grass, this view seems to be supported as the number of tillers decrease as competition increases. Perhaps the competition for nitrogen makes the production of tillers less important, as they are primarily for capturing light. Decreasing the number of tillers will however also reduce the leaf surface area and therefore affect the light reception, which will ultimately affect the quantity of couch grass.

The mean tillers per shoot showed a trend in experiment with rye-grass (Exp.1& Fig.11). But in experiment with red clover (Exp. II) there was no such clear reduction between control and rye-grass or red clover (Fig 12) instead they were all at approximately the same level which incidentally was the same level as treatment (Medium competition) was in the first experiment . Also in the case of experiment with red clover (Exp. II), where both the competitive plants are there, still there is no decrease in numbers of tillers and shoots. So it may be because red clover and rye-grass have some effect upon each other that affects the results. Chestnutt, Bartholomew& Binnie (1980) have shown that a third species can alter the relative contribution of two other species in mixture.

Number of shoots per pots showed a decrease and the results are significant with increasing competition from rye-grass (Exp.1& Fig.13). Light and nutrients play an important role in the morphology of couch grass. The significant results may be because of competition from rye-grass for light and nutrients, that made couch grass to produce lesser number of shoots. For the second experiment with both rye-grass and red clover the results are insignificant (Fig. 14).

6 .3 Rhizome length, branching points and nodes

Mean rhizome length (Fig. 15 & 16) and total rhizome length (Fig. 17 & 18) showed insignificant differences in both the experiments but there is a trend towards slight increase in rhizome length from ‘Control’ to ‘High competition’. This increase in rhizome length maybe because couch grass tries to grow longer rhizomes to be able to get a shoot up where there is less competition. Since there were no significant differences for rhizome biomass between the treatments, this could be a purely morphological change.

To control a perennial grass, the most important thing is to limit the below ground storage organs, since the plant will use anything stored in their rhizomes in the next season. There was a trend towards decreasing mean branching points and the mean number of nodes, as the amount of rye-grass increased (Fig.19& 21). This is important in the case of couch grass as the decrease in number of new nodes and branching points may reduce the couch grass generation in the following year. While couch grass concentrated more on increasing rhizome length, it failed to produce new nodes and branching points. However, for red clover the results are insignificant (Fig. 20 & 22).

6 .4 Rhizome weight and above ground biomass

We expected the rhizome weight to go down even faster than above ground biomass with increasing competition, as they allocate fewer resources to the belowground parts, instead the aboveground biomass decreased significantly while the below ground biomass remained unchanged. As we can see from Fig. 23 & 24 rhizome weight is not significantly different between treatments in either experiment; if anything the rhizome weight is on average slightly higher with competition than without.

For aboveground biomass, we expected a decrease as competition increases and the results support that with a steep decrease for the aboveground biomass in Exp. I (Fig. 25). For Exp. II (Fig. 26), there is a trend towards lower aboveground biomass due to competition (regardless of cover crop type). The decrease in the amount of tillers, shoots, leaf area and density seem to be contributing in the decrease of above ground biomass of couch grass.

At the beginning all rhizomes have the same amount of energy. During the growing season the couch grass in the control treatment should be able to store more energy in its rhizomes than the other treatments, but we cannot see any significant change in rhizome weight from ‘Control’ to ‘High competition’. So we cannot conclude that it concentrated on above ground rather than below ground as above ground biomass decreased significantly, while the rhizome was same in all treatments. This might be because couch grass does not wish to waste energy for competition or may be it is using a lot of energy for maintaining competition, and therefore not getting enough energy for propagation. But for some reason it does not seem to have grown its rhizome network during the experiment. One interesting finding is that the rhizome length showed a slight increase and this may be due to couch grass desiring to move away from competition. However, since the longest average length (for High Competition in experiment 1) is approximately the same as the average starting length (average 15 cm) it is hard to assign great relevance to that.

7. Conclusion

In the experiment I (rye-grass) and experiment II (rye-grass and/or red clover), the amount of aboveground couch grass decreased especially in experiments with rye-grass, where the highest level of competition reduced the biomass to one third of the control. This is congruent with Dyke (1976) who found that growth of couch grass in barley was reduced 50% by the under sowing of Italian rye-grass (*Lolium multiflorum*) or red clover (*Trifolium pretense)*. When we view the results of mean tillers, leaf area, number of shoots and leaf density as a whole, all of these seem to be affecting above ground couch grass weight. We expected couch grass might concentrate on above ground when competition comes, but while aboveground biomass did decrease with increasing competition, the belowground did not increase in the control. Thus, couch grass does not appear to have stored anything in its rhizomes in any of the treatments. We can conclude that at the beginning couch grass had grown very well as it is evident from shoot length but later due to the competitive pressure from cover crops, it could not perform as showing decreased production of tillers and shoots, in the latter stage of the growing season. No significant results were obtained for rhizome weight, which means we cannot determine that the couch grass was concentrated on below ground instead of the above ground part. One interesting finding is that the subsequent propagation of couch grass might be lower where there is high competition compared to low or no competition.

The results lead to a conclusion that competitive plants, such as rye-grass in this experiment, have the potential to reduce the growth of couch grass. These affect the morphology and biomass allocation of couch grass that may lead to the decrease of propagation even for the next generations. It is important to conduct more studies in this area of research and to not restrict it to growth chambers alone but to also investigate in field conditions to study how morphology and biomass allocation change, since the experiment in lab have limitations in providing natural conditions.

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