Re-Growth Ability of Broad Dock Plant (Rumex obtusifolius) In Relation To Root Fragment Weights And Nitrogen Availability

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ABSTRACT
Rumex obtusifolius is a very serious weed of pasture and crops. In glasshouse experiment, its re-growth from root fragments was measured using differences in numbers of plants emerging, (shoot) dry weight, number of shoots and root dry weight. Four root fragment weights, 5, 10, 15 and 20 gm were tested, with seed used as a control, against three levels of nitrogen application 0, 100, and 200 kg/ha. Very high plant emergence responses (84%) occurred at 100 kg/ha of nitrogen, which were significantly different from either alternative nitrogen levels (14% and 16% respectively). Mean dry weight (gm/plant), root dry weight (gm/plant) and shoot number (per plant) confirmed similarly high, and statistically significant (P ≤ 0.001) growth responses to nitrogen applied at 100 kg/ha, compared to the control. Rumex obtusifolius re-growth was similar when 0 or 200 kg/ha nitrogen was applied, with no significant differences between them in any growth measures. Growth from root fragments compared to seed was significantly (P ≤ 0.05) higher, across all four measures. The strongest re-growth response measured by emergence came from 5 gm fragments, compared to other weights tested. Emergence (number of plants) and shoots (per plant) were higher when arising from root rather than seed, with a significant difference (P ≤ 0.05) at all fragment weights, but with no pattern between fragment weights. Dry weight and root dry weight were also significantly higher (P ≤ 0.05) when originating from root fragments, and both increased with increasing fragment weight, with the strongest responses from 20 gm fragments. Interactions between nitrogen levels and root fragment weights confirmed that Rumex obtusifolius plants emerged and grew, as shown by all four measures, most strongly and highly significantly (P ≤ 0.001) from root fragments with moderate (100 kg/ha) level of nitrogen application and results were significantly different from the seed controls. Growth from seed and growth with no (0 kg/ha) or excess (200 kg/ha) nitrogen applications, compared to root fragments and moderate nitrogen application respectively was lower across all four growth measures. These results confirmed high emergence responses of Rumex obtusifolius from root fragments, with a likely dependence on moderate nitrogen levels, with, however, growth suppression at higher nitrogen concentrations.

INTRODUCTION
Weeds are widespread plant species which usually grow in most natural ecosystems world-wide. They grow voluntarily in agricultural, grass lands and pastures (Sher and Alyemeny, 2011). However, they are described as harmful, obnoxious species (Strokey, 2006), with adverse effects on the desirable plants (Chaudhary and Akram, 1987), and can act as important constraints in farming areas (Williams and West, 2000). They compete with the grown crops for existing resources required for emergence and growth which usually weaken crops growth and result in low productivity. The losses in crops yield generally arise from competition with weeds for space, water, nutrients, trace elements, light, and other resources (Dunbabin, 2007; Zhao et al., 2006; Alyemeny,
Weeds were also found to grow in grass or arable lands despite application of many control methods (Belz et al., 2007; Javaid et al., 2007; Khan et al., 2005). They also affect desirable plants by excreting toxic materials either from their living or shriveling parts (Evidente et al., 2007; Singh et al., 2005). Weeds also were reported to host many pests (Oudejan, 1994). Rumex L. (Polygonaceae), comprise more than 200 species which can be annual, biennial and perennial herbs (Zaller, 2004). Rumex are very common perennial weeds grow usually north of the equator, but some of its species have been also recorded almost everywhere. They are often considered weeds, however some are also cultivated for their digestible leaves. Rumex obtusifolius is known to vary in different forms, varieties, and subspecies (Cavers and Harper, 1958).

Rumex obtusifolius (Broad leaved dock) is among the five common weeds worldwide (Zaller, 2004), adapted to a wide altitudes from sea level to 1500 m, and has been described as a troublesome weed of grasslands as well as arable crops. Rumex species are of great significance in the agricultural systems as they affect the cultivated plants or native pasture species for space and other resources. In Germany, for example, seven of 10 pastoral farms were reported to be heavily invaded by Rumex species (Bach, 1992; Hofmann, 1992). 60 % of grasslands in Japan, were recorded to be also invaded by Rumex species (Hongo, 1986). In Europe, 80 % of the herbicides application in grassland farming is directed to control weeds, were said to be for Rumex control (Gallery, 1989).

The traits which make R. obtusifolius and other perennial Rumex species so difficult to control include their ability to germinate from seed, combined with massive seed production, and multiple repeat flowerings in any given year; seed which may persist viable under the soil for long times and can emerge in many climatic conditions, with rapid establishment; and a persistent taproot system, which readily regrows after cutting or from fragments left after damage (Cavers & Harper, 1964; Gwynne & Murray, 1985; Pino et al., 1995; Pye, 2008). An abundance of dock seedlings at various growth stages can be expected in croplands, because they are very widespread and abundant plants widely reported to become established in such open habitats (Cavers & Harper, 1964), a characteristic likely to be supported by their reproductive and regenerative qualities which also likely contributes to the widely reported difficulties in chemical control of these species. Zaller, 2004, reviewed most of the research papers on Rumex, covering its ecology and control and concluded that, despite this effort, there are still many of its ecological aspects and, particularly non-chemical, control that have yet to be investigated. Haggaer (1980), assumed that widespread Rumex obtusifolius occurrence in arable lands is a consequence of excessive nitrogen application. Niggli (1985) found that increasing nitrogen stimulated Rumex obtusifolius growth, and Hatcher et al., 1997, in controlled environments, confirmed that nitrogen application at 200 kg/ha resulted to an increase in Rumex species leaf area in the autumn but not necessarily utilize extra nitrogen application. However, in contrast, Rumex obtusifolius seedling emergence was negatively affected by high levels of nitrogen (Kristalova, et al., 2011). Clonal growth of Rumex obtusifolius from subterranean stems with the ability to produce new tap roots (Zaller, 2004), is the usual regenerative system. Re-growth has been found to occur even from fragments of root stocks more than 50 days old (Monaco and Cumbo, 1972), and root longevity of Rumex obtusifolius was reported to be four years or longer (Cavers and Harper, 1964). Root fragments regeneration of Rumex species from was confirmed to occur from the top parts of the taproot (Healy, 1953; Hudson, 1955; Pino et al., 1995), however, other studies have raised the possibility of regeneration from all parts of the root (Adolf and Linke, 1992). This research aims to make a significant contribution in an important and as yet still poorly understood area of the biology and ecology of this species, presenting new findings regarding its re-growth ability in relation to root fragment weight and nitrogen availability.

**MATERIALS AND METHODS**

**Growth Trials**

Glasshouse experiment was carried out in summer / early autumn (August-October) 2014, at the University of Reading, UK, average temperature ranged between 16 and 22 °C. A two-factor randomized block design was followed, with 4 root fragment sizes: 5, 10, 15, and 20 cm and seed as a control. Three levels of nitrogen (Urea, 46.5%) application: 0, 100 and 200 kg/ha were applied. Fifteen blocks of 10 pots per treatment were applied to bring the whole experiment to 150 pots. 5” pots were used, soil comprised 75 % clay and 25 % peat. Pots were watered regularly during the experimental period. Seed obtained commercially were used as a control treatment for root fragment weights and sown one per pot. Nitrogen was mixed with the soil prior to commencement and no other nutrients were added. Pots were watered regularly and trials ran for 10 weeks from commencement after which above ground fresh weight/pot, shoot numbers/pot and root weight/pot were measured.

**Root preparation**

Root tissue of Rumex obtusifolius was collected from the University of Reading grounds, whole roots of middle aged plants were dug out, collected to ensure nearly equal aged plants. Root slicing took place on the same day, sections from the top of the tap root were sliced off vertically and shaved to the required weight. Prepared root weights were: 5, 10, 15, 20 gm.
Statistical Analysis
An ANOVA was undertaken using GENSTAT (GENSTAT Version 18, VSN International, Hemel Hempstead, UK). Mean comparisons were performed by a least significant difference (LSD) multiple comparison test.

RESULTS

1. Effect of nitrogen on Rumex obtusifolius emergence and re-growth
Taking all root fragment sizes as a whole, Fig.1; 1.1 and 1.2, below, shows a very high emergence response of Rumex obtusifolius root fragments at 100 kg/ha N application, which was significantly (P ≤ 0.001) different from either other level (0 or 200 kg/ha). Rumex healthy shoot emergence was 84% at 100 kg/ha of nitrogen, 14% at 0 kg/ha, and 16% at 200 kg/ha, with no significant difference between the two lower emergence levels. These results confirmed a high emergence response of Rumex to nitrogen at 100 kg/ha, however, emergence was suppressed when the nitrogen level was 200 kg/ha.

2. Effect of nitrogen on Rumex obtusifolius growth
Different measurements of Rumex obtusifolius growth, dry weight, shoot numbers and root dry weight all showed high and significant (P ≤ 0.001) growth responses at 100 kg/ha of nitrogen application (Fig.1:1.3, 1.4 and 1.5) compared to the other nitrogen treatments and neither other treatments was significant.
Fig. 1: Effect of variation of nitrogen concentration on emergence and growth of *Rumex obtusifolius*. 1.1 represents emergence percentage (%), 1.2 represents mean number/pot, 1.3 represents mean of dry weight (g)/pot, 1.4 represents mean of tillers number/pot, 1.5 represents mean of root weight (g)/pot. Nitrogen was applied to *R. obtusifolius* root fragments, at 3 levels as shown (0, 100, 200 kg/ha). SED represents standard error of difference of means.

3. **Effect of root fragment weight variation on Rumex obtusifolius emergence**

Fig. 2; 2.1 and 2.2, below, shows a significant difference in *Rumex obtusifolius* emergence from root fragments compared to seed. Root fragment of 5 gm weight gave the highest emergence percentage.

4. **Effect of variation of root fragment weight on Rumex obtusifolius regrowth**

Mean dry weight of above-ground parts of *Rumex obtusifolius* was significantly (P ≤ 0.05) higher when grown from a root fragment, compared to seed, at any tested (5, 10, 15 or 20 gm) weight. Mean dry weight increased...
as root fragment weight increased (Fig. 2: 2.3). Tiller numbers were also significantly (P ≤ 0.05) higher when Rumex plants grew from root fragments compared to those of seed origin. However, mean tiller numbers did not differ significantly at different root fragment weights (Fig. 2: 2.4). Mean root weight was significantly (P ≤ 0.05) higher with Rumex plants grown from root fragments compared to those of seed origin. Mean root weight increased as root fragment weight increased, and fragments of 20 gm produced significantly (P ≤ 0.05) higher root weight than those of seed origin or other lower fragment weights of 5 or 10 or 15 gm fragments which there was not any significant between their root weights (Fig. 2: 2.5).
Fig. 2: Effect of variation of root fragments weight on emergence and growth of *Rumex obtusifolius*. 2.1 represents emergence percentage (%), 2.2 represents mean number/pot, 2.3 represents mean of dry weight (g)/pot, 2.4 represents mean of tillers number/pot, 2.5 represents mean of root weight (g)/pot. *R. obtusifolius* root fragments, were examined at; Seed (control), four originating root fragment weights; 5, 10, 15, 20 (g)/pot. SED represents standard error of difference of means.

5. **Effect of interaction between nitrogen and variation in root fragment weights on Rumex obtusifolius emergence and growth:**

Analysis of the interactions between nitrogen levels and variation in root fragment weights on *Rumex obtusifolius* growth confirmed previous results. Emergence, was high (P ≤ 0.001) at all root fragment weights in moderate levels of nitrogen (100 kg/ha) (Fig.3; 3.1 and 3.2), dry weight (gm/plant) (Fig.3; 3.3), number of shoots (per plant) (Fig.3; 3.4), and root dry weight (gm/plant) (Fig.3; 3.5), all followed a similar pattern. Emergence occurred at all nitrogen levels, for all initial root fragment weights, including the seed control, this is confirmed by the, clearly related, number of shoots produced. All four fragment weights, with no added nitrogen or with nitrogen at 200 kg/ha, showed weak growth, emergence from seed was, however, consistently higher at all nitrogen levels, but still relatively low level compared to 100 gm/ha with root fragments.
3.1

Percentage of emerging Rumev plants (%)

SED = ± 15

N kg/ha

Seed 0 100 200 0 100 200 0 100 200 0 100 200 0 100 200
0 100 200 10 15 20

Root fragment weights (g)

3.2

Mean of emerging Rumev plants / pot

SED = ± 0.15

N kg/ha

Seed 0 100 200 0 100 200 0 100 200 0 100 200 0 100 200
0 100 200 5 10 15 20

Root fragment weights (g)
Fig. 3: Rumex obtusifolius emergence and growth responses to the interaction between nitrogen levels and root fragment weights. 3.1 represents emergence percentage (%), 3.2 represents mean number/pot, 3.3 represents mean of dry weight (g)/pot, 3.4 represents mean of tiller numbers/pot, 3.5 represents mean of root weight (g)/pot. Nitrogen was applied to R. obtusifolius root fragments, at 3 levels as shown (0, 100, 200 kg/ha) and R. obtusifolius root fragments, were examined at; Seed (control), four originating root fragment weights; 5, 10, 15, 20 (g)/pot. SED represents standard error of difference of means.

DISCUSSION

High levels of plant emergence of Rumex obtusifolius with nitrogen applied at 100 kg/ha which was significantly (P ≤ 0.001) different from zero nitrogen application and from nitrogen at 200 kg/ha is an important finding of this study. It confirms Stilman's et al. (2012) finding of a link between larger R. obtusifolius populations and higher soil nitrogen concentrations, and of Haggar (1980), who noted that excessive nitrogen in arable lands is one of the commonest factors associated with R. obtusifolius persistence. The much higher rate of emergence (84%) found at 100 kg/ha nitrogen application, compared to 0 (14%) and 200 kg/ha (16%) reflects both the importance of nitrogen availability as well as the suppressive effect of nitrogen when the concentration is too high, and the finding was similar when measured by dry weight, tiller numbers and root dry weight. Kristalova et al. (2011), also found negative effects on R. obtusifolius emergence at very high nitrogen concentrations. Re-growth demonstrated by all four measures, plant emergence, (tiller) numbers, mean dry weight and mean root dry weight was significantly (P ≤ 0.05) higher from root fragments compared to seed. This is in accordance with the widely reported capacity amongst Rumex species in general to re-grow from root fragments left in the soil post cultivation (Gwynne and Murray, 1985; Pino et al., 1995). R. obtusifolius emergence was highest from the smallest tested fragments (5 gm) confirming the ability of this species to regenerate from very small root fragments under glasshouse conditions. It has been reported that regeneration in R. obtusifolius generally takes place from the upper parts of the taproot (Healy, 1953; Hudson, 1995; Pino et al., 1995), and this was the case in this study. However, root fragments without buds were also able to generate shoots, which confirms the findings of Adolf and Linke (1992) who reported that regeneration could also occur from all root parts but not those of Hughes (1938, cited in Pino et al., 1995) who assumed that regeneration ability was associated with the presence of buds, as he found fragments without buds (i.e. parts below the root-collar) were unable to germinate. Dry weight of shoots and roots followed a similar pattern, both increased with the weight of the root fragment, but there was no clear pattern in either plant emergence or number of shoots, which are related. The finding that shoot dry weight increases with fragment size, but that the number of shoots does not, is surprising given that larger root fragments might be expected to have higher numbers of buds, and appears instead to indicate stronger growth from a single shoot when root fragment weighs are larger, as well as greater investment by the plant in root growth. Root dry weight was highest from the largest (20 gm) root fragments, which supports the likelihood that plant re-growth is stronger from larger root fragments. Rumex
obtusifolius emerged and grew, at least for the duration of the trials, most strongly from root fragments at moderate nitrogen levels as evidenced by significant differences between seed (the control) and root fragment of any size, for all four growth measures. These findings point to the need for further work to refine the levels of nitrogen application which most significantly affect re-growth, and the longer term impacts of both nitrogen levels and fragment weight on Rumex development and re-growth capabilities, and to transfer the results to field and crop level trials.

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REFERENCES


