Effect of Cutting on Growth and Seed Production of *Rumex obtusifolius* L. and *Rumex crispus* L. in Eastern Hokkaido

II. Cutting at Different Maturing Stages with respect to Plants Established from Seeds.

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Introduction

In the previous report⁹⁾, *Rumex obtusifolius* was shown to have an advantage over *R. crispus* in terms of seed production at regrowth after cutting, especially when cut at the beginning of seed ripening or later. This suggests that *R. obtusifolius* plants colonizing sown grasslands can produce some seeds irrespective of cutting time and thereby contribute to the establishment of other individuals from seeds. This ability of *R. obtusifolius* is one of its most important features as a grassland weed⁶⁾.

The previous experiment⁹⁾ was conducted using roots trimmed to equalize weight. This preparation of roots and transplanting may affect growth and seed production for both *Rumex* species. It is therefore necessary to compare the growth response of overwintered plants with that of transplanted plants. The present study was designed to elucidate the effect of cuttings taken at different maturing stages during the subsequent two seasons with respect to plants established from seeds.

Materials and Methods

A field experiment was conducted at Obihiro in Hokkaido during 1984 to 1986. The experimental plot was prepared as described previously⁹⁾. Seeds of the two *Rumex* species, which had been collected from an abandoned

field, were sown in the experimental field on 14 June 1984. They were placed at 30 cm intervals in eight 20-m long rows. The two species were sown in alternate rows spaced 80 cm apart. Four or five seeds were sown at each point; they were thinned to one plant after emergence. Plants were allowed to grow in the first season.

Cutting treatments were carried out during two seasons in 1985 and 1986. Six plants selected at random were used for one of nine cutting treatments. Cutting were done on 7 June 1985 and 4 June 1986, and subsequently at one-week intervals. Plants were cut to a 5 cm height. At regrowth after cutting, the sampling method was different in the two seasons. Plants were dug up 60-75 days after each cutting in the second season. However, an individual inflorescence within each plant was cut separately in the third season, when most perianth segments turned a dark-brown color. Plants were dug up after the last sampling on 13 October. Root samples were separately taken from each 10-cm horizon up to 50 cm depth.

The same method as in the previous report⁹⁾ was used for measuring dry matter production of different components and seed production; the number of seeds produced was also measured. The seeds were stored in paper bags under room condition for approximately three months. The viability of the

seeds was tested on moist filter papers in petri dishes in an incubator at 25 °C under light for 14 hours and at 15 °C under dark for 10 hours. Fertilizer (30 kg N, 55 kg P₂O₅ and 55 kg K₂O per hectare) was broadcast to the experimental field before seeds were sown in the first season, and twice this amount the following spring.

Results and Discussion

1. Production of dry matter and seed

The mean production of DM and seeds during the two seasons is shown in Table 1. The number and height of inflorescences were significantly different between the two species. *R. obtusifolius* had more inflorescences but was lower in height. Both species produced similar DM and seeds as was the case in the previous experiment⁹⁾.

2. Percentage of viable seed

The beginning of flowering or seed ripening was decided by the first appearance of the respective organ in a harvested sample. *R. crispus* produced viable seeds one week earlier than *R. obtusifolius* during undisturbed growth in the second and third seasons (Fig.

1). However, seed production was seriously affected by weather conditions, especially temperature. The seed ripening in both species began during 28 June to 5 July in the second season, but during 7 to 14 July in the third season. Viable seed productions started on 21 July in *R. obtusifolius* and 14 July in *R. crispus*, although these dates were observed only in the third season. The delay of seed ripening in the third season seems to have been due to relatively low temperatures during the period after flowering. From the calculation of these data, total accumulated temperatures above a base of 5°C required to form viable seeds were 598°C in *R. obtusifolius* and 534 °C in *R. crispus*. More than 50 % germination was attained by 675°C and 611°C for the respective species. Thus, the requirement for accumulated temperatures was 10-12 % higher in *R. obtusifolius* than in *R. crispus*.

At regrowth after cutting, both species showed high percentages of viable seeds until September. Flowering and seed ripening are usually accelerated by a long daylength and high temperature¹⁴⁾. MAUN & CAVERS¹³⁾ ob-

Table 1. Results in growth of *R. obtusifolius* and *R. crispus*.

	<i>R. obtusifolius</i>	<i>R. crispus</i>	LSD (P=0.05)
Inflorescence height ^{b)} (cm)	151 ^{a)}	168	5.3**
Inflorescence no. ^{b)} (per plant)	6.9	4.6	1.7**
DM production ^{c)} (g/plant)			
Aerial part	154	132	34 ^{ns}
Underground part	75	68	19 ^{ns}
Total	229	200	33 ^{ns}
Seed production ^{c)}			
Seed weight (g/1,000 seeds)	1.23	1.12	0.08**
Seed DM (g/plant)	19.7	13.2	5.6 ^{ns}
Seed % in aerial DM (%)	12.8	10.0	3.5 ^{ns}
Viable seed No. (× 1000/plant)	13.9	10.0	4.0 ^{ns}

a) Figures shown are the mean of two seasons.

b) Mean of 4 cutting treatments during July.

c) Mean of a total of 9 cutting treatments. Aerial and underground DM are the sum of two samplings (cutting plus regrowth) and the result sampled in late autumn, respectively.

** ; significant at P=0.01, ^{ns} ; not significant.

Fig. 1. Viable seed percentage of *R. obtusifolius* (○) and *R. crispus* (△) at cutting time (solid) and at regrowth (open) in the third season. Vertical line attached to symbol shows confidence interval at $p=0.05$.

Fig. 2. Viable seed production of *R. obtusifolius* and *R. crispus* in 9 successive cuttings. The result was obtained from the mean of two seasons. ▨; at cutting time, □; at regrowth, I; s.e.

served that seed production of *R. crispus* was maximum under a 15-h daylength, but seed weight and viability were not affected by any weather conditions. In this experiment, both species produced viable seeds 62 to 68 days after cutting in the third season. Total accumulated temperatures above a base of 5 °C during this period were more than 700°C. This suggests, therefore, that viable seed production at regrowth is accelerated by a high temperature¹²⁾.

3. Effect of cutting time on viable seed production

Viable seed productions of both species decreased sharply when aerial parts were cut at the beginning of seed ripening (Fig. 2). This tendency was the same as found in the previous experiment. The least production corresponded to cutting 6 (6-11 July) in *R. obtusifolius* and cutting 4 (24d-28 June) to cutting 5 (2-5 July) in *R. crispus* in the two seasons.

The pattern on viable seed production at regrowth is shown in Fig. 3. Both species produced more than 8,000 viable seeds in

total at regrowth in the first 3 cuttings. Growth stages at these cuttings were from elongation of flower stalk to flowering. However, viable seed production was significantly higher in *R. obtusifolius* than in *R. crispus* after cutting 4 (beginning of seed ripening). *R. crispus* produced less than 400 viable seeds as a total at regrowth of cuttings 6 and 7. In contrast, *R. obtusifolius* continued to produce 1,900 to 2,400 viable seeds in total until early October.

Sown grasslands are regularly disturbed by mowing or grazing. For example, hayfields sown by timothy (*Phleum pratense*) are mown twice a year in eastern Hokkaido. The first harvest is generally done during late June to early July. Grazing pastures are usually utilized five to eight times during early June to early October. Under this management, the chance for *Rumex* plants to produce viable seeds may be restricted. As mentioned earlier⁹⁾, *R. obtusifolius* has a higher ability to produce seeds irrespective of cuttings at various maturing stages and environmental conditions.

Fig. 3. Viable seed production of *R. obtusifolius* and *R. crispus* at regrowth in the third season. Figures in parentheses and arrows show cutting treatments and cutting times, respectively. Broken lines indicate no seed production. I : s.e.

4. Root distribution

The distribution of root DM in soil is shown in Fig. 4. Both species showed similar root DM weights including crown in 0-10 cm and 10-20 cm horizons. Root DM weight was significantly greater in *R. obtusifolius* than in *R. crispus* in 20-30 cm and deeper horizons. The sum of root DM weights in the 20-50 cm horizon was 17.0 g (17.9 % of total) in *R. obtusifolius*, whereas 5.3 g (6.6 %) in *R. crispus*. Thus, *R. obtusifolius* developed a notably larger root system³⁾.

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Fig. 4. Distribution of root dry matter weights of *R. obtusifolius* (▨) and *R. crispus* (▤) in soil in the third autumn. These results were obtained from mean of 9 successive cuttings in the third season. Horizontal lines show LSD at $p=0.05$.

obtusifolius in sown grasslands is positively associated with that of annual arable weeds⁸⁾. The author observed in other experiments that the short life expectation of *R. obtusifolius* plants in intensively managed grasslands and higher percentages of its seedlings to develop to a reproductive stage in a dense vegetation in the second season. In the present experiment and the previous report⁹⁾, *R. obtusifolius* demonstrated that it possess advanced features in terms of seed production after cutting and root distribution in deeper horizons. These observations suggest that *R. obtusifolius* may adapt to sown grasslands by modifying both its reproduction and life expectancy. Seeds produced by colonized plants in sown grasslands are pooled in a seed bank⁷⁾. Seedlings from the bank may survive if they find suitable gaps, and mature plants produce seeds again. *R. obtusifolius* seems to have more of various features required for this population dynamics than *R. crispus*⁴⁾.

Finally, it is important to recognize that *Rumex* species may show various degrees of intra-specific variation^{1,2)}. In this experiment, seeds of the two species studied were collected from an abandoned field where they coexisted. Further study is necessary to eluci-

date genetic variation among the wide populations of *R. obtusifolius*^{5,10,11).}

Summary

The growth response and seed production were compared between *R. obtusifolius* and *R. crispus* after cutting at different maturing stages at Obihiro in Hokkaido during 1984 to 1986. Seeds were sown in the field on 14 June 1984. Different cutting regimes were carried out during the second and third seasons.

1. *R. obtusifolius* developed more inflorescences but was lower in height than *R. crispus*. Both species produced almost the same DM and seeds on an average of all cutting treatments.

2. *R. crispus* produced viable seeds about one week earlier than *R. obtusifolius* during undisturbed growth in both seasons. The requirement for total accumulated temperatures above 5 °C base was 10-12 % higher in *R. obtusifolius* than in *R. crispus*.

3. Viable seed productions of both species decreased sharply when aerial parts were cut at the beginning of seed ripening in early July.

4. Both species produced more than 8,000 viable seeds at regrowth in the first 3 cuttings (from elongation of flower stalk to flowering). However, viable seed production at regrowth was significantly higher in *R. obtusifolius* than in *R. crispus* after cutting 4 (beginning of seed ripening).

5. Both species showed the similar distribution of root DM in the 0-20 cm horizon in soil. However, root DM weight was significantly greater in *R. obtusifolius* than in *R. crispus* in the 20-50 cm horizon.

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北海道東部におけるエゾノギシギシとナガバギシギシの生長と 種子生産におよぼす刈取りの影響

II. 種子から育成した個体についての異なる生育段階での刈取り

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摘 要

異なる生育段階で刈取った時の生長と種子生産におよぼす影響について、エゾノギシギシ (*R. obtusifolius* L.) とナガバギシギシ (*R. crispus* L.) で比較検討した。実験は1984年から1986年の間、帯広市において行った。1984年6月14日に両種の種子を播種し、2年目と3年目に時期を変えて刈取った。

1) ナガバギシギシと比べて、エゾノギシギシの方が多くの花茎を生産したが、花茎は低かった。すべての刈取り処理区を平均すると、両種ともほぼ同様の種子を生産した (Table 1)。

2) 2年目と3年目の刈取り前の生育では、ナガバギシギシの方がエゾノギシギシより約1週間早く発芽可能な種子を生産した。5℃以上の積算温度に換算すると、エゾノギシギシの方がナガバギシギシより10-12%高い温度を必要とした (Fig. 1, 2)。

3) 種子の登熟初めの7月上旬に地上部を刈取ると、両種の発芽可能な種子生産は明らかに低下した (Fig. 2)。

4) 抽苔期から開花期にかけて刈取ると、両種とも再生時に8000粒以上の発芽可能な種子を生産した。一方、種子の登熟期以降に刈取ると、再生時の発芽可能な種子生産量はナガバギシギシよりエゾノギシギシの方が明らかに高かった (Fig. 3)。

5) 土壌中の0-20cmの層において、両種の根の分布はほぼ同様であった。一方、20-50cmの層においては、ナガバギシギシよりエゾノギシギシの方が明らかに多くの根の乾物重を分布させていた (Fig. 4)。