PROBLEMS WITH THE RE-ESTABLISHMENT OF THORN HEDGES IN THE CAMBRIAN MOUNTAINS ENVIRONMENTALLY SENSITIVE AREA

JOHN WILDIG, BERNARD GRIFFITHS

ADAS Pwllpeiran, Cwmystwyth, Aberystwyth, Dyfed SY23 4AB

TIM MILSOM

Central Science Laboratory, Ministry of Agriculture, Fisheries & Food,
Tangley Place, Worplesdon, Surrey, GU3 3LQ

ABSTRACT

Hedges are an important feature of middle hill land within the Cambrian Mountains Environmentally Sensitive Area but many are in poor condition through lack of management. Re-establishment of Hawthorn (*Crataegus monogyna*) hedges by planting is hindered by grazing animals. Double fencing of hedges will relieve grazing pressure but this often results in competition between ground vegetation and young hawthorns, to the detriment of the latter. Weed control should alleviate the competition but methods need to be effective under conditions of high exposure and high rainfall. A field experiment was carried out at ADAS Pwllpeiran to evaluate the effects of three types of weed control (glyphosate, propyzamide, mulching) on survival and growth of hawthorn. The treatments plus a control were laid out along a newly planted hawthorn hedge, at 290 metres altitude, in a randomised block design. Mulching slightly enhanced the growth of young hawthorn plants whereas propyzamide had no discernible effect. Glyphosate had an adverse effect on growth and survival of hawthorn.

INTRODUCTION

Hedgerows are an important feature of the upland landscape in the Cambrian Mountains of central Wales and have historical interest. Many date back to the period of enclosure of middle hill-land or Ffridd in the 19th century (Davies and Davis, 1973), when labour was readily available to carry out planting and management. However, the condition of these hedges deteriorated during the 20th century through lack of management which, in turn, was the result of the vicissitudes of the hill farming industry and changes in land use from sheep walk to forestry (Parry and Sinclair, 1985). During the 1960s and 70s, hill farming underwent an unprecedented expansion but this led to further deterioration of hedges because stocking densities on middle hill-land were increased to very high levels with the result that the remnants of hedges were browsed out. Moreover, the decline in farm labour and the economics of hill farming made fencing a more attractive option to hedge management.

In recent years, there has been a renewal of interest in hedges on farms in the Cambrian Mountains Environmentally Sensitive Area (ESA) partly because of their shelter value for stock but also because of their importance as landscape features. These concerns are reflected in the management prescriptions within the ESA (Anon, 1989). However, the condition of many hedges is now so poor that replanting is required to restore them.

Re-establishment of hawthorn (*Crataegus monogyna*) hedges by planting is hindered by grazing animals. Though this problem can be remedied by double fencing, the reduction of grazing pressure within fenced enclosures may often result in intense competition between existing ground vegetation and hawthorns, to the detriment of the latter. The objective of the experiment was, therefore, to determine whether the survival and growth of young hawthorn plants could be enhanced by weed control on an exposed site with high rainfall. Three weed control strategies, two chemical and one physical, were compared.

METHODS

The experiment was carried out at ADAS Pwllpeiran, which is situated within the Cambrian Mountains ESA.

A post and wire fence was erected parallel to, and 2m apart from, an existing fence along the margin of a pasture, at about 290m altitude. In January 1991, a double row of hawthorns with 25cm spacings between plants and rows was planted down the middle of the enclosure between the two fences. The hawthorn plants were obtained from a local supplier but were not a native variety. Each hawthorn was cut back to 5cm in height to mitigate the effects of die-back due to exposure to wind.

The hedge enclosure was split into 12 plots, each of which was 10 metres long and contained 80 hawthorn plants. Four treatments were applied to the plots in a randomised block design with three replicates. The treatments were as follows: (i) a contact broad-spectrum herbicide (glyphosate) applied in May 1991 in relatively calm conditions at 1.4kg/ha AI, using a knapsack sprayer fitted with a shielded spray-head; (ii) a residual broad-spectrum herbicide (propyzamide) applied in December 1991, using a granular formulation at a rate of 1.52 kg/ha AI; (iii) a mulch mat of 400 gauge black polythene, laid down at the time of planting; (iv) a control, where no vegetation management was carried out.

Twenty hawthorn plants from each plot were marked at the start of the experiment for repeated growth measurements. Growth was assessed in June 1992 and again in November 1993 from measurements of the height of the plant and diameter of the main stem. Mean values were taken for each plot and used as dependent variables when assessing treatment effects by analysis of variance. The variance of the means was checked for homogeneity across treatments. Growth increments for each plot were calculated by subtracting the height (or stem diameter) for each marked plant on a given sampling date from that on the next sampling date and then taking the mean of the differences. Ground vegetation cover in each plot was estimated visually to the nearest 5%.

RESULTS

Nearly half of the young hawthorns (47%) planted in January 1991 had died by June 1992, when the first growth assessments were made. However, the percentage surviving in each plot varied from 11% to 81% and differed significantly between treatments (Table 1).

The hawthorns grew from a uniform 5cm in January 1991 to 41 cm, on average, by June 1992, although the height increments varied from 12cm to 54cm between plots. Their height in June 1992 was not correlated with ground vegetation cover (Kendall rank correlation coefficient = 0.0177, n=12, P=0.47) but it did differ significantly between treatments (Table 2).

TABLE 1 Survival of hawthorn plants between January 1991 and June 1992, expressed as percentage surviving per plot, in relation to weed control treatment

Treatment	Mean of plot means	Standard Error	n
Propyzamide	69.6	2.3	3
Glyphosate	16.3	3.8	3
Polythene mulch	75.0	3.6	3
Control	52.1	9.1	3

ANOVA $F_{3,8} = 24.15$, $P<0.001$

TABLE 2 Height of hawthornplants in June 1992, expressed as mean height per plot (cm), in relation to weed control treatment

Treatment	Mean of plot means	Standard Error	n
Propyzamide	44.4	3.2	3
Glyphosate	21.7	2.6	3
Polythene mulch	53.7	2.5	3
Control	45.3	0.9	3

ANOVA $F_{3,8} = 30.83$, $P<0.001$

By November 1993, the average height of the hawthorns was 63cm but the growth increments between June 1992 and November 1993 varied from 2.5cm to 34cm between plots and differed significantly between treatments (Table 3). The rate of increase in stem diameter over the same period also differed significantly between treatments (Table 3).

TABLE 3 Increases in height[1] and stem diameter[2] of hawthorn plants between June 1992 and November 1993, expressed as mean difference per plot, in relation to weed control treatment

Treatment	Height (cm) Mean & standard error of plot means		Stem diameter (cm) Mean & standard error of plot means		n
Propyzamide	22.9	2.5	0.43	0.041	3
Glyphosate	8.5	3.0	0.13	0.055	3
Polythene mulch	29.8	2.2	0.60	0.003	3
Control	24.5	0.4	0.34	0.053	3

1.ANOVA $F_{3,8} = 16.51$, $P<0.001$. 2. ANOVA $F_{3,8} = 19.96$, $P<0.001$.

The treatment effects were explored further by making *a posteriori* comparisons of the treatment means using Tukey's test. On average, hawthorn survival in the glyphosate plots was lower than that in the others (Table 1). Growth between 1991 and 1992 in the glyphosate plots was also slower (Table 2) and this effect carried over into 1993 (Table 3). There were no differences between the other treatments and the control except in 1993 when stem diameters of plants in the mulched plots had increased by a greater amount than those in the control.

DISCUSSION

These findings imply that, at the level of replication used in the experiment, mulching at the time of planting produced a slightly greater increase in growth of young hawthorn plants but that propyzamide, applied 10 months after planting, did not have a detectible effect. Glyphosate appeared to have an adverse effect on growth and survival and it is known that broad-leaved trees and shrubs can be particularly susceptible to this herbicide in summer (Robinson 1985). Even though a shield had been fitted to the spray head, and spraying was done on a day with little wind, it is thought that droplets of glyphosate may have been deflected by the luxuriant ground vegetation onto the young hawthorn plants with the result that some were killed outright, while the growth of others was retarded. However, recent experiments with tree seedlings suggest that alternative contact herbicides, particularly haloxyfop, may be less damaging (Clay *et al.*, 1992). Fluazifop-P-butyl, which has been used for the selective control of grasses in field margins (Marshall and Nowakowski, 1992), may also be appropriate.

The data suggested that mulching enhanced growth between 1992-93 and this method may be a viable alternative to herbicides, particularly in exposed sites where the combination of high rainfall and high winds make spraying impracticable. In this experiment, polythene silage pit sheets were cut up for mulch mats mainly because they were cheap, available on the farm and appeared to be suitable for the task. However, other materials which are readily available within the ESA, such as sheeps' wool, might be equally effective and should be evaluated.

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THE RE-INTRODUCTION OF NATIVE AQUATIC PLANTS INTO FENLAND DITCHES

S. J. TOWN, S. R. RUNHAM

ADAS Arthur Rickwood Research Centre, Mepal, Ely, Cambridgeshire, CB6 2BA

ABSTRACT

Drainage ditches are a necessary part of the fenland farming scene, forming the commonest type of field margin. They can provide a valuable habitat for flora and fauna. When maintained routinely by dredging (slubbing) or complete clearance, it can take many years for a ditch to regain a diverse range of flora. A trial was set up at ADAS Arthur Rickwood Research Centre, in Mepal Fen, to investigate the suitability of artificially introducing a range of native, aquatic plants to a depleted ditch. The small-scale replicated trial was implemented from 1989 to 1993. Six plant species (*Alysma plantago-aquatica, Butomus umbellatus, Caltha palustris, Iris pseudacorus, Nymphoides peltata* and *Sagittaria sagittifolia*), which were either already occurring locally or in the nearby Ouse washes, were chosen and planted into a typical 'slubbed' fenland ditch. Species were assessed twice yearly (in early summer and autumn) for survival, proliferation and colonisation and also for their ability to compete with other vigorous species which colonised naturally. Results suggested that the *Iris pseudacorus* and *Sagittaria sagittifolia* (the two most prolific), together with the *Alysma plantago-aquatica* and *Butomus umbellatus*, could be successfully introduced into a cleared or depleted ditch; whilst the *Nymphoides peltata* and majority of *Caltha palustris* plants gradually disappeared.

INTRODUCTION

Drainage ditches are vital to the well-being of fenland farming and have to be dredged or cleared routinely to ensure the free drainage of the land. They also provide an important semi-natural 'corridor' for wildlife in an area of intensive arable farming, often with few other suitable habitats (Milsom *et al.*, in press). Following a maintenance operation, it can take a considerable time for a ditch to regain a diversity of plant species; meanwhile, the fauna associated with a particular species can disappear.

The ditches can be more rapidly restored and ecologically enhanced by introducing a wide variety of suitable native plants. Planting can be used to increase species diversity in comparison with natural colonisation. It can also be used to favour dominance of particular species, limiting opportunities for undesirable species to colonise the whole ditch.

Drainage operations in recent years, have been so extreme that wetland habitats are now much reduced. Consequently, many aquatic species have declined drastically (Evans, 1991).

Conservation of some plants and associated animal species could be encouraged by transplanting. Taller species intercept blown leaves before they reach the water's surface and also catch and store seeds to provide winter food resources, together with nesting habitat, for birds, including wildfowl (Brooks, 1981). Planting can also protect the ditch banks from erosion. Landscape architects are becoming more aware of the need to include aquatic plants as an integral component of river improvement schemes (Spencer-Jones & Wade, 1986).

METHODS

The ditch selected was a typical fenland drainage ditch, 6 m wide, with a mean water depth of 0.8 m, situated at ADAS Arthur Rickwood, Mepal, Cambridgeshire. The adjacent fields consisted of a loamy peat up to 0.9 m deep with a 30% organic matter content over fen clay of the Adventurer's Shallow series. There was a willow hedge on the north-west side which was removed in spring 1992 and replaced by a 2 m margin of uncropped land. A margin of at least 2 m was maintained, by regular rotavation, on the cropped south-east side of the ditch throughout the experiment. The bank tops were trimmed in spring 1992 but the remainder of the ditch was left uncut throughout the experimental period. The water was maintained at a fairly constant depth in spite of drought affecting nearby ditches during the summer of 1991.

The ditch was mechanically cleared of plant debris and silt in 1988 and a 22 m section divided into 1 m wide plots. The experimental design consisted of a randomised complete block with three replicates. There was a 1 m wide guard at each end and also between each replicate. The six species selected for re-introduction (Table 1) occurred naturally either in nearby ditches or in the nearby Ouse Washes. They were obtained as pot-grown transplants and two plants were planted into the ditch margin, one on opposite sides of each plot, at their preferred depth (see Table 1) on 7 November 1989.

The establishment of each species was recorded, followed by twice yearly assessments to determine growth rate. This was done using a scoring system of 0-3 (where 0 = dead or disappeared, 1 = alive, 2 = growing well and spreading within the plot, 3 = growing very well and spreading outside the plot). The final growth rate score data, assessed on 22 September 1992, was subjected to analyses of variance. The pH of the water in the ditch was recorded once each year. Weather records were taken at a meteorological site 1 km from the experimental ditch site.

RESULTS AND DISCUSSION

All plants, except two of the original six fringed water lilies, survived transplantation and the winter of 1989/90 (temperatures down to -10.0°C) and were growing vigorously on 10 July 1990. *I. pseudacorus* was the most prolific, having begun to spread outside some of the plots after two years and outside all of the plots by the third year (Figure 1). *S. sagittifolia* also spread outside the plots by June 1992. *A. plantago-aquatica* colonised well within their plots and occasionally spread outside, but one disappeared, probably due to a substantial colonisation of the same plot by *T. latifolia*. *B. umbellatus* also colonised their plots well and occasionally spread to adjacent plots.

TABLE 1. Aquatic plant species chosen for re-introduction.

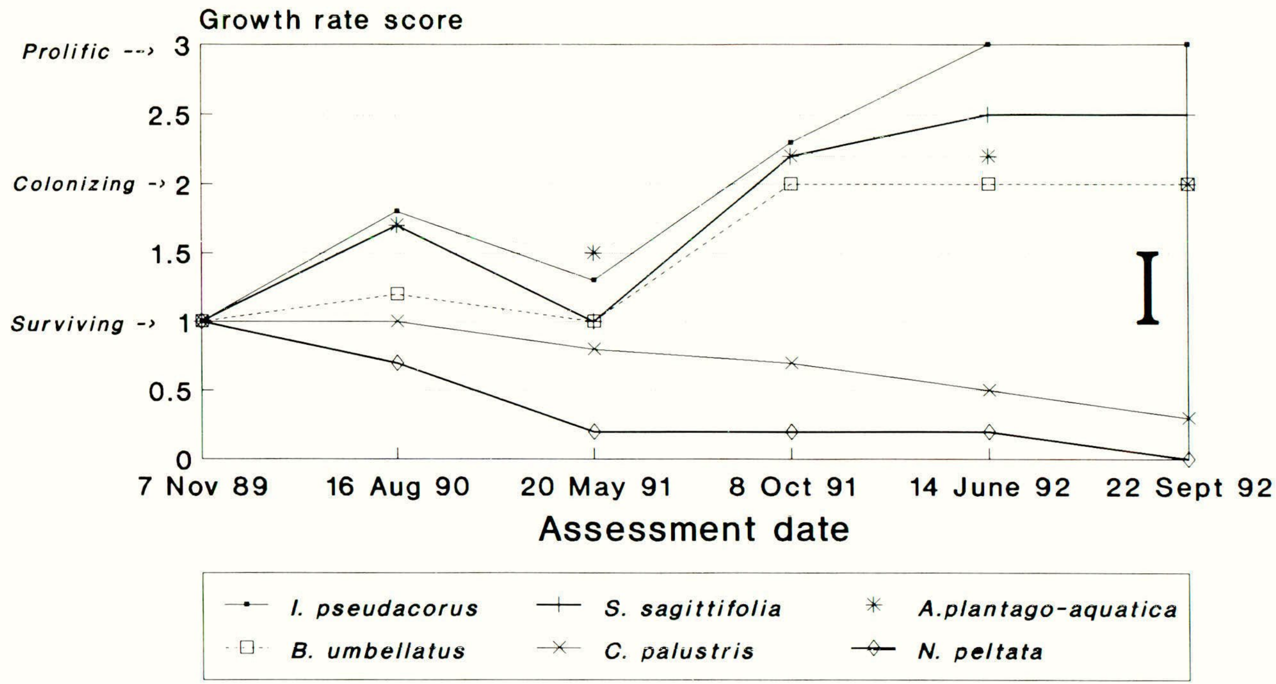
Species	Common English name	Growth habit	Habitat requirement *(Nutrient requirement)	Value to wildlife
Alysma plantago-aquatica	Water-plantain	Submerged emergent (floating)	Shallow margins up to 0.75 m deep. (Eut)	Shelter and perches for invertebrates e.g. dragonflies.
Butomus umbellatus	Flowering rush	Emergent (submerged) (floating)	Shallow margins on clay 0.5-1.5 m. (Eut to mes)	Nesting by wildfowl.
Caltha palustris	Marsh marigold	Emergent	Margins, away from fast flow. (Eut to oli)	Shelter and perches for insects.
Iris pseudacorus	Yellow flag iris	Emergent	Shallow margins at or above water level. (Variable nutrient)	Shelter and perches for invertebrates. Limited for nesting.
Nymphoides peltata	Fringed water lily	Floating submerged	Still to slow water 0.5-3.0 m deep, neutral or alkaline. (Eut)	Shelter and perches for fish and invertebrates, attractive to wildfowl.
Sagittaria sagittifolia	Arrowhead	Submerged floating emergent	Shallow to moderately deep 0.1-1.0 m. Tolerant of low pollution level only. (Eut-mes)	Harbours invertebrates, vegetation eaten by wildfowl.

* Key to Nutrient Requirement

eut - eutrophic, requires an ample supply of nutrients, especially nitrate and/or phosphate.

mes - mesotrophic, requires a moderate supply of nutrients.

oli - oligotrophic, requires a low supply of nutrients. (Haslam *et al.*, 1982; Newbold *et al.*, 1989).



N.B. *Vertical bar represents SE mean (6df) excluding I. pseudacorus and N. peltata.*

Figure 1. Mean score of growth rate of species of aquatic plants introduced into a fenland ditch over a period of three years.

C. palustris and *N. peltata* did not perform well after transplantation. *C. palustris* gradually declined over the three year period until only two plants remained in September 1992. *C. palustris* appeared to have suffered from competition with vigorous species which naturally occurred in the ditch section. These were primarily *J. effusus, T. latifolia* and *A. plantago-aquatica*, all of which had colonised the *C. palustris* plots by September 1992. *C. palustris* may also have been adversely affected by the acidity of the water, the pH of which ranged between 4.0 and 5.0 during the course of the experiment, as they tend to occur more frequently in slightly alkaline water.

N. peltata lacked vigour following transplantation and had disappeared by September 1992 (Figure 1). This species prefers neutral or alkaline water and would have suffered from the levels of acidity recorded. The acidity in this ditch can be related to the fen clay in adjacent soils which itself can have very low pH levels (below 3.0). Some fenland ditches border peat soils over sand and gravel, and have higher pH levels.

Vigorous growth by some dominant competitive species may have been encouraged by nutrients contained in the water. These were recorded as between zero and 17 mg/l for nitrate-N and zero and 7 mg/l for phosphate-P, in a related experiment on a nearby site. It is not known to what extent the growth of each species was influenced by these, or other available nutrients.

The plants would possibly have been more prolific if planted in blocks or clumps so that species which might not survive mixed planting can establish themselves before coming into competition with more vigorous species. This may apply particularly to rhizomatous species, which naturally interlock to form a tough blanket which outcompetes other species (Brooks, 1981). This was possibly one of the contributing factors towards the success of *I. pseudacorus*.

At the end of the experiment, the floristic and amenity value of the ditch had been enhanced by the survival of introduced species which apart from *A. plantago-aquatica,* did not occur naturally in other parts of the ditch following slubbing in 1988.

It was not possible to analyse the data from all six species due to extremes of *I. pseudacorus* and *N. peltata*, which data were not normally distributed, even following transformation. Therefore, the remaining four species only were subjected to analyses of variance. There were no significant differences between *A. plantago-aquatica, B. umbellatus* and *S. sagittifolia*, which all proliferated equally well. There was a significant difference between each of the above three species and *C. palustris*, which colonised relatively poorly.

CONCLUSIONS

The results suggest that *I. pseudacorus, S. sagittifolia, A. plantago-aquatica* and *B. umbellatus* could all be successfully introduced into a newly cleared or species poor ditch of similar condition. The successful establishment of these species provided both a useful habitat for invertebrates such as dragonflies, and shelter and nesting sites for wildfowl and other birds. It would be advantageous to expand the experiment using a range of fenland ditches with a diversity of available nutrients and levels of pH, nutrients and pollution.

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