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Dormant season vegetation management in broadleaved transplants and direct sown ash (*Fraxinus excelsior* L.) seedlings

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Abstract

In northern temperate climates, broad-spectrum contact acting herbicides could be used in the dormant season to remove established herbaceous weeds, and release trees from competition. Unfortunately, there is little published information on broadleaved tree tolerance. In an experiment on open-grown 2-year-old planting stock, 1.1 kg a.i. ha^{-1} paraquat was found to be generally safe to spray over dormant oak (*Quercus robur*), ash (*Fraxinus excelsior*), sycamore (*Acer pseudoplatanus*), cherry (*Prunus avium*), birch (*Betula pendula*), alder (*Alnus glutinosa*), and sweet chestnut (*Castanea sativa*), provided no immature buds, bark, or leaves were present. Survival of these species was unaffected, although there were occasional reductions in subsequent growth. Poplar (*Populus* sp.) and willow (*Salix* sp.) were severely damaged. Growth and survival of dormant beech (*Fagus sylvatica*) transplants were also apparently unaffected. Previous work has suggested that younger seedlings may respond differently than older, larger transplant stock, particularly where seedlings have grown amongst dense weed cover and are less dormant. Hence in a further experiment on 1-year-old container grown ash seedlings kept outdoors, glyphosate and paraquat were applied at two doses as an overall spray in January and before bud-burst in March. None of the treatments had any apparent adverse effects. In a field experiment, plots of ash seedlings were kept weed-free or grown with a natural population of weeds for one season, then paraquat sprayed at five doses (0.4–2.0 kg a.i. ha^{-1}) in late March over the dormant seedlings. Paraquat had no apparent effect on either plant type. First-year weed competition reduced height increment but not survival, although growth recovered once weeds were removed. Seedlings grown in unweeded conditions flushed earlier than those grown in weed-free conditions, potentially making them more susceptible to early spring frosts. This work suggests applications of up to 1.1 kg a.i. ha^{-1} paraquat may be tolerated by dormant ash seedlings grown in open conditions, and this could be a useful treatment for controlling over-wintering weeds in direct sown woodlands, forest nurseries and in natural regeneration situations, where an overstorey of trees is not present.

Keywords: Herbicides; Weed control; Vegetation management; Dormant season; Direct seeding; Paraquat; Glyphosate; *Quercus robur*; *Fraxinus excelsior*; *Acer pseudoplatanus*; *Prunus avium*; *Betula pendula*; *Alnus glutinosa*; *Castanea sativa*; *Fagus sylvatica*; *Populus* sp.; *Salix* sp

1. Introduction

Competition from weeds for light, water and nutrients in forest nursery seedbeds, and in direct sown, naturally regenerating, or transplanted trees on establishment sites in the UK, leads to reduced tree growth and survival (Davies, 1987; Williamson and Morgan, 1994; Willoughby and Clay, 1996; Harmer et al., 2000). This can be a particular problem when trying to establish trees on lowland sites formerly under arable cropping, where seed banks of weed species are large, and soil moisture deficits are common in the summer. Effective post-emergence residual herbicide programmes have been identified for transplants (Willoughby and Clay, 1996), and are being developed for direct seeded trees (Willoughby et al., 2003, 2004a), to maintain weed-free conditions and maximise survival and growth in the first season after planting or sowing.

Recent direct seeding experiments confirm the importance of weed control to minimise tree seedling death and suppression, in particular in the first growing season following germination when root systems are not well developed (Willoughby et al., 2004b). Clay and Dixon (1997) found with poplar (*Populus* sp.) and willow (*Salix* sp.) cuttings that allowing growth of annual weeds in the year of planting but controlling weeds from that point on, had no effect on survival but tree biomass after 4 years was reduced by 60%. By contrast,

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allowing uncontrolled weed growth for 2 years severely reduced both survival and growth of poplar cuttings. In their work the particular weed species present appeared to affect survival, with a dense cover of creeping thistle (*Cirsium arvense* (L.) Scop.) killing more poplar plants than annual weeds. Löf et al. (2004) also found that weed competition in the year of planting affected seedling or transplant growth more than survival.

However, even if the benefits of first year weed control in direct sown seedlings are accepted, given the limited number of safe potential herbicide treatments (Willoughby et al., 2004a) and the expense of alternatives such as hand weeding (Willoughby et al., 2004c), there may be occasions when vegetation is left inadequately controlled at the end of the tree first growing season. Most pre-emergence herbicides control germinating weeds, and to be effective need to be applied to bare soil in the spring. The effect of these residual herbicides often diminishes before the end of the growing season. Hence recommended herbicide regimes often require an end of season clean up of vegetation that develops late in the growing season (Willoughby et al., 2004a). With seedlings planted at regular spacing and the less regularly located seedlings that arise from direct seeding, natural regeneration and some nursery production systems, the application of directed sprays of broad-spectrum contact herbicides to achieve end of season control of established herbaceous weeds can be difficult to achieve safely.

Promising results have been found when using glyphosate, glufosinate-ammonium and paraquat as overall sprays on dormant tree seedlings in the UK. However, selectivity varies with tree species (Willoughby and Clay, 1996), and only a limited range of perennial weed species will have sufficient live, above ground growth, to be susceptible to treatment with contact acting herbicides when trees are dormant. Robinson (1985) reported that many deciduous shrub and tree species can be safely sprayed with glyphosate when dormant, but results may vary with time of application and dose rate (Clay, 1972; Garnett and Williamson, 1992; Stott et al., 1974; Willoughby, 1996). Glufosinate-ammonium can be sprayed after 1 March in the UK (Whitehead, 2004); overall application in March has been found to be safe on broad-leaved species but very damaging on conifers (Willoughby, 1996). Paraquat has been regarded as safe as an overall spray of dormant fruit trees and bushes providing no green wood or buds are present (Fryer and Makepeace, 1978). However, Harmer et al. (2000) found this treatment applied in December caused tip die back of beech (*Fagus sylvatica* L.) seedlings whereas glyphosate was safe. This damaging effect was thought to be due to greater susceptibility of seedlings grown under a canopy of trees and amongst weed vegetation. Dormant poplar and willow coppice have been sprayed with all three herbicides after cut-back with little damage, although treatment when buds were emerging has caused more injury (Parfitt, 1989; Clay et al., 1990; Clay and Dixon, 1996).

These results suggest that there are a number of potentially useful contact herbicide treatments but reasons for occasional damage need investigation. There is also a need to assess whether seedlings subjected to weed competition in their first year are more susceptible to contact herbicide damage than larger plants grown in weed-free conditions. Three experiments were set up to investigate the effects of paraquat or glyphosate on young, dormant broadleaved trees. In the first experiment, 2-year-old transplants of 10 broadleaved species grown in open conditions in a nursery were treated with paraquat at three doses and three timings in the dormant season. The second experiment examined the effect of two rates of glyphosate or paraquat applied at two dates in the dormant season on smaller, 1-year-old, pot-grown ash (*Fraxinus excelsior* L.) seedlings. In the final experiment, paraquat was applied at five doses to dormant 1-year-old direct-sown ash seedlings in March, established in either unweeded or weed-free conditions to give trees of varying size and vigour.

2. Materials and methods

2.1. Experiment 1

In the autumn of 1997, 2-year-old transplants of oak (*Quercus robur* L.), ash and beech, and 1-year-old undercut transplants of sycamore (*Acer pseudoplatanus* L.), cherry (*Prunus avium* L.), birch (*Betula pendula* Roth), alder (*Alnus glutinosa* (L.) Gaertn.), sweet chestnut (*Castanea sativa* Mill.), and unrooted cuttings of poplar and willow, were planted into a weed-free transplant bed at Headley Research Nursery, UK (51°08′N, 1°51′W), a site which receives an annual average of 804 mm of rainfall and 1798 growing degree days (above 4 °C). Soil type according to Mackney et al. (1983) was a humic–ferric podzol, Shirrell Heath 1 series. A pH of 5.5 was maintained by liming before planting.

Three herbicide treatments and a control were applied at three dates, arranged in two randomised blocks, giving 24 plots in total per species. This gave nine treatment combinations, plus a control, each repeated three times per block. Each species plot consisted of 10 trees at 10 cm spacing, and 10 species plots made up a treatment plot, with a 1.5 m buffer between treatment plots. A base dressing of 200 kg ha^{-1} 0:24:24 ($N:P_2O_5:K_2O$) fertiliser was applied before planting, and three top dressings of 100 kg ha^{-1} 25:0:15 ($N:P_2O_5:K_2O$) fertiliser were applied during the growing season, with 6 mm of irrigation being applied over 2 h if no rainfall occurred within 24 h of the application. Paraquat (Gramoxone 100; 200 g a.i. l^{-1} SL; Syngenta) was applied at one of three rates, 0.6, 1.1 or 2.2 kg a.i. ha^{-1} (recommended application rates for weed control in forestry using paraquat are usually between 0.6 and 1.1 kg a.i. ha^{-1}; Syngenta, 2002). Applications were made on three dates, 26 November 1997, 29 December 1997, and 12 March 1998 using a Cooper Pegler CP3 Knapsack Sprayer fitted with a green nozzle, giving an output of 1200 ml a minute at a pressure of 100 kPa and a volume rate of 200 l ha^{-1}. Treatments were carried out in dry, frost-free conditions. All trees appeared to be dormant at the first two application dates. For the final application in March, a few trees in some species had started to flush—the state of dormancy at this final spray date is given in Table 1.