

Experiment 1.2.

To increase the abundance and availability of plant species, such as spring germinating weeds, and associated invertebrates.

Materials and methods

The study was carried out at three ADAS sites representing a range of soil types over three years (Table 1), moving to a different field each year. The study combined a range of herbicide treatments with three row space/cultivation treatments in a factorial design. The experiment was a completely randomised design except at BX in 2005 where the study was a split plot design with herbicide treatments nested within spacing/cultivation treatment. Herbicide treatments were different at Boxworth to those at Gleadthorpe and High Mowthorpe reflecting the different weed communities. In the first year, a larger number of herbicide treatments were studied than in the following years. The results from the first year were used to refine the treatment list with the most interesting treatments chosen for the following two years of the trial. For simplicity, only those treatments which were applied in all three years have been included in the analyses presented here. At Boxworth two of the 2003 treatments were different to subsequent years and in 2004/5 clodinafop-propargyl was applied to all treatments to control grass weeds (Table 2). The spacing/cultivation treatments were: conventional spacing (Conv), wide spaced rows (WSR) and wide spaced rows with a spring cultivation after spring herbicide application (WSR+Cult). Wide spaced rows were drilled by blocking off every other coulter, but the overall seed rate was the same as for Conv. In the first year there were three replicates of each treatment. This was increased to five in subsequent years. Plots were three or four metres wide by 24 m long.

Table 1 Summary of site details.

Site	Soil type	Row width Conv/WSR (cm)	No. of herbicide treatments	Plot width (m)
Boxworth	clay	12/24	8	3
Gleadthorpe	sand	12/24	7	4
High Mowthorpe	chalk	12/24	7	3

The range of herbicide treatments applied included 'untreated', 'full weed control' and a range of pre-emergence, post-emergence and spring herbicides which were applied in combination or individually (Table 2 & Table 3). Details of products used and target weed species are presented in Table 4. Generally products were applied at manufacturers recommended rates. The exception was at Boxworth where pendimethalin + flufenacet was applied both at full rate and at 75% full rate in combination with clodinafop-propargyl. Full details of crop management are presented in Appendix 1.

At High Mowthorpe *Avena* spp. were removed from plots by hand in June 2003.

Table 2 Herbicide treatments applied at Boxworth¹.

Pre-em. herbicide	Post-em. herbicide	March herbicide
pendimethalin + flufenacet	flupyr-sulfuron-methyl	amidosulfuron

pendimethalin + flufenacet @ 75% recommended rate	flupyr-sulfuron-methyl	
pendimethalin + flufenacet	flupyr-sulfuron-methyl	
pendimethalin + flufenacet	flupyr-sulfuron-methyl	amidosulfuron
pendimethalin + flufenacet	flupyr-sulfuron-methyl	amidosulfuron

¹Topik applied post-emergence to all treatments in 2004 and 2005. In 2004 clodinafop-propargyl @ 125 ml ha⁻¹ + Toil adjuvant @ 1 l ha⁻¹. In 2005 clodinafop-propargyl @ 125 ml ha⁻¹ + Fortune adjuvant @ 0.75 l ha⁻¹.

² 2003 treatment included Ally/Starane in April/May, not Eagle in March.

³ 2003 treatment included a pre-emergence application of Avadex.

Table 3 Herbicide treatments applied at Gleadthorpe and High Mowthorpe.

Pre-em. herbicide	Post-em. herbicide	March herbicide
diflufenican + trifluralin	diflufenican + isoproturon	amidosulfuron
	diflufenican + isoproturon	amidosulfuron
	diflufenican + isoproturon	florasulam
	diflufenican + isoproturon	mecoprop-p

Table 4 Weeds controlled and products applied.

Active ingredients	Target weeds	Product
pendimethalin + flufenacet	grasses + dicots including <i>Galium aparine</i>	Crystal
flupyr-sulfuron-methyl	dicots + <i>Alopecurus myosuroides</i>	Lexus
amidosulfuron	<i>Galium aparine</i> + other dicots	Eagle
clodinafop-propargyl	<i>Alopecurus myosuroides</i> + <i>Avena</i> spp.	Topik
clodinafop-propargyl + trifluralin	<i>Alopecurus myosuroides</i> , <i>Avena</i> spp., dicots	Hawk
diflufenican + trifluralin	<i>Poa annua</i> + dicots including <i>Galium aparine</i>	Ardent
diflufenican + isoproturon	grasses + dicots including <i>Galium aparine</i>	Panther
florasulam	grasses + dicots including <i>Galium aparine</i>	Boxer
mecoprop-p	<i>Stellaria media</i> , <i>Galium aparine</i> + other dicots	CMPP-p

Assessments

Agronomy

Disease monitoring

Disease was assessed on untreated plots in mid-late June, but earlier if leaf 4 was greater than 50% dead. Percentage infection of each disease and green leaf area were assessed on leaves 1, 2 and 3 separately on mainstems or tillers. This was done at 10 stops per plot. Any field scale disease problems were recorded if patchy in nature. Where stem base diseases such as eyespot or takeall were present 25 tillers were taken from each plot.

Number of fertile tillers

Numbers of fertile tillers were assessed per plot either side of 5 x 0.5m lengths of row per plot.

Crop yield

Plots were taken to yield and harvested using a plot combine. A sample of grain was assessed for moisture content, thousand grain weight (TGW) and specific weight (Spwt) in the laboratory.

Trash levels in harvested seed

After experiencing high levels of trash in the 2004 harvest year the protocol for the final year was amended. If there were high levels of weeds in the sample from the plots untreated with herbicide then a sample of grain from each harvested plot was assessed for level of trash.

Other records

A field diary containing site and input details was recorded

Vegetation

Vegetation was monitored on one occasion in late June to assess the overall effects of the treatments. Five randomly positioned 0.25 m² quadrats (0.5 x 0.5 m) were sampled on each plot. Percent cover of each weed species was recorded plus crop, bare ground (viewed from below the canopy), bare ground (viewed from above the canopy) and litter. Cover was recorded in the following categories, with the midpoint value used for analysis: 0-1%, >1-2%, >2-5%, >5-10%, >10-20%.....>90-100%. Total plant cover could sum to more than 100% because vegetation is present at different heights in the canopy.

In order to estimate food resources available to other groups, reproductive status of each species was recorded using the following categories: vegetative growth only, flower shoots and buds present, flowering, seeds present/dehiscing. These categories were recorded at proportions of 1-25%, 26-50%, 51-75% and 76-100%.

To obtain an estimate of potential seed availability as a food source over the autumn and winter, seed production was assessed pre-harvest in late July in a subset of herbicide treatments under conventional spacing (BX: a 'untreated', h 'full weed control', b 'pre-em only', d 'spring only'; GT & HM: a 'untreated', d 'spring only' g 'post-em followed by spring' NB. different spring herbicide in 2003). Three randomly located 0.25 m² quadrats were sampled per plot and samples bulked. All weed vegetation was removed from the quadrats and recently shed seeds were sampled from the soil surface using a portable vacuum. In the laboratory, seeds were separated from vegetative matter by hand, identified and counted. Seeds were extracted from the soil surface sample by washing the soil through a 500 µm mesh sieve to remove the fine soil particles followed by floating off the organic matter using a saturated solution of CaCl₂. Seeds were then removed from other organic matter by hand under ×2 magnification, identified and counted. Seed numbers of both mature seed (assumed to be viable) and immature seed were assessed. Because sampling was carried out before harvest, some of the immature seed would have become viable before the vegetation was cut. Also, immature seed may still form a potential food source for other species.

This assessment of seed production will not represent total seed production through the season. Some seed shed before sampling would have become incorporated into the soil and some would already have been taken by granivorous species. However,

this approach will indicate the potential food source available to other species after harvest.

Invertebrates

Arthropods were sampled using a Dvac suction sampler, between 2 and 7 days after vegetation sampling. In each site/year a subset of treatments were sampled based on preliminary vegetation data in order to sample the most potentially interesting treatments. One sample was collected from each plot consisting of five sub-samples of ten seconds each. Samples were identified to family.

4.2.4.3 Statistical analysis

Each site/year was initially analysed separately, followed by an across year analysis where treatments (or a subset of treatments) were identical. Percent cover data (vegetation) were angular transformed and count data (seeds and arthropods) were $\log_{10}(x+1)$ transformed prior to analysis. Data for species richness (number of species per plot) were not transformed. Data was analysed using a two factor analysis of variance to determine the effects of herbicide treatment, spacing/cultivation treatment and any interaction between them. Analysis of contrasts was used to compare:

- conventional spacing vs wide spaced rows
- wide spaced rows vs wide spaced rows + cultivation

Where there was no interaction between treatments, the interaction term was dropped from the model and the data reanalysed to include analysis of all pairwise comparisons of herbicide treatment means using Duncan's multiple range test.

Seed data was collected only from the conventional spacing treatment, therefore a one factor analysis of this data was carried out. Seed data were analysed both as 'viable' and 'total'. All analyses were carried out using General Analysis of Variance (ANOVA) with blocks specified as 'block'. All analyses were carried out using Genstat 8.1, 2005, Lawes Agricultural Trust.

Plant species were classified in groupings relating to their desirability with respect to both agronomic issues and biodiversity benefits (in terms of benefits to birds and invertebrates) (Table 5) and also as grasses or broad-leaved species. Desirability groupings were also combined into all desirable species (Group 1 + Group 2; named 'Groups12') and all neutral/desirable species (Group 1 + Group 2 + Group3; named 'Groups123'). Unless numbers were very low, all these groupings were analysed, plus crop, litter, bare ground cover and total weed cover (sum of all individual species). For each site/year, a small number of common species were analysed as individual species.

Table 5 Plant groupings relating to the desirability with respect to both agronomic issues and biodiversity benefits.

Very desirable (Group 1)	Desirable (Group 2)	Undesirable (Group 4)
<i>Chenopodium album</i>	<i>Cerastium</i> spp.	<i>Alopecurus myosuroides</i>
<i>Fallopia convolvulus</i>	<i>Fumaria officinalis</i>	<i>Anisantha</i> spp.
<i>Poa annua</i>	<i>Matricaria discoides</i>	<i>Avena</i> spp.
<i>Persicaria lapathifolia</i>	<i>Matricaria recutita</i>	<i>Bromus</i> spp.
<i>Persicaria maculosa</i>	<i>Tripleurospermum inodorum</i>	<i>Cirsium arvense</i>
<i>Polygonum aviculare</i>	<i>Senecio vulgaris</i>	<i>Elytrigia repens</i>

<i>Raphanus raphanistrum</i>	<i>Sonchus spp.</i>	<i>Galium aparine</i>
<i>Sinapis arvensis</i>	<i>Viola arvensis</i>	<i>Lolium spp.</i>
<i>Stellaria media</i>	<i>Viola tricolour</i>	Rumex obtusifolius
		Volunteers

Group 3 = Neutral species, considered neither particularly desirable nor undesirable.

Invertebrates were analysed as both taxonomic groups (Table 6) and six functional groupings (Table 7) plus total arthropods.

Table 6 Invertebrate taxonomic groups for analysis.

Order	Sub-order	Family	Common name	Life stage
Araneae			Spiders	Adult
Opiliones			Harvestmen	Adult
Hemiptera	Homoptera		Hoppers	Adult
Hemiptera	Heteroptera		True bugs	Adult
Neuroptera			Lacewings	Larvae
Lepidoptera			Butterflies and moths	Larvae
Coleoptera		Carabidae	Ground beetle	Adult
		Staphylinidae	Rove beetes	Adult
		Cantharidae	Soldier beetle	Adult
		Elateridae	Click beetle	Adult
			Other beetles	Adult
Diptera	Nematocera	Tipulidae	Cranefly	Adult
	Other		Gnats, mosquitos and midges	Adult
	Nematocera		Hoverfly and horsefly	Adult
	Brachycera		Flies	Adult
	Aschiza		Flies	Adult
	Acalypterae		Flies	Adult
	Calyptera		Fly larvae	Larvae
			Total number of flies	All
			Total number of beetles	All
			Total number of invertebrates	All

Table 7 Invertebrate composite variates for analysis.

Composite variate	Components
Nectar feeders	Aschiza, Elateridae, Lepidoptera (adults)
Herbivores	Homoptera, Orthoptera, Symphyta larvae, Lepidoptera larvae, Curculionidae, Chrysomelidae
Omnivore/mixed	Heteroptera, Nematocera, Carabidae, Staphylinidae, Acalyptera, Calyptera
Predators	Bracycera, Cantharidae, Neuroptera larvae
CFI	Homoptera, Heteroptera, Aphids, Neuroptera larvae, Lepidoptera larvae, Carabidae, Curculionidae, Symphyta larvae, Elateridae
Skylark Food	Araneae, Opiliones, Homoptera, Hemiptera, Neuroptera, Lepidoptera, Carabidae, Staphylinidae, Cantharidae, Elateridae, Tipulidae