School of Biology

AGROFORESTRY RESEARCH GROUP

Agroforestry Experiment AF2 - Silvoarable with Poplar

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University of Leeds
School of Biology

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Background

During the 1970s Bryant and May made extensive plantings of hybrid poplar in Southern England at the standard spacing for poplar of 8 m x 8 m. The trees were for the production of matches, and the strips of land between them were cropped on a 2-year rotation, alternating wheat and bare fallow in such a way that, in any given year, one side of a row of trees was under wheat and the other in fallow. In the early years of the plantation this cropping pattern gave some cash income from the crops, with the fallow strips allowing for easy management of the system. Before the trees had time to reach maturity, however, the company changed its timber procurement policy, sold the land, and allowed the trees to be removed.

Current over-production of food in the EC, the need for more home-produced timber and the availability of modern fast-growing and disease-resistant Belgian poplar hybrids have recently rekindled interest in silvoarable agroforestry with poplar.

The UK Silvoarable Network experiment at the University of Leeds

This experiment, partly financed by MAFF, is one in a set of three replicates of one experiment, the other two being run by the Cranfield University at Silsoe College and the Royal Agricultural College at Cirencester. Instead of the 8 m x 8 m between trees in the Bryant and May system, these trials have a rectangular spacing with 10 m between rows and 6.25 m between trees within the rows. While giving the same number of trees per hectare, the 10-m row spacing allows an agriculturally more practical 8-m arable cropping alley between the trees.

The basic purpose of the experiment is to test the effects of the trees on the arable yields and the effects of the arable crop on tree growth. To this end and until 1999 there were four cultivation treatments:

1) Arable cropping of alleys on both sides of a tree row every year;

2) Bare fallowed alleys on both sides of a tree row each year;

3) Crop and fallow on alternate sides each year as described above for the Bryant and May system;

4) A conventionally and continuously cropped control area without trees to the west (prevailing wind) side of the silvoarable treatments.

All cropped arable areas have the same cereal or pulse crop and receive the same husbandry in any one year, and the yields of all three relevant treatments are measured.

Superimposed upon and factorially combined with these three silvoarable cultivation treatments are sub-plots consisting of four different poplar hybrids - Beaupré, Gibecq, Trichobel and Robusta (see plan overleaf). The first three cultivars are modern Belgian clones, and Robusta is a spontaneous hybrid that appeared in France in the last century, which has been widely planted since, and which serves as the control variety in this trial. The heights and girths of the trees are now measured every year.

In 1999, a new experimental phase was begun. The alternate treatment 3 above was converted to continuous cropping on both sides of the tree row. A new set of treatments were applied to the tree rows in autumn 1999, following removal of the plastic mulch strips:
1) vegetated: sown sward of cocksfoot, red fescue, and timothy grasses and white clover;
2) bare, no vegetation, maintained bare by herbicide.

The new combinations of arable and understorey treatments are:
1) continuous cropping on both sides of the tree row, vegetated understorey;
2) continuous fallow on both sides, vegetated understorey;
3) continuous cropping on both sides, bare understorey.
These combinations allow the original comparisons of effects of trees on crops and crops on trees to be continued.

The objective for the period from 1999 to 2003 was to use the new treatments to:
1) assess the effect of silvoarable agroforestry on biodiversity as measured by the presence and species composition of the carabid beetle fauna;
2) assess the effect of a vegetated understorey on growth of established trees;
3) assess the effect of different understorey treatments on the spectrum and incidence of weeds in the adjacent crop by botanical observations.

DEFRA funding of the project ended in 2003.

22/04/05

EXPERIMENTAL DESIGNS

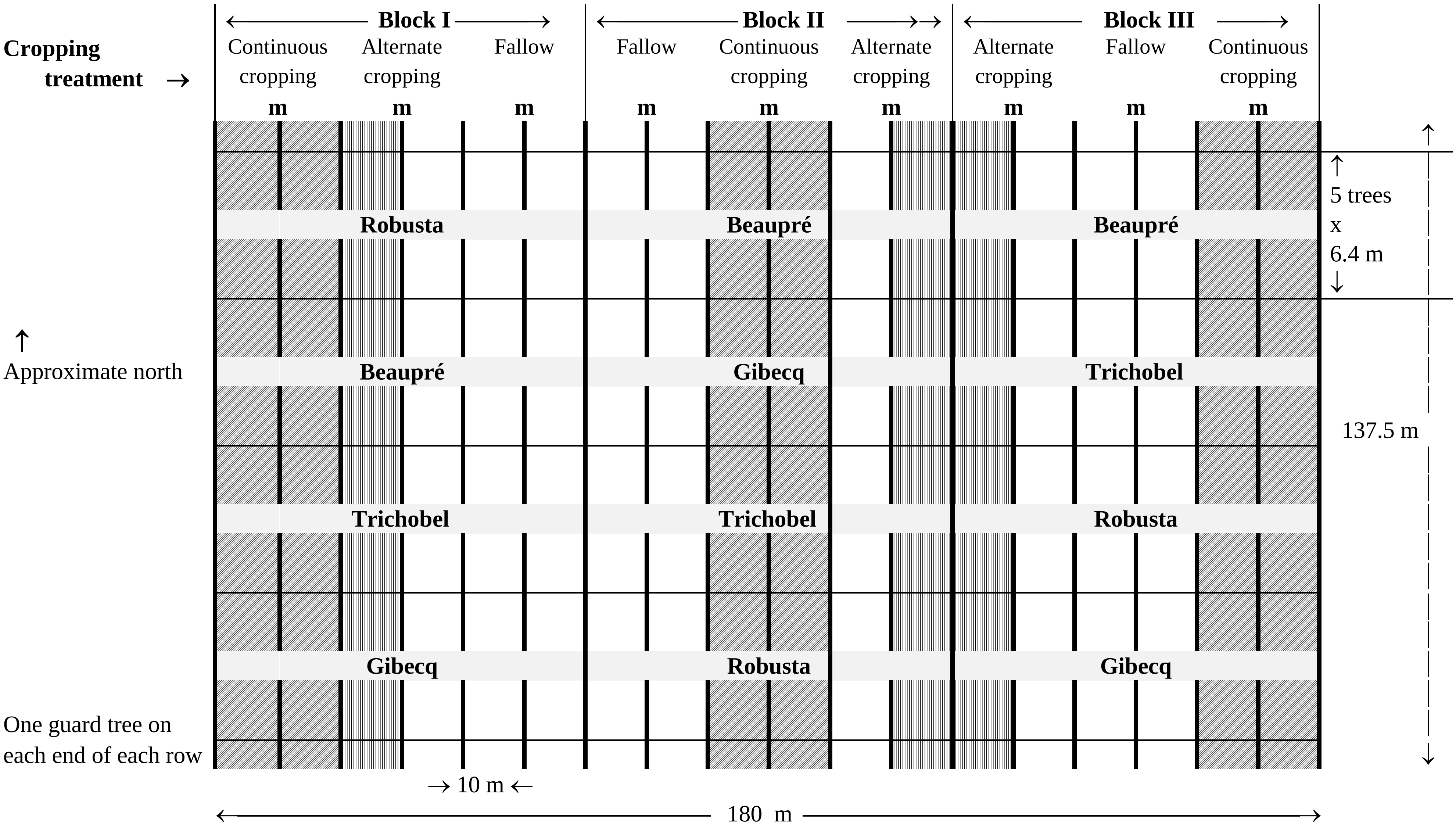
The following three figures show

Figure 1. The field plan pre-1999 with three arable alley treatments - continuously cropped, continuously fallow, and alternately cropped and fallow, and one understorey treatment – plastic mulch with no vegetation between mulch and crop. (page 3)

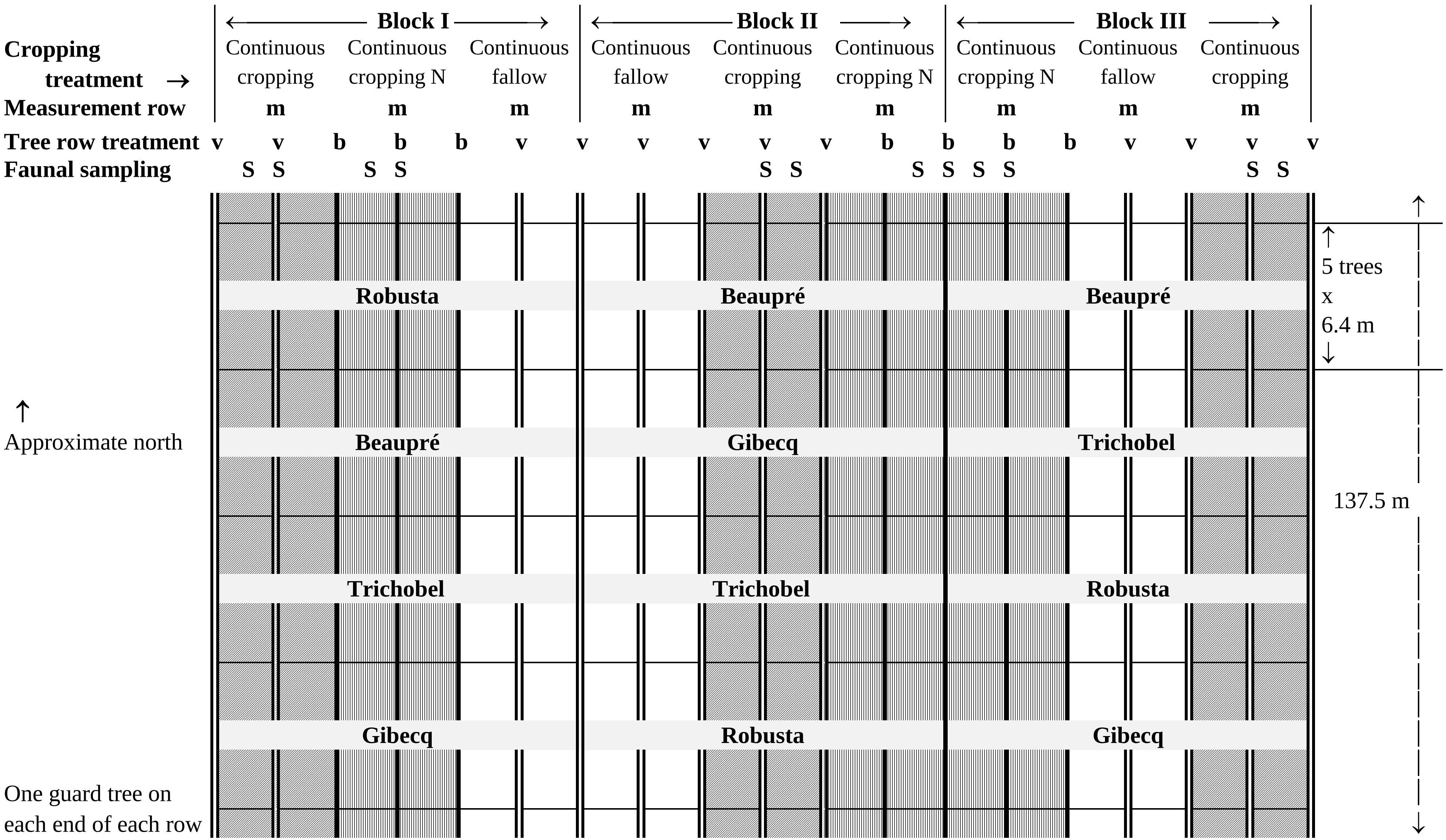
Figure 2. The field plan post-1999; with two arable alley treatments - continuously cropped and continuously fallow, and two tree-row understorey treatments – bare ground and vegetated. (page 4)

Figure 3. The faunal sampling plan, also post-1999. (page 5)

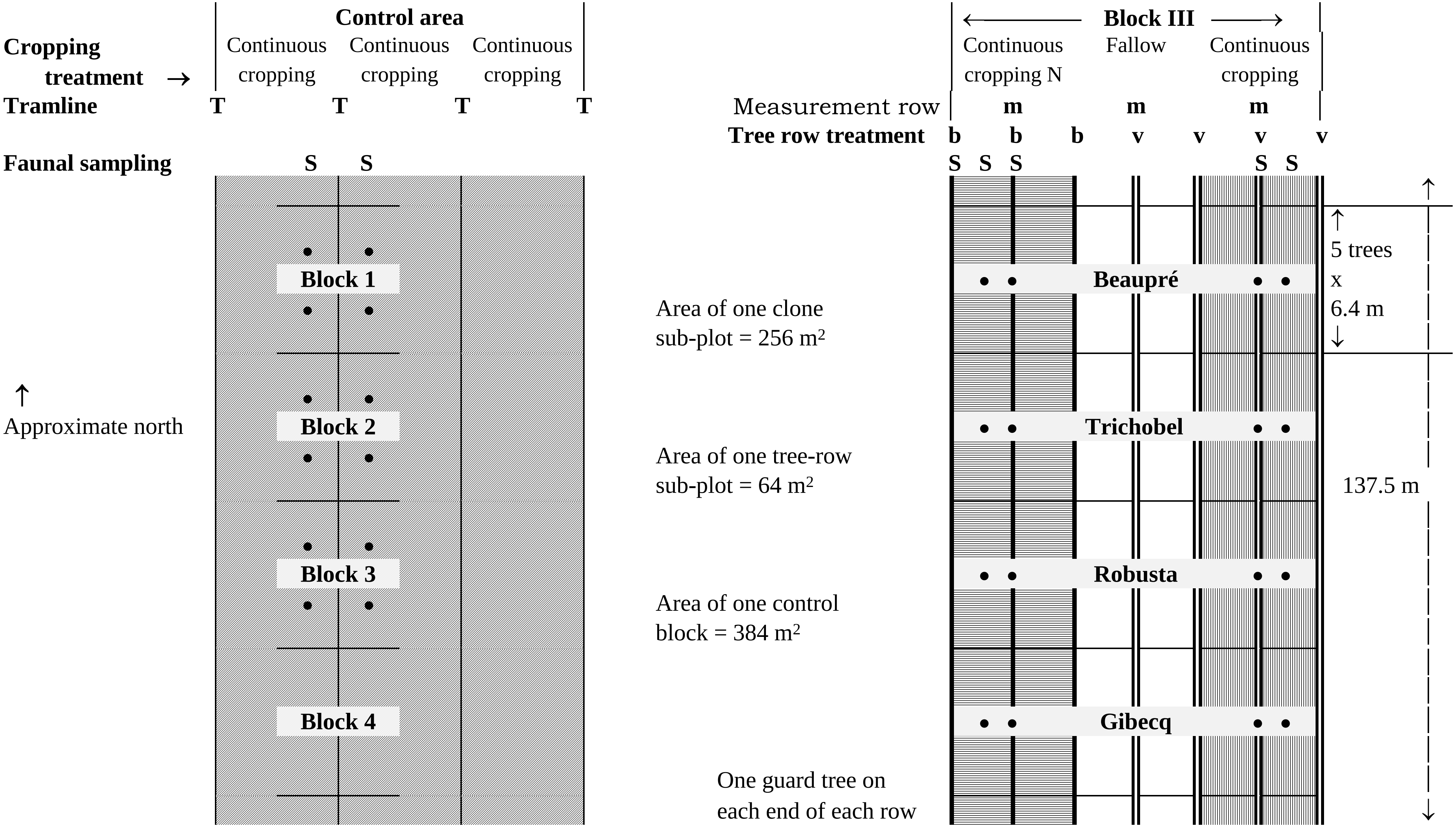
Silvoarable with Poplar – Field Plan pre-1999: All thick vertical lines represent rows of trees of which those marked **m** are measurement rows. Unshaded alleys are either permanent fallow or fallow alternating with crop; shaded alleys are either permanently cropped or crop alternating with fallow.



Silvoarable with Poplar – Field Plan post-1999: Rows marked **v** have sown and managed herbaceous vegetation in the understorey; rows marked **b** have bare earth. N = new treatment. Faunal sampling takes place in alleys and tree rows marked by **S**.



Silvoarable with Poplar – Faunal Sampling Plan: Schematic plan of part of the experimental design showing only one block of the agroforestry area. **T** represents the position of tramlines in the control area. **S** = position of faunal samples, • = pitfall trap (Note : pitfall traps in the first non-measurement row (not shown) will be in the same line across the plot).



SOME RESULTS

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METEOROLOGICAL DATA

Table 1. Summary of annual rainfall and the mean air temperature at the three sites for the period from 1992 to 2002 inclusive and for 2001 and 2002.

Period	Site					
	Cirencester		Leeds		Silsoe	
	Annual rainfall (mm)	Mean air temperature (°C)	Annual rainfall (mm)	Mean air temperature (°C)	Annual rainfall (mm)	Mean air temperature (°C)
2001	812	9.8	590	9.0	787	10.1
2002	964	10.4	765	9.8	659	10.9
Mean 92-02	860	9.9	666	9.5	662	10.2

EFFECTS OF POPLAR CLONE AND ARABLE TREATMENT ON HEIGHT AND DIAMETER OF TREES

1. Effect of poplar clone

Table 2. Mean height (m) and b) mean diameter (cm) of each poplar clone across the three cropping treatments during the winters of 98/99 and 01/02 and the mean for the three sites combined.

a) Height

Hybrid	Site						Mean	
	Cirencester		Leeds		Silsoe			
	98/99	01/02	98/99	01/02	98/99	01/02	98/99	01/02
Beaupré	12.5 [a]	15.3[a]	11.2 [a]	15.4[a]	12.1 [a]	17.7[a]	11.9 [a]	16.1[a]
Trichobel	10.4 [b]	14.4[ab]	9.3 [b]	13.4[b]	9.6 [b]	14.5[b]	9.8 [b]	14.1[b]
Robusta	9.8 [bc]	13.4[b]	8.6 [b]	12.6[bc]	9.7 [b]	14.3[b]	9.4 [bc]	13.5[c]
Gibecq	9.1 [c]	11.9[c]	7.6 [c]	11.7[c]	10.0 [b]	13.6[b]	8.9 [c]	12.5[d]
Mean	10.4	13.7	9.2	13.3	10.4	15.0	10.0	14.0

Note: Within each column, numbers followed by the same superscript letter are not significantly different (at P=0.05).

b) Diameter

Hybrid	98/99	01/02	98/99	01/02	98/99	01/02	98/99	01/02
Beaupré	18.3[a]	21.8[a]	19.9 [a]	24.2[a]	18.4 [a]	25.2[a]	18.9 [a]	23.7[a]
Trichobel	16.3[b]	22.7[a]	17.5[b]	23.2[a]	14.1[c]	20.8[b]	16.0[b]	22.3[b]
Robusta	14.1[c]	19.1[b]	15.9[bc]	20.4[b]	14.2[bc]	20.8[b]	14.8[c]	20.0[c]
Gibecq	13.8[c]	18.3[b]	15.7[c]	19.8[b]	15.4[b]	20.5[b]	15.0[c]	19.7[c]
Mean	15.7	20.5	17.3	21.9	15.5	21.8	16.2	21.4

2. Effect of arable treatment

Table 3. Mean height (m) and b) mean diameter (cm) of the four poplar clones across each of the three cropping treatments at each site during the winters of 98/99 and 01/02 and the mean for the three sites combined

a) Height

Treatment	Cirencester		Leeds		Silsoe		Mean	
	98/99	01/02	98/99	01/02	98/99	01/02	98/99	01/02
Fallow	11.1^{a}	14.6^{a}	9.7^{a}	13.7^{a}	11.1^{a}	15.6^{a}	10.6^{a}	14.6^{a}
Alternate[1]	10.6^{b}	13.8^{ab}	9.4^{a}	13.5^{a}	10.1^{b}	15.1^{b}	10.0^{b}	14.1^{b}
Cropped	9.7^{c}	12.9^{b}	8.8^{b}	12.8^{b}	9.9^{b}	14.4^{c}	9.5^{c}	13.4^{c}
Mean	10.4	13.7	9.2	13.4	10.4	15.0	10.0	14.0

b) Diameter

Treatment	98/99	01/02	98/99	01/02	98/99	01/02	98/99	01/02
Fallow	17.9^{a}	23.1^{a}	19.0^{a}	23.9^{a}	17.4^{a}	23.9^{a}	18.0^{a}	23.5^{a}
Alternate[1]	15.8^{b}	20.5^{b}	17.8^{b}	22.2^{b}	15.1^{b}	21.6^{b}	16.2^{b}	21.4^{b}
Cropped	13.3^{c}	17.9^{c}	15.6^{c}	20.4^{c}	14.0^{c}	20.1^{c}	14.3^{c}	19.5^{c}
Mean	15.7	20.5	17.3	22.2	15.5	21.9	16.2	21.4

Note: Within each column, numbers followed by the same superscript letter are not significantly different (at P = 0.05).

[1]: Since autumn 1999, the alternately-cropped treatment has been continuously cropped with a bare understorey.

CROP YIELDS

Table 4. Mean yields (t ha^{-1}) of the wheat crops in the control area, the continuously-cropped area and what was the alternately-cropped area in the silvoarable system at each site for 1999 to 2002, expressed in terms of the cropped area. The values in brackets express the yield as a proportion (%) of the control.

			Treatment							
Site	Year	Crop	Control		Continuous			Alternate		
Cirencester	1999	Winter beans	-		-			-		
	2000	Winter wheat	4.10	a	3.60	b	(88)	3.69	b	(90)
	2001	Spring wheat	4.19	a	3.10	b	(74)	3.12	b	(74)
	2002	Winter barley	5.38	a	2.02	c	(38)	2.72	b	(51)
Leeds	1999	Winter barley	5.63	a	5.50	b	(98)	6.40	a	(114)
	2000	Winter wheat	6.55	b	6.04	c	(92)	7.04	a	(107)
	2000	Winter wheat	*8.97*[2]	*a*	*6.04*	*c*	*(67)*	*7.04*	*b*	*(78)*
	2001	Winter wheat	6.38	a	4.70	b	(74)	4.00	c	(63)
	2002	Winter barley	7.86	a	5.39	b	(69)	5.28	b	(67)
Silsoe	1999	Spring wheat	3.42	a	2.64	b	(77)	2.19	c	(64)
	2000	Winter wheat	4.53	a	4.49	a	(99)	4.29	b	(95)
	2001	Bare fallow	0.00		0.00			0.00		
	2002	Winter barley	4.21	a	2.96	b	(70)	2.58	c	(61)

Note: Yields followed by the same letter are not significantly different for that year and site.

[1]: In 2000, 2001 and 2002, the alternately-cropped treatment has been continuously-cropped with a bare understorey.

[2]: This control yield is taken from a separate faunal control area.

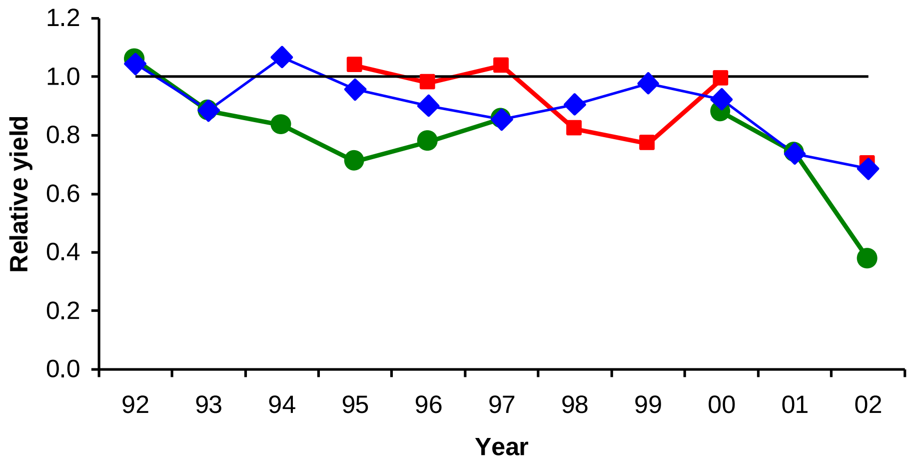


Figure 4. Effect of age of trees on the crop yield in the continuously-cropped alleys relative to control yields at Cirencester: ●, Leeds: ◆, and Silsoe: ■.

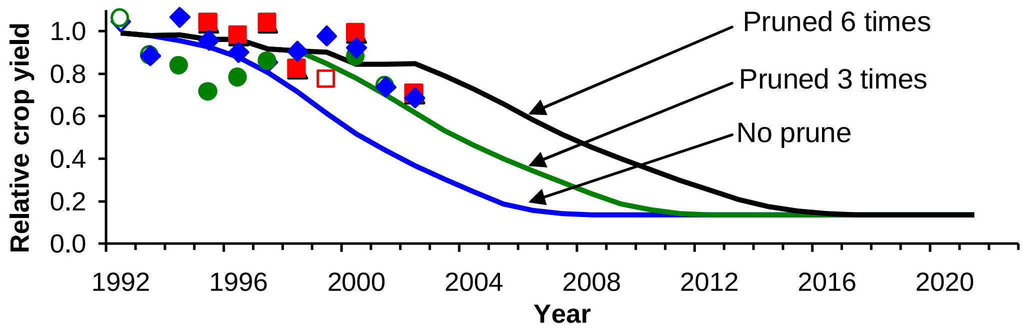


Figure 5. The predicted effect of pruning on crop yields relative to that of a sole crop with trees of a yield class of 9 (assuming an LAI = 4 and a light extinction coefficient = 0.5). Actual relative yields at each of the three sites in each year: winter crop at Cirencester ●; spring crop at Cirencester: ○; winter crop at Leeds ◆; spring crop at Leeds: ◇; winter crop at Silsoe: ■; spring crop at Silsoe: □.

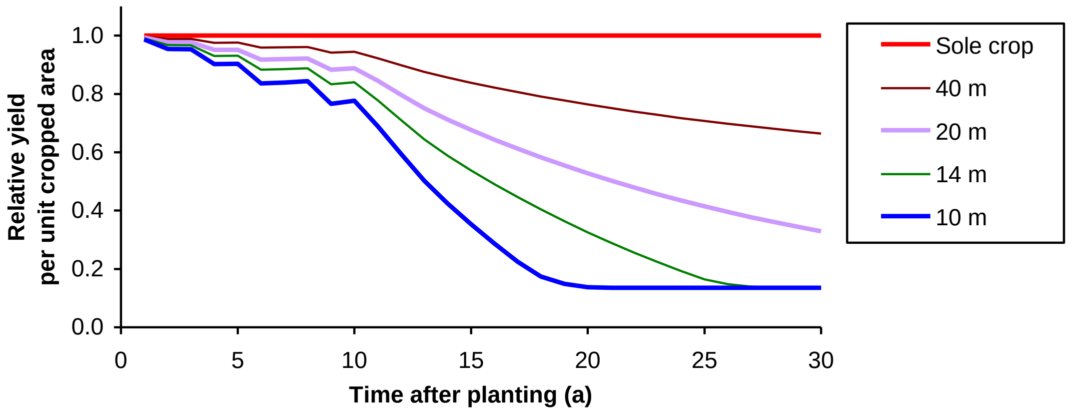


Figure 6. Predicted effect of alley width on the relative yield of the arable crop with trees of yield class 14 in the tree rows.

MANAGEMENT OF THE TREE ROW UNDERSTOREY

Table 5. Number of plant species (including crop) per square metre in the arable control area, in alleys subtending vegetated tree rows, and alleys subtending bare tree rows on two sampling occasions in 2000, 2001 and 2002 at Leeds. Values are means (n = 24).

Treatment	2000		2001		2002	
	Apr-May	June	Mar-May	Jun-Jul	Mar-May	Jun-Jul
Arable control	3.3 a	4.0 a	2.6 a	1.5 a	1.1 a	2.0 a
Alley by vegetated understorey	3.8 ab	6.6 b	3.8 b	3.3 b	3.3 c	5.6 b
Alley by bare understorey	4.2 b	4.0 a	2.5 a	2.5 b	2.2 b	5.2 b

Table 6. The cover (%) of non-crop species in the arable control area, alleys subtending vegetated tree rows, and alleys subtending bare tree rows on two sampling occasions in 2000, 2001 and 2002 at Leeds. Values are sums of means (n = 24).

Treatment	2000		2001		2002	
	Apr-May	June	Mar-May	Jun-Jul	Mar-May	Jun-Jul
Arable control	2.2 a	16.9 ab	4.0 a	1.0 a	0.1 a	5.1 a
Alley by vegetated understorey	2.5 a	21.5 b	4.3 a	10.5 c	3.2 c	21.2 c
Alley by bare understorey	4.0 b	15.2 a	3.2 a	4.6 b	1.1 b	10.0 b

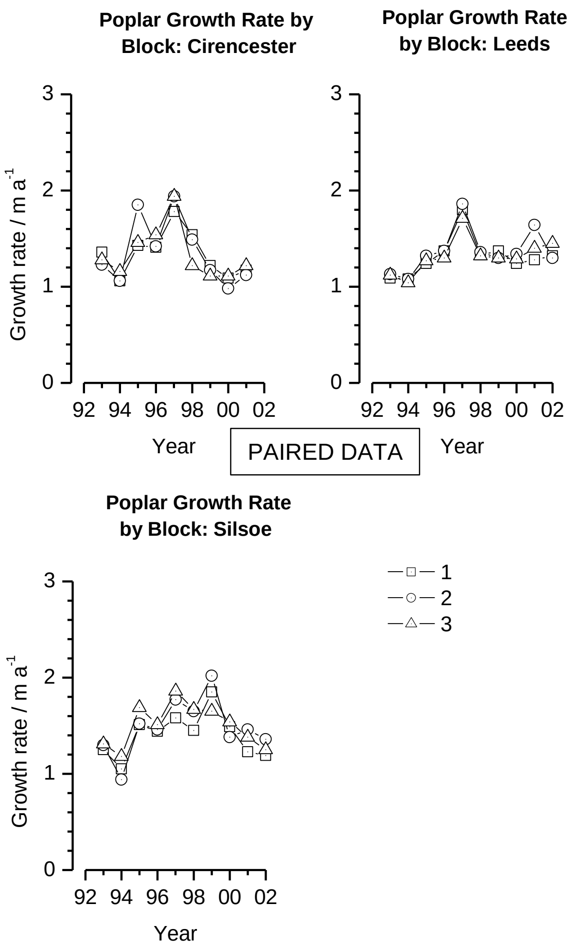
Table 7. The cover (%) of crop and selected non-crop species in the arable control area, alleys subtending vegetated tree rows, and alleys subtending bare tree rows between June and July in 2000, 2001 and 2002 at Leeds. Values are means (n = 24).

	2000			2001			2002		
	Arable	Alley next to		Arable	Alley next to		Arable	Alley next to	
	control	veg. tree-row	bare tree-row	control	veg. tree-row	bare tree-row	control	veg. tree-row	bare tree-row
Wheat	**70**	55	62	**62**	60	61			
Barley							**75**	54	60
Bare ground	**9**	18	19	**26**	22	27	**14**	25	26
Agropyron repens	**0**	2	0	**0**	5	1	**2**	8	2
Bromus sterilis	**0**	2	0	**0**	3	1	**0**	1	1
Poa annua	**10**	9	9	**0**	0	0	**0**	0	0
Veronica sp.	**4**	3	1	**0**	0	0	**0**	0	0

DISSECTING TREE GROWTH

Absolute values of height and girth may not reveal dufferential responses of growth to weather, disease, and drought between hybrids, sites, blocks and treatments from year to year. The following figures show the changes in growth rate of height with time.

Figure 7. The annual growth rate in height with time
a) comparing the three blocks at each site;



b) comparing the three sites for each hybrid;

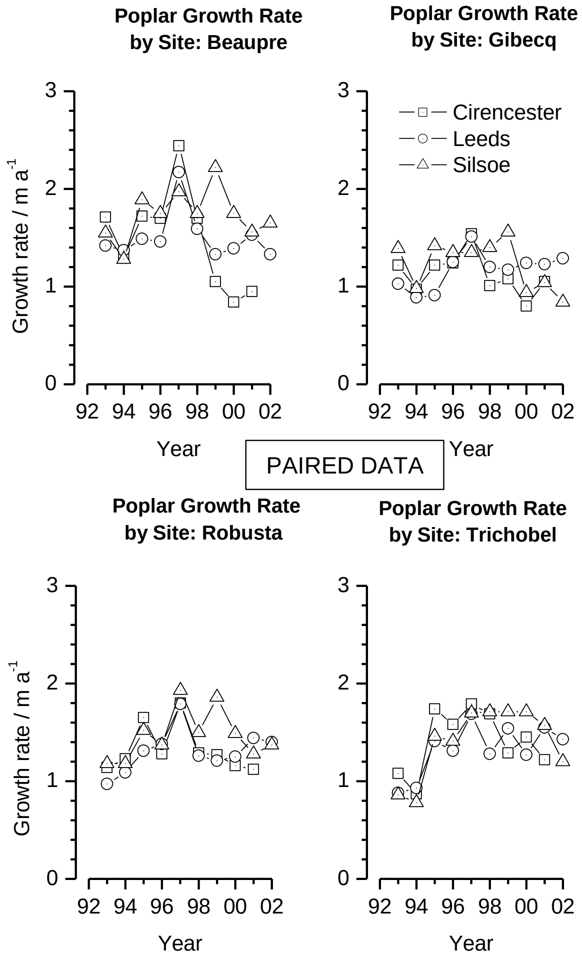
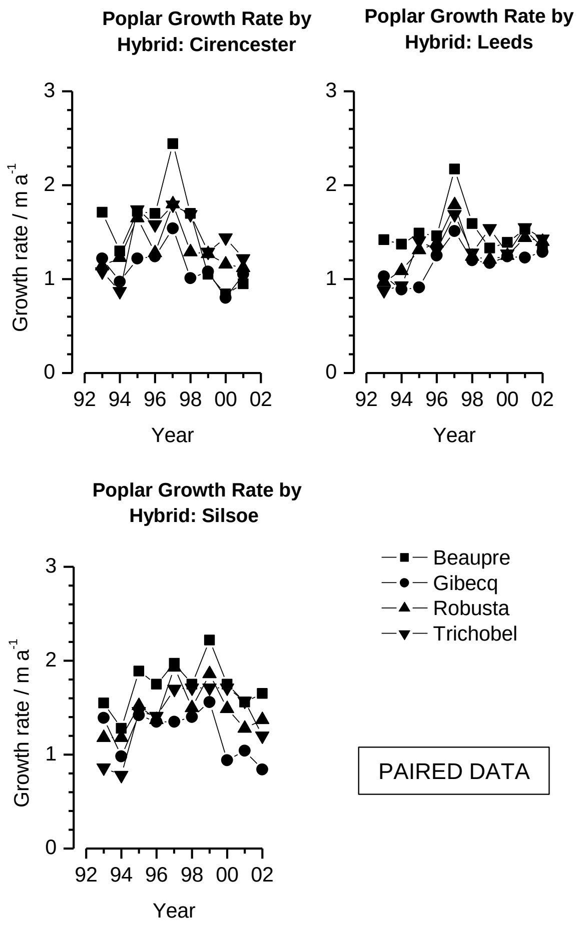
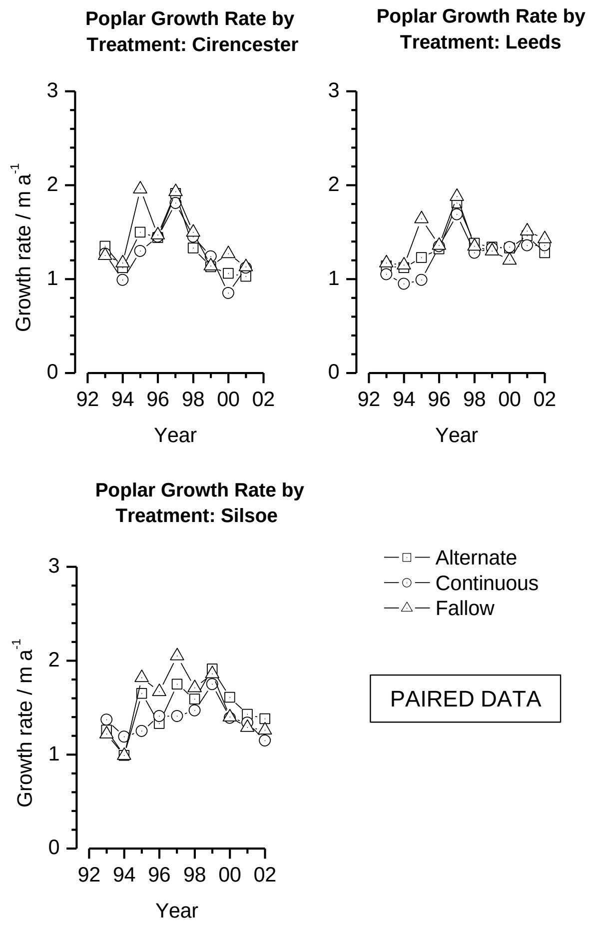


Figure 7. The annual growth rate in height with time

c) comparing the three hybrids at each site;



d) comparing the three treatments at each site.



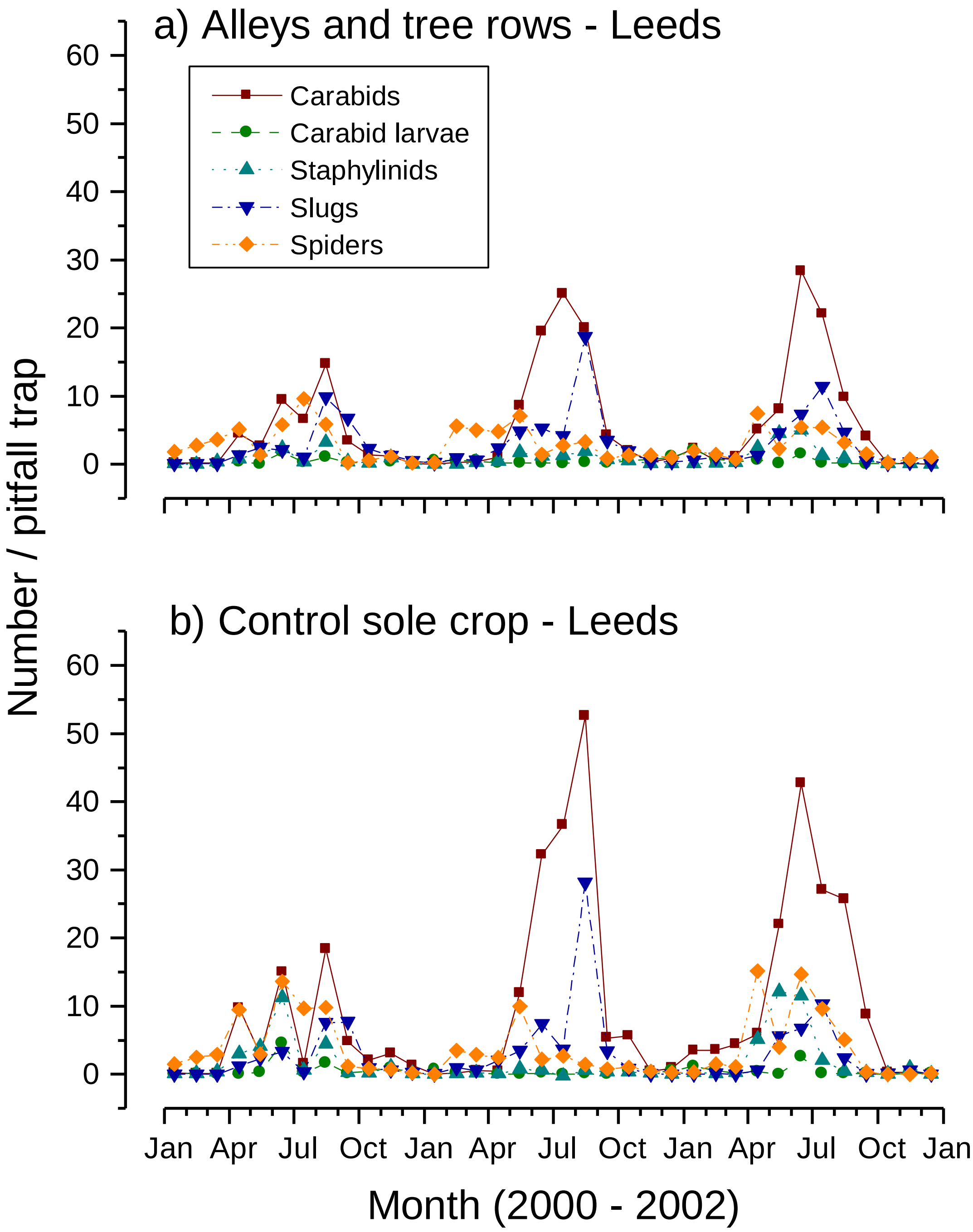


Figure 8. Numbers of invertebrates within selected categories collected from pitfall traps at Leeds in (a) the agroforestry treatment (cropped alleys and tree understoreys combined) and (b) the control crop at each site from January 2000 to December 2002. Values are means (n = 60 and 12 respectively).

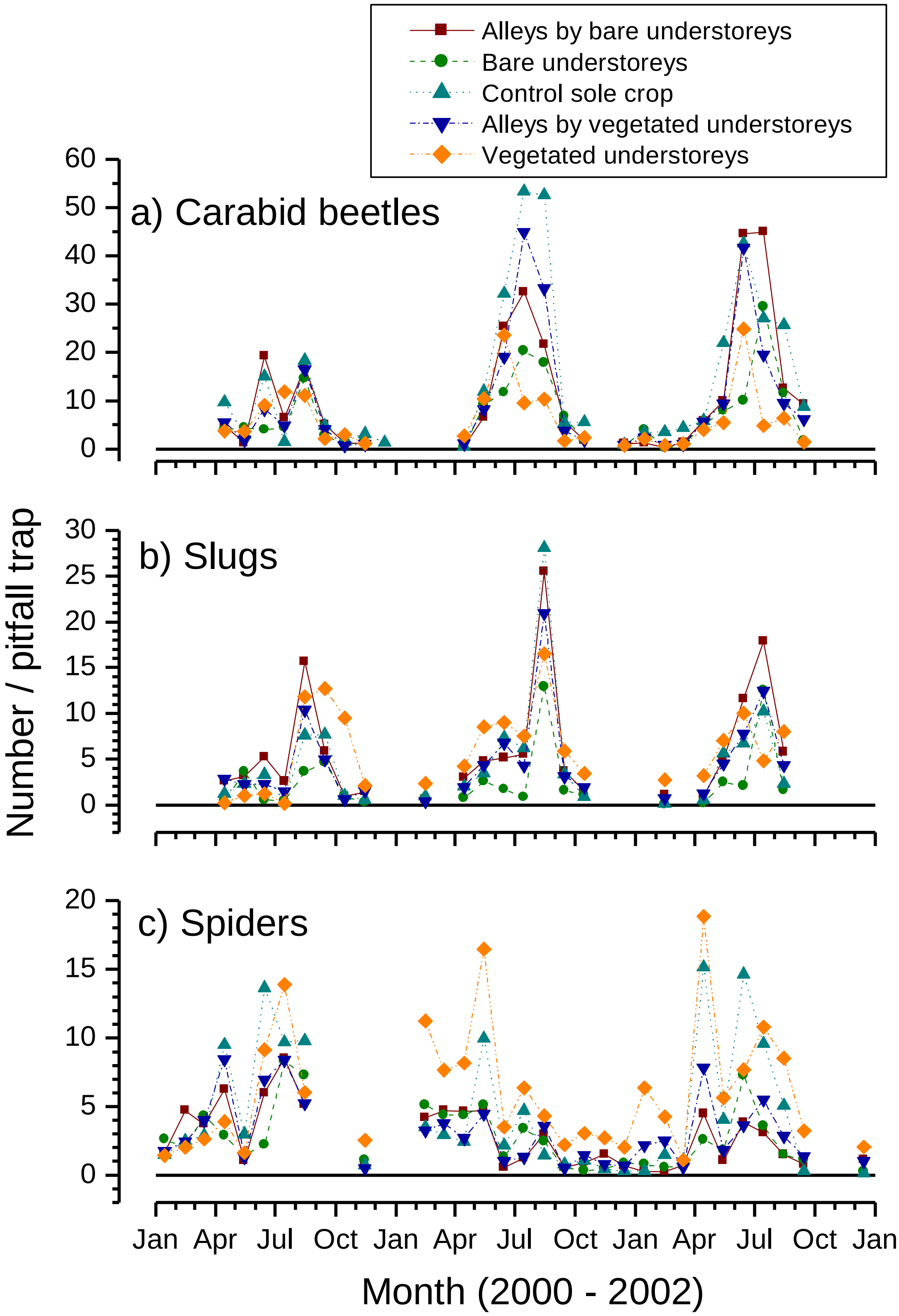


Figure 9. The effect of five ground-storey treatments on numbers of a) carabid beetles, b) slugs and c) spiders trapped in pitfall traps at Leeds from January 2000 to December 2002. Values are means (n = 12).

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