The use of fertilizers in the establishment phase of common ash (*Fraxinus excelsior* L.)

N. Culleton, W. E. Murphy and A. McLoughlin

Teagasc Research and Development, Johnstown Castle, Co. Wexford

Summary

This trial reports on the effects of adding varying rates of nitrogen, phosphorus, potassium and lime to a newly planted stand of common ash (*Fraxinus excelsior* L.) on a lowland fertile mineral soil at Johnstown Castle, Co. Wexford. The site is a moderately well drained loam over a clay loam, with a pH of 6.7 and phosphorus and potassium levels of 8.5 and 75 mg/kg soil respectively. Adding a range of fertilizers did not consistently improve height or diameter increment in any one year of the six year establishment phase. In addition, foliar concentrations of nitrogen, phosphorus, potassium and calcium assessed for the range of treatments did not differ significantly from those recorded for the treatment control. It is concluded that there is no need to add fertilizer during the establishment phase of common ash, when planted on a fertile lowland site.

Introduction

Common ash (*Fraxinus excelsior* L.) is one of the most nutrient demanding of all broadleaved species. When grown under fertile conditions, the species can achieve annual growth rates significantly greater than those achieved by either oak (*Quercus* spp.) or beech (*Fagus sylvatica* L.) (Wardle, 1961; Helliwell, 1982). It is reported that a three year old ash transplant will extract from the soil four times the amount of potash, three times the amount of nitrogen, and twice the amount of lime required by an oak seedling of the same age (Anon., 1947).

One of the main factors governing growth response to fertilizer is the stage of development of the stand. Taylor (1991) defines three stages. The first stage occurs between the time of planting and the age at which the stand reaches full canopy closure, i.e. when adjacent crowns begin to interlock. The second stage occurs after full canopy closure, while the third stage occurs towards the end of the rotation. This study is concerned with the plant response to fertilizers during the first stage. During this phase, the foliage represents a considerable proportion of the total stand biomass and is increasing annually, requiring large amounts of nutrients. These nutrients must come from the pool of available soil nutrients, as there is little input from other possible sources at this early stage. Therefore, any nutrient deficits in the soil must be balanced by fertilizer application.

McDonald (1929), reporting on a fertilizer experiment in New Zealand on an ash plantation, found that nitrogenous fertilizers promoted growth and general tree health, with lime, phosphorus and potassium having nil or negative effect on growth. Evans (1986) found that breast height diameter increment was significantly increased by nitrogen fertilizer for at least the first three years after application, with potassium fertilizer significantly promoting diameter increment on one site. Using foliar analysis, Evans (1986) demonstrated that fertilizer application significantly altered leaf nutrient levels. However, evidence of improved foliar uptake following fertilizer application did not in itself entail that trees grew more rapidly. Fitzsimons and Luddy (1986), reporting on a fertilizer trial in Gorey Forest, Co. Wexford in 1978, suggested a positive response in ash to applications of nitrogen, phosphorus and potassium on mineral soils of less than YC 10 which are neither waterlogged nor excessively dry. Gordon (1964) examined height growth of ash in the Lake District and found that the humus/nitrogen ratio was related to foliar nitrogen concentrations. Sites with low humus/nitrogen ratios were likely to be sites with high nitrogen availability, resulting in increased height growth rates.

This trial reports on the performance of ash trees planted in 1989 at Johnstown Castle, Co. Wexford, and subjected to a series of fertilizer treatments.

Materials and methods

The trial was carried out on a fertile lowland site previously used for intensive livestock production, with a sward dominated by *Lolium perenne* receiving 250 kg N/ha. The soil is a well to moderately well drained brown earth with stratified loam over clay loam. Grass was sprayed off with glyphosate four weeks before planting. Planting was carried out in March/April, 1989 at a 2 m x 2 m spacing. A total of 2,400 trees, with a mean height of 80 cm, were planted.

Eight post-planting fertilizer treatments, each involving 10 rows of 10 trees, were imposed. Treatments were laid down in a randomized block design with three replications. The treatments used are outlined in Table 1.

Fertilizer was applied by hand in a wide circle around each individual tree. Almost complete weed control was maintained from time of planting until 1994, using glyphosate application in May and late July.

Soil samples to a depth of 10 cm were taken for all treatments at the time of planting. Further samples were taken in October 1994, to a depth of 0-15 cm, 16-30 cm, 31-45 cm, 46-60 cm, 61-75 cm, and 76-90 cm. Samples were analyzed for pH, phosphorus, potassium and magnesium, using techniques described by Byrne (1979).

All trees were measured for height at the end of each growing season. Tree diameter at 30 cm above ground was measured in 1989, 1990 and 1991. In 1991 and each subsequent year, tree diameter at 1.3 m above ground level was also

Table 1. *Fertilizer treatments imposed on trees planted in 1989.*

Treatment	*kg N/ha*	*kg P/ha*	*kg K/ha*	*Lime t/ha*
NPKL	30	40	80	15
Control	0	0	0	0
PKL	0	40	80	15
NKL	30	0	80	15
NPL	30	40	0	15
NPK	30	40	80	0
N_2PKL	60	40	80	15
NPKL_2	30	40	80	30

N applied at 3 rates, 0, 30 and 60 kg/ha/yr, from 1989 to 1992
P applied at 2 rates, 0 and 40 kg/ha/yr, from 1989 to 1992
K applied at 2 rates, 0 and 80 kg/ha/yr, from 1989 to 1992
Lime applied at 3 rates, 0, 15 and 30 t/ha, in 1989 only

recorded. Leaf samples were taken in July, 1991, June and August, 1992, and again in July, 1993. Two to three leaves per tree were selected from the mid-canopy level. Foliar analyses for nitrogen, phosphorus, potassium and calcium were carried out on composite leaf samples, i.e. leaf samples of 20 trees/treatment, using techniques described by Byrne (1979).

Results and discussion

Soil sampling

At the commencement of the trial, soil fertility to a depth of 10 cm suggested that soil nutrient levels were quite high, with phosphorus and potassium levels at 8.5 and 75 mg/kg soil respectively. The mean pH was 6.7. As the years progressed, it became evident that fertility at the soil surface was only of short term relevance to tree growth, with roots having the ability to penetrate to considerable depths into the soil after a few growing seasons. Although ash maintains most of its roots at the surface, it was felt that an examination of soil fertility to a depth of 90 cm would be useful in these trial conditions. A summary of the results is given in Table 2.

In general terms, soil fertility throughout the depth of the profile was good. Potassium levels did not fall below 30 mg/kg soil, while pH did not go below 5.9. The sharp decline in phosphorus levels below 15 cm is not unexpected, as this element is considered to be relatively immobile in the soil (Cooke, 1967), with

Table 2. *Soil fertility at various soil depths in the 1994 fertilizer treatments.*

Soil Depth cm	*Element*	*NPKL*	*Control*	*PKL*	*NKL*	*NPL*	*NPK*	*N_2PKL*	*NPKL$_2$*	*LSD (p<0.05)*
0-15	P mg/kg	14.2	4.6	8.8	5.6	12.0	14.2	8.8	12.0	3.3
	K mg/kg	88	90	98	102	80	135	108	140	35
	Mg mg/kg	580	507	526	577	548	543	528	583	50
	pH	7.1	6.9	7.0	7.1	7.0	7.0	7.1	7.2	0.1
16-30	P mg/kg	2.4	0.8	1.8	1.5	1.7	4.3	1.4	1.1	0.4
	K mg/kg	60	32	60	63	53	70	51	65	6.0
	Mg mg/kg	532	481	481	461	461	483	372	396	80
	pH	6.7	6.5	6.5	6.7	6.7	6.5	6.8	6.7	0.3
31-45	P mg/kg	0.8	0.6	0.6	0.7	0.6	1.3	0.8	0.6	0.2
	K mg/kg	51	31	50	47	47	40	49	33	10
	Mg mg/kg	536	420	477	347	409	383	354	366	60
	pH	6.4	6.2	6.4	6.6	66	6.2	6.4	6.7	0.5
46-60	P mg/kg	0.5	0.4	0.7	0.4	0.6	0.6	0.6	0.5	0.3
	K mg/kg	51	30	53	45	47	50	43	32	12
	Mg mg/kg	450	401	450	350	363	367	390	378	90
	pH	6.3	6.2	6.5	6.1	6.4	6.2	6.3	6.4	0.4
61-90	P mg/kg	0.5	0.4	0.4	0.4	0.5	0.4	0.6	0.4	0.2
	K mg/kg	43	30	41	40	37	50	45	45	8
	Mg mg/kg	432	500	390	421	408	401	480	351	40
	pH	6.1	6.1	6.3	5.9	6.0	6.0	6.0	6.2	0.4

applied phosphorus tending to remain within the top three to four centimetres (Culleton *et al.*, 1994). The main loss of phosphorus from the soil is through overland flow rather than leaching (Tunney *et al.*, 1994).

Tree growth parameters

At the start of the trial, mean tree height and diameter at 30 cm above ground was 80 cm and 10 mm respectively.

Height growth: The height of trees for each year of the trial is summarized in Table 3.

Table 3. *Effect of fertilizer treatments on tree height (cm) (1989-1994).*

	1989	*1990*	*1991*	*1992*	*1993*	*1994*
NPKL	101	173	256	371	425	497
Control	103	173	234	356	416	490
PKL	102	175	236	351	393	469
NKL	101	171	252	366	425	500
NPL	104	189	272	372	430	480
NPK	103	186	261	364	416	486
N_2PKL	100	165	248	348	394	470
$NPKL_2$	102	167	246	350	402	476
LSD ($p<0.05$)	8	14	22	45	53	60

Over the five year period, the mean increase in height was almost 70 cm/yr. Given that stem elongation begins in late May and ends during early August with the appearance of apical buds, this gives a mean daily growth rate of approximately one centimetre. There were no consistently significant differences between treatments. The phosphorus levels in the top 15 cm were less than 5 mg/kg of soil, and yet growth appeared to be unaffected. This suggests that when phosphorus levels are at 5 mg/kg of soil and potassium levels are at 90 mg/kg of soil, growth will not be limited by these elements. Further work is required to examine growth rates at phosphorus and potassium levels lower than those recorded in this trial. Added lime had no effect on tree growth, reflecting the generally-held view that ash growth is only restricted when pH falls below 5.6 (Wardle, 1961; Evans, 1984).

Many studies have reported that ash plantations respond to added nitrogen (Evans, 1986; Fitzsimons and Luddy, 1986). There is little or no evidence of such a response in this trial. The results suggest that there was adequate nitrogen in the control plots. The site was fertile with adequate amounts of organic matter. Significant quantities of nitrogen would also have been released by pre- and post-planting weed control, and may have subsequently become available for uptake by tree roots. It is the opinion of the authors that if vegetation control was not practised, the response to nitrogen may well have been different. It could also be argued that much of the nitrogen applied before planting may have been leached through the ground before the young, undeveloped roots had developed sufficiently to absorb it. Furthermore, due to the mobility of nitrogen in the soil, it is possible that older, more established ash trees may respond to nitrogen application better than the recently established trees in this trial.

Diameter growth: Tree diameter measurements are summarized in Table 4.

Table 4. *Effect of fertilizer treatments on tree diameter (cm) (1989-1994).*

	1989 at 30 cm	*1990 at 30 cm*	*1991 at 30 cm*	*1991 at 1.3 m*	*1992 at 1.3 m*	*1993 at 1.3 m*	*1994 at 1.3 m*
NPKL	12.2	23.2	34.0	20.7	35.0	44.9	60.1
Control	12.4	23.1	29.1	20.7	34.7	44.6	58.9
PKL	11.8	23.0	28.4	20.2	32.4	42.1	57.7
NKL	12.3	24.0	33.0	23.5	32.4	46.3	55.5
NPL	12.5	25.6	34.8	18.7	31.8	43.4	50.6
NPK	13.0	26.5	34.7	20.5	38.1	48.3	52.3
N_2PKL	11.6	23.0	31.1	22.5	33.2	42.5	54.7
$NPKL_2$	12.1	24.0	32.2	25.0	35.2	43.4	53.9
LSD ($p<0.05$)	4.2	5.2	5.7	3.7	6.8	6.9	7.5

The results are similar to those found with tree height, with no consistently significant differences in diameter increment between treatments. It would appear that there were adequate nutrients in the soil, with no need to add more in the form of fertilizers.

Foliar analysis: The results of the foliar analyses carried out during this trial are summarized in Table 5.

Fertilizer regimes did not have a consistently significant effect on foliar nutritient levels. These results are in general agreement with Evans (1986), who argued that foliar analysis of broadleaf species as a diagnostic tool for identifying nutrient deficiencies must be used with caution. Benton *et al.* (1991) recorded foliar nutrient concentrations of N, P, K and Ca in *F. americana* L. at 2.0%, 0.48%, 0.80% and 2.39% respectively.

Table 5. *Foliar analyses for all treatments in 1991, 1992 and 1993.*

		NPKL	*Control*	*PKL*	*NKL*	*NPL*	*NPK*	*N_2PKL*	*NPKL$_2$*	*LSD ($p<0.05$)*
10th July, 1991	% N	2.7	2.68	2.7	2.4	3.3	3.0	3.2	3.3	0.6
	% P	0.22	0.26	0.22	0.24	0.22	0.24	0.23	0.23	0.18
	% K	0.90	0.81	0.88	0.75	0.87	0.81	0.87	0.85	0.27
	% Ca	1.65	1.82	1.71	1.87	1.78	1.82	1.86	1.69	0.24
29th June, 1992	% N	2.9	2.9	2.8	3.0	3.1	2.9	2.9	2.9	0.3
	% P	0.23	0.23	0.25	0.25	0.24	0.21	0.24	0.21	0.19
	% K	0.88	0.87	0.89	0.88	0.93	0.91	0.87	0.90	0.25
	% Ca	1.8	1.6	1.9	1.7	1.7	1.8	1.9	2.0	0.1
6th August, 1992	% N	3.2	2.7	2.9	2.8	2.8	3.0	3.1	2.9	0.4
	% P	0.18	0.16	0.18	0.18	0.17	0.18	0.17	0.19	0.08
	% K	0.9	0.9	1.0	1.1	1.1	1.0	0.9	1.0	0.09
	% Ca	1.9	2.1	2.3	2.4	2.3	2.2	1.9	2.0	0.97
10th July, 1993	% N	2.5	2.3	2.5	2.8	2.6	2.5	2.6	2.3	0.4
	% P	0.19	0.20	0.17	0.23	0.18	0.19	0.22	0.18	0.15
	% K	0.91	0.84	0.90	0.88	0.83	0.97	0.87	0.90	0.23
	% Ca	1.9	2.0	1.8	1.9	2.0	1.6	1.8	2.1	0.6

Conclusion

On rich fertile agricultural soils, there is no need for additions to common ash plantations of nitrogen, phosphorus and potash during the six years after planting. When the pH is in the region of 6.0, there is no advantage to be gained by applying lime.

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