- *A provenance trial comparing plants produced from eight home-collected and six imported seed sources was assessed for Christmas tree characteristics after six years in the field.*
- *Site was found to significantly affect all traits assessed except for crown shape. This highlights the importance of proper site selection for the production of quality Christmas trees.*
- *Provenance had significant effects on growth, foliage colour and resistance to needle necrosis but had little or no effect on leader status, stem form, crown shape and aphid attack.*
- *Current Season Needle Necrosis affected 37% of the trees across sites but affected 66% of the trees on one site.*
- *Several Irish home-grown seed sources of noble fir provide excellent planting stock for the production of quality Christmas trees with superior traits including good growth, good form, blue foliage and low incidence of needle necrosis.*

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The importance of provenance and site selection on the production of quality noble fir (*Abies procera*) Christmas trees

***Dr David Thompson*[1]**

Introduction

In 1996 a good cone crop in Irish stands of noble fir (*Abies procera*) prompted a comparison of home-collected sources of noble fir with several imported seed sources for the production of Christmas trees. Because some of these home-grown sources had been established with noble fir material from US and some of the best Danish sources they could provide an easily accessible source of good Christmas tree material.

Data were collected from 8,000 trees planted on four sites and significant effects were found in many traits. While a more complete analysis of these data will be necessary, it is important to present growers with some initial results that may be of practical importance. More detailed results will be presented in a later publication.

▲ View of one of the noble fir Christmas tree provenance trials after five growing seasons.

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Materials and Methods

Seed was collected from eight home-grown stands and was compared with seed from three imported Danish sources (including a Danish noble fir seed orchard), one Welsh source and two imported US sources (Table 1). Seed was sown in the spring of 1997, grown for one year in containers, lined out in a nursery bed for the second year and planted in the spring of 1999. The trials consisted of 10 tree row plots of each seed source randomly replicated four times in each trial so that there were in total 40 trees per seed source in each trial. Data were collected in the spring of 2004 in four of the trials established in commercial Christmas tree farms (Kavanagh's Christmas Tree Farm, Kilmurry, Co Wicklow; The Emerald Group Christmas Tree Farms at Borris and Camolin, Co Wexford; and the Coillte Christmas Tree Farm at Elphin, Co Roscommon). Assessments were made after six growing seasons in the field and before shaping and other cultural work began. In total 14 different traits were assessed (Table 2) to quantify differences in the major commercially important Christmas tree traits.

Table 1: Seed sources used in this study.

Home-collected sources	
Provenance Name	**Original Seed Source**
Down's Hill	6/Q/59 Washington
Ballinahinch	Denmark (unknown)
Carrigroe	47/F/52 Denmark (unknown)
Ballyhighland	Home-collected Bree Forest
Ballyboy	Home-collected Virginia Forest
Corrin Hill 1	6/Q/51 Mollala, Oregon
Corrin Hill 2	Home-collected Avondale
Ballycondon	77/F/62 Frijsenborg (c 26)
Imported seed	
Frijsenborg (Norringure 34b stand F 454)	
Palsgard 68A	
Danish seed orchard Flensborg (consisting of 100 clones from 9 seed sources selected specifically for blue foliage colour)	
Welsh Blue (UK selection)	
Fanno/Riley (US seed source)	
Mary's Peak (US seed source)	

Results

A summary of the results is presented across sites in Table 3 and across provenances in Table 4. Survival was affected by both site and provenance: ranging from 72 to 99% across the four sites, and from 61 to 97% among provenances. Site and provenance also affected tree height after six years in the field: ranging from 77.5 to 130 cm across sites and from 94 to 151 cm among provenances. The variation in both survival and heights across sites illustrates the importance of suitable site selection for production of quality Christmas trees.

The percentage of trees with more than five buds in the topmost whorl also varied across both sites and provenances. It ranged from 7 to 35% across sites and from

Table 2: Traits assessed in the trials and the type of data collected.

Trait	Type of Data
Survival	Count of trees measured
Height	Measured in cm
Number of buds in topmost whorl	Count of buds
Leader Status	1= no leader present 2= leader short, bent or distorted 3= straight leader
Foliage Colour	1= yellow 2=green 3=blue
Main Stem Status	1= distorted 2= straight
Crown Symmetry	1= one full face 2= two full faces 3= three full faces 4= four full faces
Crown Density	1= light 2= medium 3= full
Crown Status	1= short and squat 2= full 3= tall and narrow
Lammas Growth	Count of affected trees
Frost Damage	Count of affected trees
Current Season Needle Necrosis (CSNN)	Count of affected trees
Yellow Tip	Count of affected trees
Chemical Damage	Count of affected trees

Table 3: Effect of the four different sites in this study on the quality traits in noble fir. All of the traits listed below were statistically significant between sites.

Site	Surv %	Ht cm	WB %	Ldr %	Col %	Stm %	Sym %	Den %	NN %	Aph %	Lam %
A	72	77	8	8	38	80	68	80	8	0	0.2
B	99	109	17	8	52	87	79	90	26	24	1
C	87	127	28	12	52	88	82	91	46	0	2
D	79	131	35	19	57	91	84	92	66	0	5
Ave.	84	111	22	12	50	86	78	88	36	1.5	2

Surv = Survival percentage
WB = Percent of trees with five or more buds in the topmost whorl
Colour = Percent of trees classed as blue
Sym = Percent of trees with four full faces
NN = Percent of trees affected by Needle Necrosis
Lam = Percent of trees with Lammas growth

Ht = Height in cm
Ldr = Percent of trees with one straight leader
Stm = Percent of trees with a single, straight main stem
Den = Percent of trees classed as 'full'
Aph = Percent of trees attacked by aphids

Table 4: Effect of the 14 different provenances used in this study on quality traits in noble fir. All of the traits listed below showed statistically significant differences between provenances. Traits are arranged with the 'best' provenances at the top and the poorest at the bottom.

Surv %	Height cm	WB %	Colour %	Symm %	Den %	CSNN %	Lammas %
DH 97	F/R 151	MP 46	FB 77	MP 91	DH 94	BD 21	FB 0.0
FB 94	CR 120	CR 31	BH 67	F/R 86	BD 93	DH 27	DH 0.2
F/R 89	MP 119	F/R 29	SO 59	SO 84	CH2 92	WB 38	BH 0.8
BH 88	BC 118	CH2 29	DH 57	DH 84	MP 90	CR 38	SO 0.9
MP 86	DH 114	DH 26	PG 52	BB81	BB 88	CH2 39	CH2 1.2
CH1 85	BD 112	BB 24	BB 49	PG 81	BC 87	CH2 39	BD 1.5
BB 85	SO 112	CH1 22	CH2 48	BC 81	CR 87	BB 40	CH1 1.6
CR 83	C1 109	BD 22	CR48	CR 79	CH1 87	BH 41	PG 2.4
BD 83	C2 108	BC 21	BD 47	CH1 77	F/R 87	BC 44	MP 2.4
BC 83	FB 108	FB 18	CH1 46	CH2 76	BH 87	MP 44	CR 2.5
Ch2 82	BB 106	SO 18	BC 44	BD 76	SO 86	PG 45	BC 2.8
SO 77	BH 102	PG 16	WB 37	FB 76	WB 83	SO 47	WB 2.9
WB 70	PG 95	BH 14	MP 13	WB 76	FB 80	F/R 51	BB 3.2
PG 61	WB 94	WB 11	F/R 8	BH 73	PG 78	FB 51	F/R 19.1
Ave. 83	Ave. 112	Ave. 23	Ave. 47	Ave. 80	Ave. 87	Ave. 41	Ave. 3.0

Surv = Survival percentage
WB = Percent of trees with five or more buds in the topmost whorl
Symm = Percent of trees with four full faces
CSNN = Percent of trees affected by Current Season Needle Necrosis

Height = Height in cm
Colour = Percent of trees classed as blue
Den = Percent of trees classed as 'full'
Lammas = Percent of trees showing Lammas growth

DH= Down's Hill
CR= Carrigroe
CH1= Corrin Hill 1
BB= Ballyboy

BC= Ballycondon
PG= Palsgard
MP= Mary's Peak
WB= Welsh Blue

BH= Ballinahinch
BD= Ballyhighland
CH2= Corrin Hill 2

FB= Frijsenborg
SO= Seed Orchard Flensborg
F/R= Fanno/Riley

11 to 46% across provenances. Taller trees tended to have more buds in the top whorl than smaller trees. The percentage of trees with a single, straight leader was quite low and affected only by site and ranged from 7 to 19% across sites. The percentage of trees with a blue foliage colour was affected by both site and provenance and varied from 38 to 57% across sites but ranged from 8 to 77% of the trees across provenances, illustrating the importance of provenance in this trait.

The percentage of trees with a straight main stem was affected only by site and ranged from 80 to 91% across sites. The lack of straight stems does not appear to present a large problem, but it is interesting to note that the high frequency of poor quality leaders reported above does not necessarily result in poor stem quality later. The percentage of trees with four full faces was affected by both site and provenance. It ranged from 68 to 84% across sites and 73 to 91% among provenances. On average 78% of the trees across all sites had four full faces so this does not appear to be an important quality issue.

The percentage of trees that were classed as having a 'full' crown was affected both by site and provenance. It varied from 80 to 92% across sites and ranged from 78 to 92% across provenances. On average 88% of the trees in all sites were classed as having a full crown again suggesting that this is not an important quality issue. Crown shape was defined as either 'full' (well balanced) or 'tall and narrow' as compared to 'short and squat' and was not affected by either site of provenance. Across sites 91 to 93% of the trees and among provenances between 89 and 96% of the trees fell into these two categories again not indicating a significant quality problem.

Current Season Needle Necrosis (CSNN) ranged from 8 to 66% across sites and averaged 37% confirming it is a serious problem in Irish Christmas tree farms. CSNN incidence was affected both by site and provenance. Across provenances it ranged from 21 to 51% demonstrating that the correct provenance can help reduce the problem. Aphid damage affected 7% of the trees, but occurred in only one site and there was no difference in the degree of attack across provenances. 'Yellow Tip' was observed in only about 4% of the trees, which is too low a level to identify any site or provenance effects. Lammas growth occurred in only 2.1% of the trees, but it occurred only at the site with the fastest overall growth and occurred only in the fastest growing provenance (Fanno/Riley). No frost damage was noted in any of the trials.

SOME TERMS EXPLAINED

Current Season Needle Necrosis (CSNN): the formation of tan bands on needles which can spread to the entire needle in late June. They turn red brown by midsummer thus greatly reducing the value of the tree. The cause is unknown.

Yellow Tip: the yellowing of the tips of the needles of the entire tree thus giving the tree a not unattractive (to some) "frosted" appearance. The cause is unknown.

Lammas growth: breaking of buds and shoot elongation in late summer (after 1 August, St. Lammas Day) which may result in poor stem form or leader damage.

Discussion

Even though the main objective of this study was to compare the provenance (genetic) effects of different seed sources, site was found to have a profound effect on the production of quality Christmas trees. It affected survival, height, number of buds in the top most whorl, leader status, foliage colour, main stem status, crown symmetry, crown density, CSNN, Lammas growth, aphid attack and chemical damage. Only crown shape was not affected by site. These results highlight the importance of proper site selection for the production of quality Christmas trees and suggest that further research may be needed to identify the site properties important for the production of quality trees. It is also important to point out that even the best seed sources will not produce quality trees on the wrong sites.

Provenance was found to have a highly significant effect on survival, height, number of buds in the uppermost whorl, foliage colour, crown symmetry, crown density, CSNN and Lammas growth. Provenance had no effect on leader status, stem form, crown shape, aphid attack and chemical damage.

Selection of the proper provenance will result in trees with a good survival and growth rate, good blue foliage colour and resistance against CSNN. Proper site selection and good cultural practices can take care of producing a good shape and well-furnished tree.

In the last few years a belief has developed among Irish Christmas tree growers that it is necessary to have a large number of buds in the topmost whorl of plants in the nursery bed to produce quality trees. Results in this study showed that while the number of buds did depend on the provenance (and the site) the number of buds was more correlated with tree height with taller trees having more buds. **Thus the belief that the bud number can identify superior plants or seed sources in the nursery appears to have no basis in fact.**

The provenances most affected by CSNN were Frijsenborg (51%), the Danish seed orchard (47%) and Palsgard (45%), while Christmas tree growers seem to be of the opinion that they should be more resistant to CSNN than US sources. While it is true that 50% of the Fanno/Riley (an Oregon source) trees were affected by CSNN, only 30% of trees from Down's Hill (a Washington source) were affected. These results suggest that more work needs to be done to determine the influence of provenance on CSNN.

It is interesting that the three imported Danish sources ranked lower than the home-grown material. Surprisingly, the Danish seed orchard, apart from good blue colour, good crown symmetry and low CSNN provided no other quality improvements. However, this may be due to the fact that the trees were originally selected for blue foliage production, and not specifically for Christmas tree production. Perhaps the reputation of the Danish sources as being 'the best' may be over-rated. There are other Danish sources that may produce high quality Christmas trees that were not tested in these trials, because no seed of these sources was available at the time. These provenances will have to be tested in a future noble fir provenance trial, currently in the seed collecting stage.

It is also very important to be precise when discussing the different Danish noble fir seed sources. It is simply not enough to refer only by a seed source name such as 'Frijsenborg' because the Danish National Catalogue of Approved Seed Stands lists some 25 different seed stands all derived from the original stand called Frijsenborg and they are not all the same in terms of the quality of the trees they produce. Therefore great care needs to be used to get the full details of exactly which seed stand you are talking about, especially regarding Frijsenborg material.

This study is one of the first attempts to quantify the effect of different seed sources on the quality of Irish grown Christmas trees. In the absence of a good understanding of what constitutes a 'quality' tree 14 different criteria were assessed. It would be useful if a 'selection index' for Christmas tree quality could be developed. Such an index would concentrate on the most important traits and would give more weight to the more important traits (e.g. colour) in the overall assessment. This would have to be developed with the assistance of the Irish Christmas Tree Growers' Association and would help both improve the accuracy and speed of future assessments.

Finally, it is important to note that these results are only after six growing seasons in the field. Ideally a similar set of assessments can be carried out just prior to harvest of these trees to compare with these results.

▲ A blue noble fir from the Down's Hill (home-collected) provenance.

Conclusions

The results demonstrate clearly that some of the material collected from Irish grown stands can provide high quality Christmas tree by providing good growth, good numbers of buds in the top whorl, good foliage colour and some protection against CSNN.

- Of the home collected material in these trials, only the plants produced from the stand at Down's Hill were consistently above average in all eight of the traits which were under genetic control.
- The next best group were those that were above average in six out of the eight traits and included Ballyboy, Ballyhighland and Carrigroe (all of which were above average in colour). Mary's Peak was above average in six out of the eight traits, and provides a good green seed source.
- Fanno/Riley is above average in four out of the eight characteristics, but produces green trees and is perhaps too vigorous for European production systems.

▲ A noble fir from the Fanno/Riley (Oregon) provenance (right) compared to the Ballinahinch (home-collected) provance (left).

- Next there is a group which is above average in only three out of the eight trials which included Ballinahinch, Ballycondon, Corrin Hill 1, Corrin Hill 2 and the 3 Danish sources (the Danish seed orchard, Frijsenborg and Palsgard).
- At the bottom of the ranking, as above average in only two of the eight categories was Welsh blue, which was not found to be very blue, and has little to recommend its use.

Based on the results from these trials material from Irish grown noble fir stands at Down's Hill, Ballyhighland, Ballyboy and Carrigroe provide seed that will produce quality Christmas trees under Irish conditions. Material from the other Irish stands (Ballinahinch, Ballycondon and the two Corrin Hill sources) was generally equivalent to the Danish imported seed.

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