Benchmarking in the Walnut Industry in Canterbury, New Zealand

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What is benchmarking?

Benchmarking is used in many industries, from manufacturing to horticulture, and is a process of determining the best methods and practices for that particular industry to achieve optimal output, and efficiencies in time and economy.
In a horticultural industry such as walnut growing, the processes are obviously quite different from those that would be identified in a financial or manufacturing business. Nevertheless, it is still possible, despite the complexities of soil, climate and tree variation, to determine those practices that have the most significant effect on tree growth and walnut production.

The Aims of this Project

In the simplest case, benchmarking is used to find best practice models that can be adopted in a walnut orchard. Working together and sharing information on a range of practices will enable us to learn from each other, ultimately for the benefit of the whole industry.

This walnut orchard benchmarking project aims to achieve:

- best practice models for the establishment and maintenance of orchards by providing a framework for growers to compare the growth and productivity of their trees with those of other orchards with similar characteristics.
- methods for assessing walnut tree performance and management inputs so that any orchard can contribute to future data and compare itself with best practice models and those best practice models can then be improved.
- a knowledge of factors contributing to walnut blight incidence and other issues.
- the ability to convert good luck, bad luck and doubtful decisions into decision making tools.

The Project

After considerable research into the most likely factors to affect tree growth, a wide range of inputs were identified, and an interview was designed to survey grower's orchard conditions and practices. We also identified a number of methods of measuring outputs –

in terms of tree growth and nut production. (See Appendix 1 for the revised interview form. This interview can also be viewed on the WIG web pages, and may be completed online if you wish to participate in the project.)

Ten orchards were trialled initially, to enable us to determine the most significant conditions and practices, and best methods of measuring tree growth. From this we were able to refine the interview and simplify the measurements required so that it becomes a relatively easy process for orchardists to undertake. It is hoped that many other orchardists in Canterbury will join the project now the benchmarking process is streamlined. The larger the pool of information, the easier it will be to determine best practice.

General Description of Orchards Surveyed

There were no criteria for selecting orchards for the benchmarking project; in fact a range of orchards and management practices was desirable. Of the ten orchards surveyed one was organic, seven were producing and three were young orchards. Two were planted for hedgerow production. For comparison trees were selected of the same cultivar and year for at least two orchards. The trees were planted between 1989 and 2003. Measurements were recorded from trees planted between 1992 and 2002, giving us a range of ten years of growth.

The soil types varied from Lismores, which are quite stony soils, through Eyre stony and silt loams, to fertile Templetons and Selwyns. Most shelter belts were mature and porous although some were evergreen and dense, and some internal belts had yet to develop. The varieties of trees found in shelter belts were commonly Crows Nest Poplar, Alders, Matsodana Willows or Gums, with some Macrocarpa or Pinus Radiata on exterior belts. Internal belts could contain a variety of other species. Block sizes ranged from 60m x 60m through to 80m x 100m.

Most orchardists used a mini-sprinkler system for their walnuts and drippers for their shelter. Water was applied according to perceived need in most cases but only three orchards monitored soil moisture content.

Competition under the trees was usually managed by strip spraying, with the exception of two orchards that allowed understorey growth to the trunk. One orchard applied mulch and compost. Most orchards applied fertilizer as they felt it was needed or in response to soil or leaf analysis results.

Spraying for blight in young orchards was normally done by the orchardist but in mature orchards a contractor was employed. All used Kocide to control blight and sprayed to runoff. Most orchardists sprayed at, or close to, budburst and at least once after this.

Pruning practices varied. Orchardists had varying opinions on the pruning of young trees with some advocating heading back in winter while others took a more minimalistic approach. Some also summer pruned side branches to shape trees. Overall, whatever the age of the orchard, the main aim of all was to produce a well-shaped tree.

In each orchard, where possible, twenty-five trees of the same cultivar and year were selected. Trunk diameter at 600mm, tree height, canopy diameter and height, and shoot extension were recorded.

The Main Questions Posed by the Study are:

1. Is the trunk diameter a multi-purpose measurement of tree growth? Is it related to height/canopy height/width/volume and tree vigour?
2. Does the canopy volume and shape differ between cultivars?
3. Do different cultivars require different management practices?
4. What is the effect of soil type on tree growth?
5. What is the effect of understorey management on tree growth?
6. Does shelter and/or block size have any significant effect on tree growth?
7. How does irrigation affect production?
8. What is the effect of fertilization on tree growth?
9. How significant are pruning practices on tree growth?

Results

Yr	Cultivar	Code	Soil	600mm Trunk Diameter (cm)	Expected Trunk Diameter (cm)[a]	Management	Block Size
2002	Meyric	C	Eyres	1.84	2.10	Seasonal spray	55x100
2002	Meyric	D	Eyres	2.20	2.10	Compost and mulch	60x66
2002	Rex	C	Temp	2.17	2.32	Seasonal spray	55x100
2002	Rex	C	Eyres	2.25	2.32	Seasonal spray	55x100
2002	Rex	D	Eyres	2.46	2.32	Compost and mulch	60x66
2002	Rex	E	Eyres	2.12	2.32	Clear sprayed	84x64
2001	Meyric	C	Temp	3.76	3.40	Seasonal spray	55x65
2001	Meyric	E	Eyres	3.13	3.40	Clear sprayed	84x64
2001	Rex	C	Eyres	2.52	3.46	Seasonal spray	55x100
2001	Rex	C	Temp	3.31	3.46	Seasonal spray	55x65

2001	Rex	I	Lism.	2.47	3.46	Clear sprayed	Unknown
2001	Rex	I	Lism.	1.95	3.46	Clear sprayed	Unknown
2000	Meyric	I	Lism.	4.49	4.70	Clear sprayed	Unknown
2000	Meyric	I	Lism.	3.54	4.70	Clear sprayed	Unknown
1999	Rex	C	Temp	6.84	5.74	Seasonal spray	70x100
1998	Meyric	B	Temp	6.34	7.30	Clear sprayed circle	100x80
1998	Rex	B	Temp	6.07	6.88	Clear sprayed circle	100x80
1998	Rex	C	Temp	7.57	6.88	Seasonal spray	100x70
1997	Meyric	B	Temp	6.25	8.60	Clear sprayed circle	100x80
1997	Meyric	H	Temp	11.23	8.60	Clear sprayed	100x70
1997	Rex	B	Temp	6.14	8.02	Clear sprayed circle	100x80
1997	Rex	H	Temp	10.32	8.02	Clear sprayed	100x70
1996	Rex	H	Temp	9.60	9.16	Clear sprayed	100x70
1995	Meyric	J	Temp	13.06	11.20	Clear sprayed	Unknown
1995	Meyric	J	Temp	14.81	11.20	Clear sprayed	Unknown
1995	Rex	J	Temp	10.95	10.30	Clear sprayed	Unknown
1995	Rex	J	Temp	12.38	10.30	Clear sprayed	Unknown
1994	Meyric	F	Selw	15.43	12.50	Mown	84x53
1994	Rex	F	Selw	16.24	11.44	Mown	84x53

1992	Meyric	F	Selw	13.48	15.10	Mown	90x48
1992	Meyric	G	Eyres	13.33	15.10	Grass/compost	80x50
1992	Meyric	G	Eyres	14.45	15.10	Grass/compost	80x50
1991	Meyric	G	Eyres/ Halkett	17.41	16.40	Grass/compost	80x50
1991	Meyric	G	Eyres/ Halkett	15.45	16.40	Grass/compost	80x50
1991	Meyric	J	Temp	16.45	16.40	Clear sprayed	Unknown
1991	Rex	G	Eyres	14.23	14.86	Grass/compost	80x50
1991	Rex	G	Eyres/ Halkett	14.29	14.86	Grass/compost	80x50
1991	Rex	J	Temp	13.08	14.86	Clear sprayed	Unknown

[a] This column is the expected trunk diameter given the average for trees of that age.

Trunk Diameter

There is a significant correlation between the canopy diameter:height ratios and the trunk diameters for both Rex and Meyric, although there is a very large variability between trees. Generally Meyric has a bigger trunk diameter than Rex, and is a more spreading, hemispherically shaped tree. Trunk diameter measured at 600mm height is probably a reasonable estimate of the growth of the tree for both cultivars.

Fig. 1: Meyric: Fitted Line Plot of average canopy diameter versus trunk diameter. Trunk diameter was strongly correlated ($p<0.001$) and accounted for 52% of the variation in canopy diameter.

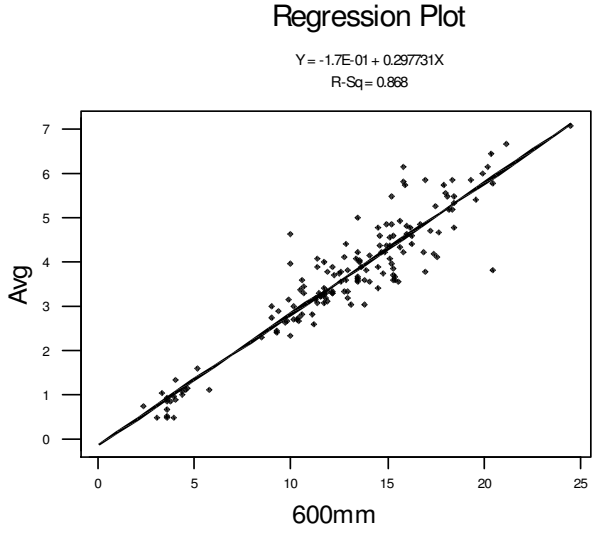
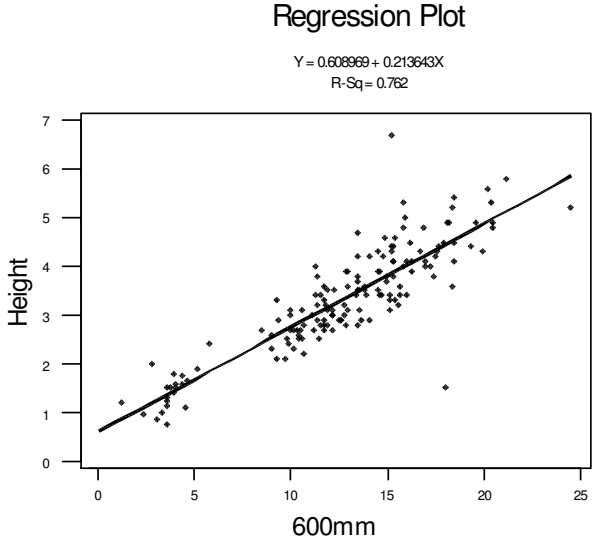


Fig. 2: Meyric: Fitted Line Plot of Height vs Trunk Diameter (at 600mm) – showing strong relationship ($P<0.001$). Trunk diameter accounts for 55% of the variation in height data.



A one tailed paired T test showed that Meyric and Rex had significantly different trunk measurements by 13 years with Meyric being 24% bigger than Rex (p=0.023). Although in very young trees the trunk diameter of Rex tends to be larger then Meyric, there is a weakly significant statistical trend for Meyric to become increasingly larger than Rex with age. One interesting reverse supporting the theory that soil is a significant factor in tree growth is in Orchard F where ten year old Rex trunk diameters were larger than Meyric of the same age. However Rex was grown in significantly better soil.

Fig. 3. The average trunk diameters at 600 mm of Meyric trees by age (383 trees sampled)

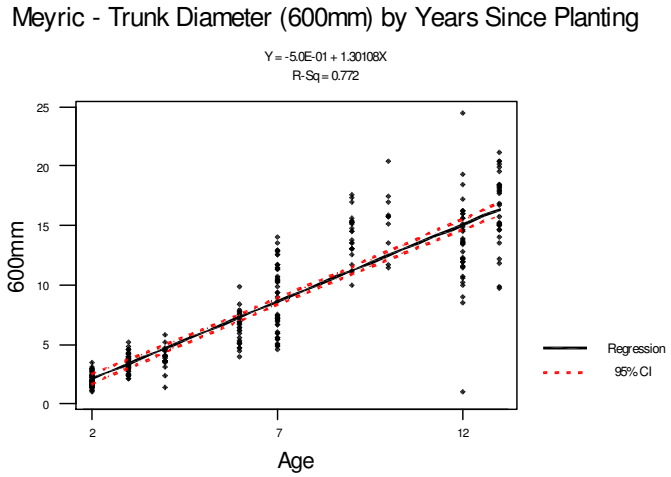
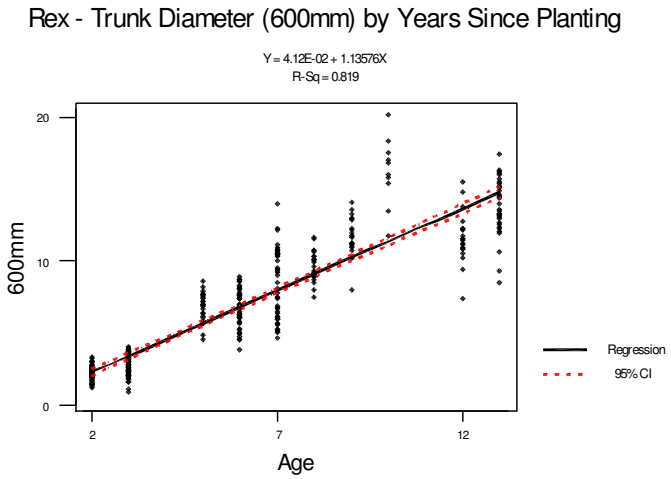


Fig. 4. The average trunk diameters at 600 mm of Rex trees by age (507 trees sampled)



Canopy volume and shape

The ratio of the height of the canopy to its diameter should give some indication of the shape of the tree and the difference between cultivars. The canopy diameter is difficult to measure accurately with some growers summer pruning and others not. There is a lot of variability in the measurements. Furthermore in non-mature trees the canopy hasn't developed. Even in less mature orchards there is a significant difference in the ratio of height to diameter between Meyric and Rex, with Rex generally having a higher ratio. This could have implications for calculating spray rates based on tree volume. It may also have some significance in the incidence of blight.

Fig. 5. The relationship between canopy shape (canopy diameter / canopy height) and years since planting for cultivar Meyric (383 trees sampled)

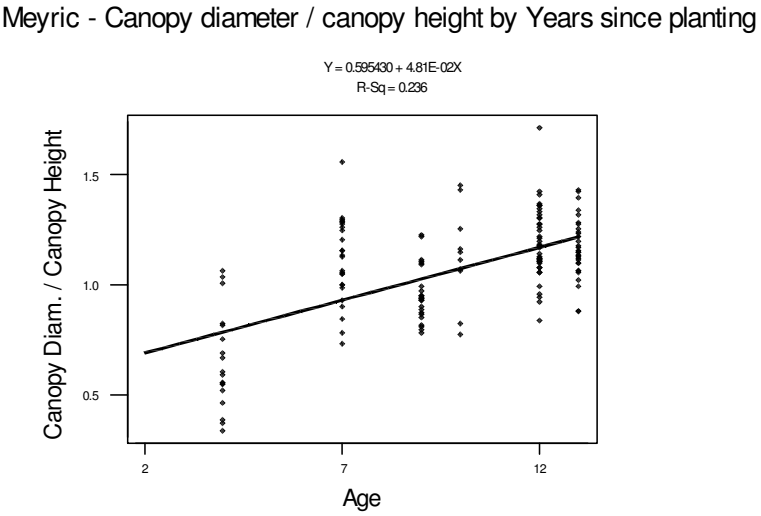
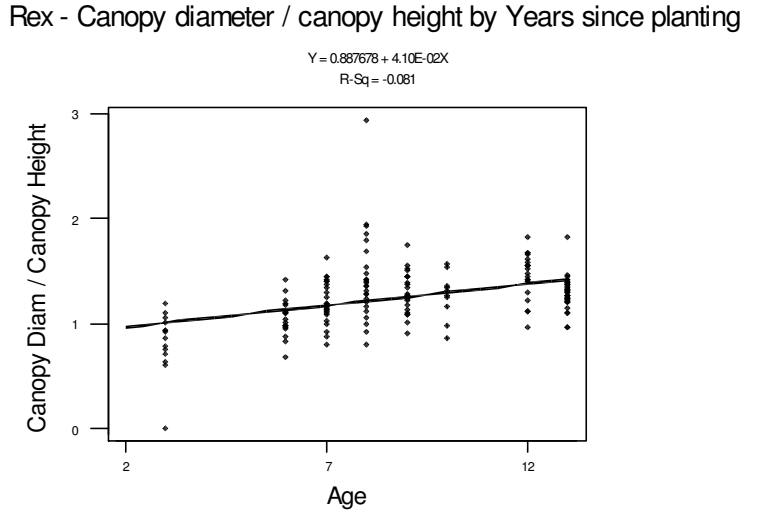


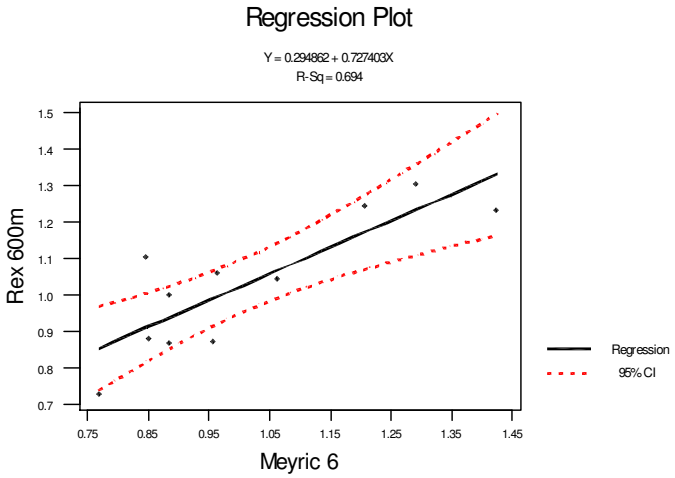
Fig. 6. The relationship between canopy shape (canopy diameter / canopy height) and years since planting for cultivar Rex (507 trees sampled)



Cultivar differences

Meyric was compared with Rex in the same year in the same orchard where possible. A regression plot showed a significant relationship in the growth of both cultivars. Orchard management practices are significant for both varieties. If Meyric performs well then Rex does too to a similar extent. This provides some confidence that the main drivers in tree performance are indeed the local conditions and management rather than it simply being related to initial tree condition. It should be noted that especially in very young trees, there may be a significant effect from such factors as season of planting, frost damage in the first season, initial tree size and condition, and how recently grafting was undertaken on the purchased trees. Caution should be exercised in interpreting data from trees at one and two years after planting.

Fig. 7. The relationship between Rex trunk diameter (at 600mm height) with Meyric trunk diameter for trees planted in the same year on the same orchard.



Soil Type

There was some indication that richer, deeper, fertile soil was better but there were insufficient replicates of soil type to prove that, for instance, trees grown on Lismore soils did comparatively poorly while those on Selwyns did well. In orchard C, Meyric grown in 2001 on Templeton soils performed above expectation, while Rex 2001 grown on Eyre soils performed below expectation. However the Meyric/Rex regression graph shows that there should be a similar performance for both cultivars indicating that the soil type may be significant. Similarly 2002 Rex on Templeton soils in orchard C was slightly below the average but Meyric grown on Eyre soils were significantly lower.

A comparison of soils for Rex showed the following observed trunk diameters at 600mm over expected trunk diameters for that age:

Selwyn 1.42 > Templeton 0.99 > Eyre/Halkett 0.88

For Meyric:

Selwyn 1.23 > Templeton 1.04> Eyre/Halkett 0.94

There is a significant difference between Selwyn and Templeton soils but not between Templeton and Eyres.

It would appear that management practices can compensate for poor soils. Both Meyric and Rex performed well on Eyre soils in Orchard D and this is likely to be due to the use of compost and mulch (see next section on understorey management).

Understorey Management

There is a statistically significant difference ($p<0.05$) between the growth of two year old trees in Orchard D and Orchards C and E. Given that trends are the same for both Rex and Meyric (R: $p = 0.018$, M: $p=0.015$), and that one of the comparison blocks is a neighbouring block on similar soil, increases the likelihood that the differences observed may be due to the mulching and composting programme implemented to overcome the limitations of the lighter stony soil. Texture, moisture retention and fertility are improved by mulching. Rex shows a 13% greater growth and Meyric 20% greater growth than comparison orchards. The use of mulch is supported by an Italian study spanning four years (Paris *et.al.*, 1997). They found that mulching (with black plastic) increased the diameter and height of trees by 130% over unmulched trees with a lucerne based interrow.

There were almost as many policies on understorey management as orchards surveyed so it is difficult to attribute any differences in the growth of trees to this apart from the mulching and composting. It is commonly accepted practice to have no competition under young trees for at least the first three years. It may be possible to attribute differences in tree growth to understorey management practices if more orchards were involved in this study.

Interestingly the only other orchard to use compost also performed well despite poorer soils.

Block size/ Shelter/ Spacing

Whilst there was some variation in shelter type and size most orchards were well sheltered. Anecdotal observations of wind damage suggest the importance of adequate shelter. It is suggested that it is better to keep blocks small to maximize the effectiveness of the shelter. Also it has been suggested that the incidence of blight within an orchard is related to the height and density of the shelter as this may affect windflow within the block. As yet no evidence has been gathered in this benchmarking project to prove or refute this hypothesis.

There was no apparent significant difference in the growth of the trees based on tree spacing. Production per hectare is higher in hedgerowed orchards, at least in the early stages. No orchards had fully reached maturity when this study was done.

Irrigation

There was an ad hoc approach to irrigation amongst the benchmarking orchards. Most were not monitored and those that did had different methods. Irrigation needs to be analysed more carefully for the benchmarking project and good monitoring records are required. It is clear from anecdotal observations that irrigation has a very significant effect on tree growth. Substantial visual differences were noted with uneven irrigation within a block; those trees that received more water were much larger. Generally it appears on Canterbury soils that the more water applied the better, with the most likely effect being leaching of nutrients if irrigation is done to excess. The excess level will depend on soil type and other factors. Further experimentation is required to determine the optimal level of irrigation for individual orchards. It is noted that a standard recommendation is to irrigate well during the rapid nut growth phase.

Fertilizing

Some orchards monitor fertility levels through soil and/or leaf analyses and apply lime and nutrients in response to the results. Others simply apply a general fertilizer such as Nitrophoska Blue TE in spring. Research does suggest that it is important to fertilize in summer as well as early spring to promote good growth for the next season. Over fertilizing appears to encourage vegetative growth to the detriment of tree shape. However very well fertilized trees were significantly larger than trees of the same age in different orchards.

Pruning

Tree training pruning is reasonably similar between orchards with most pruning to develop a well shaped tree. One potential point of difference is in summer pruning – the removal of shoot tips on lateral branches on immature trees to promote a strong leader also possibly contributes to increased trunk diameter growth (orchard D). No firm evidence on the effect of pruning practices on tree growth can be determined from this project. The Walnut Industry Group is conducting further research on the question of best pruning practices.

Conclusions

Trunk diameter at 600mm is a valid measure of the overall growth of the trees.

The average diameters of the trees at a particular year were derived from a regression analysis and Fitted Line Plot for each cultivar. As the benchmarking project progresses, further data will increase the accuracy of these statistics. When measuring trees orchardists need to be confident that their sample represents the whole block of that cultivar. To do this they need to measure 25 randomly selected trees of a cultivar in each block avoiding trees that are noticeable outliers (i.e. performing very well or poorly when the vast majority of the remainder of the block is significantly different). With the current data a difference of 3% or 5% (for Rex and Meyric respectively) between computed average trunk diameter for that cultivar and year since planting would normally indicate a significantly smaller or larger trunk diameter than average.

A significant factor contributing to variation between orchards is the soil type and fertility. Those orchards with fertile silt loams appear to have an advantage over those with lighter Eyres, Halket or Lismore soils. However a variety of management practices can alleviate some of the problems associated with these. The individual orchardist must determine whether it is worth the time and money to mulch, compost and apply fertilizer strategically.

Given Canterbury's soils and weather it is possible that some orchardists may be under watering their trees. As previously stated trees with a plentiful water supply grew strongly.

Continuing the Benchmarking Project

The easiest way to measure the growth of your walnut trees is to measure the trunk diameter at 600mm. This is best done during winter in June or July. These can then be compared with other orchards with a similar soil type to your own. You need to measure 25 randomly selected trees of the same age to achieve a statistically valid result.

Once your trees start to produce, keep a record of the nut production from each cultivar in a block. The dry weight in shell should be the standard measurement used. Once we have a range of yield data we will be able to include the effect of management practices in actual nut yield in the benchmarking output.

The percentage blight can be measured by a random count of 20 nuts (5 west, 5 south, 5 north, 5 east) on ten selected trees.

References

Cohen, M., Ameglio, T., Cruiziat, P., Archer, P., Valancogne, C. and Dayau, S. (1997). Yield and physiological responses of walnut trees in semi-arid conditions: application to irrigation scheduling. *Acta Horticulturae* (449) Vol I: 273-280.

Paris, P., Cannata, F., Olimpieri, G., Todaro, L. and Pisanelli, A. (1997). Effects of plastic mulching and intercropping with alfalfa (*Medicago sativa*) on walnut (*Juglans* spp.) growth and tree/soil water relations during early plantation phases. Progetto finalizzato MAF 'Arboricoltura da legno', sottoprogetto 'Latifoglie'. Annali-dell'Istituto-Sperimentale-per-la-Selvicoltura. 1994-1995 (25-26): 285-307.

Appendix 1: Interview to be completed on the spreadsheet on the WIG web pages

Name
Address
Email
Phone
Area planted in walnuts (block size x no. of blocks)
Orchard code
Year planted
Cultivar
No.of trees
Block size
Tree spacing
Average trunk diameter at 600mm from 25 trees (to 2 decimal places)
Soil type
Shelter grade - 0=none, 1=young shelter no higher than trees, 2=immature shelter higher than tree, 3=mature shelter spacing >2m, 4=mature shelter spaced <2m apart, 5=evergreen, mature, dense shelter
Understorey management (clear sprayed, seasonal spray, unmown pasture, mulch, mown grass, compost)
Fertiliser
Blight management (chemical and dates of application)
Percentage blight
Yield per cultivar