Assessment of blackcurrant bush size and wood quality to aid with N recommendations

MAF Sustainable Farming Fund Project L07/047

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Summary

In 2007/08 season bush measurements were made to complement crop removal and soil and fertilizer nitrogen (N) data to improve their relationships to berry yield.

Most bush parameters measured were poorly related to yield, although several showed some promise.

There was no advantage in Ben Ard and Magnus bushes being more than 140-145 cm in height when measured in late winter or 160 cm mid season (Ben Rua could be 10-15 cm shorter).

Crop density or light interception measurements generally showed most bushes should be of intermediate size although this measurement could not isolate old from young wood.

In general, new growth generated the previous season gave the best relationships to yield. The best yields came from crops with moderate to high proportions of new wood.

Crop usage data highlighted a 10-12t/ha crop will remove 80-85 kgN, 15 kgP and 50kg K/ha. Nutrients must meet the requirements for both new shoot and leaf growth and fruit yield.

New soil and fertilizer N data has reinforced existing relationships showing 100-120 kgN/ha must be available to the plant to produce a 10-12 tonne crop.

A set of guidelines has been produced for growers. These outline the best practices to maintain yield consistency and how these can be scored.

Background

In a previous study, MAF Sustainable Farming Fund project 05/008, destructive sampling of plants over two seasons gave some indication of crop removal of the major nutrients. Pot trials also showed the responsiveness of blackcurrants to macronutrients. These indicated that nitrogen was by far the major driver of yield. Accordingly field work concentrated on various soil and herbage methods to help growers estimate nitrogen requirements.

Of the soil test methods used the available N (AMN) test (0-15 cm) was at least as good as any of the new proposals suggested by Hill Laboratories for improving nitrogen fertilizer guidelines to growers. Further, if the soil AMN test was used in conjunction with the soil organic matter or total N content then estimates of crop requirements for a given yield could be made with more accuracy.

Leaf N or sap N were also measured and found to vary too much with leaf maturity and bush size to be of great use. Relationships between N status and yield were less than desirable partly because blackcurrants fruit on second year wood, so in a given year it is important to grow new wood for the following season in addition to meeting the current years' fruit requirements. The amount of plant growth, the level and frequency of pruning and the recycling of pruned and leaf fall residues will all affect the yield. Hence it is important to get some measure of these parameters to improve the accuracy of N recommendations.

Accordingly the purpose of this study was to measure and photograph various parameters that may contribute to bush size or density and relate these to yield. These were to be complemented by soil AMN and crop removal measurements to help strengthen the existing relationships established in project 05/008. The blackcurrant industry was happy to pay for crop removal work as data relating to larger (third year) bushes, more closely reflects the bush size common in commercial crops. The collation of all data would help produce a quick reference chart for growers to aid with nutrition and pruning decisions.

SECTION 1. Crop nutrient usage studies – year 3

This was a continuation of crop removal work commenced in the 2005/06 season, based on Ben Ard, Ben Rua and Magnus bushes planted at Irwell from cuttings in 2004. Full details are given in MAF SFF project 05/008. In brief, in 2007/2008, third year plants were harvested for fruit yield in January, and destructively harvested in May after being partitioned into roots, shoots and leaves.

Some plant physical parameters for the three cultivars are given in Table 1 for all three years.

Table 1. Plant and fruit weights, new wood and leaf growth, 2006-2008

		Plant Dry Wt (gms)[1] *Fruit fresh Wt (gms)*			New wood (mm) and leaf No. respectively		
		2006	**2007**	**2008**	**2006**	**2007**	**2008**
Magnus	Root	63.1	80.9	226.9			
	Shoot	58.2	323.3	583.9	2670	7290	9500
	Leaf	34.4	81.4	138.4	181	429	664
	Fruit		*179.1*	*429.2*			
Ben Ard	Root	51.4	93.2	199.9			
	Shoot	36.9	215.0	556.5	1873	4372	9173
	Leaf	28.4	61.7	125.0	156	339	714
	Fruit		*174.8*	*1237.8*			
Ben Rua	Root	71.9	77.1	236.8			
	Shoot	52.3	271.3	444.5	2147	4887	9797
	Leaf	36.6	65.0	146.4	163	289	799
	Fruit		*221.6*	*1306.3*			

[1] data mean of three plants/cultivar

In year 1 the greatest individual contributor to biomass was the roots which represented 40-45% of the plant biomass. By years 2-3, shoots alone represented approximately 60% of the plant's biomass. Initially, new wood (shoot) growth was more rapid in 'Magnus' (particularly in year 2), although all three cultivars produced a similar amount of new shoot growth in the third year. In year 1 'Ben Rua' produced a smaller number of larger leaves but by year 3 'Magnus' was producing the largest leaves, consistent with this variety. This meant nutrients were partitioned differently between shoot and leaf. The exception was 'Ben Ard' where new shoot to leaf growth was fairly consistent in all three years.

The fruit weights in 2007/08 for 'Ben Ard' and 'Ben Rua' equated to 10-11 t/ha, typical of a mature crop. Lower yields equivalent to 3.5 t/ha for 'Magnus' were a consequence of frost damage. As frost damage affects cultivars differently according to when bud burst occurs in a given season, the crop removal figures for the three cultivars for 2007/08 have been presented as those required by the plant and those lost in fruit removal, Table 2.

Table 2. Crop removal (usage) for year 3 plants, on a per hectare basis[1]

	Magnus			**Ben Ard**			**Ben Rua**		
	N	**P**	**K**	**N**	**P**	**K**	**N**	**P**	**K**
		kg/ha			kg/ha			kg/ha	
Roots	16.8	4	6.5	12.6	2.9	4.6	21.4	4.6	8
Shoots	22.2	4.1	9.2	31.3	5.1	11.1	17.3	2.8	6.9
Leaves	23.2	2.4	5	16.8	1.8	3.6	18.7	2.5	4.5
Total plant	62.2	10.6	20.6	60.7	9.8	19.3	57.5	9.9	19.4
Fruit	8.2	2.1	10.4	24.8	5.3	32.7	21.2	4.6	29.7
Total	**70.4**	**12.7**	**31**	**85.5**	**15.1**	**52**	**78.7**	**14.5**	**49.1**

[1] calculated from increase in growth between year 2 and 3 x mean herbage concentration

From a crop removal perspective and compared to the previous year, 'Ben Rua' used more nutrients for root growth, 'Ben Ard' more nutrients for shoot growth and 'Magnus' more nutrients for leaf growth. This may reflect difficulty in isolating different plant parts when sampling, or there may be varietal differences in growth. Notwithstanding this the total nutrient usage to grow a plant was fairly similar for all three varieties, approximately 60 kgN, 10 kgP and 20 kgK/ha. This represents a 75-80% increase in demand over the previous year for the 'Ben' varieties and a 60% increase for 'Magnus', probably as it grew better in year 2. Fruit removal equates to 2-2.5 kgN, 0.5 kgP and 3 kgK/tonne.

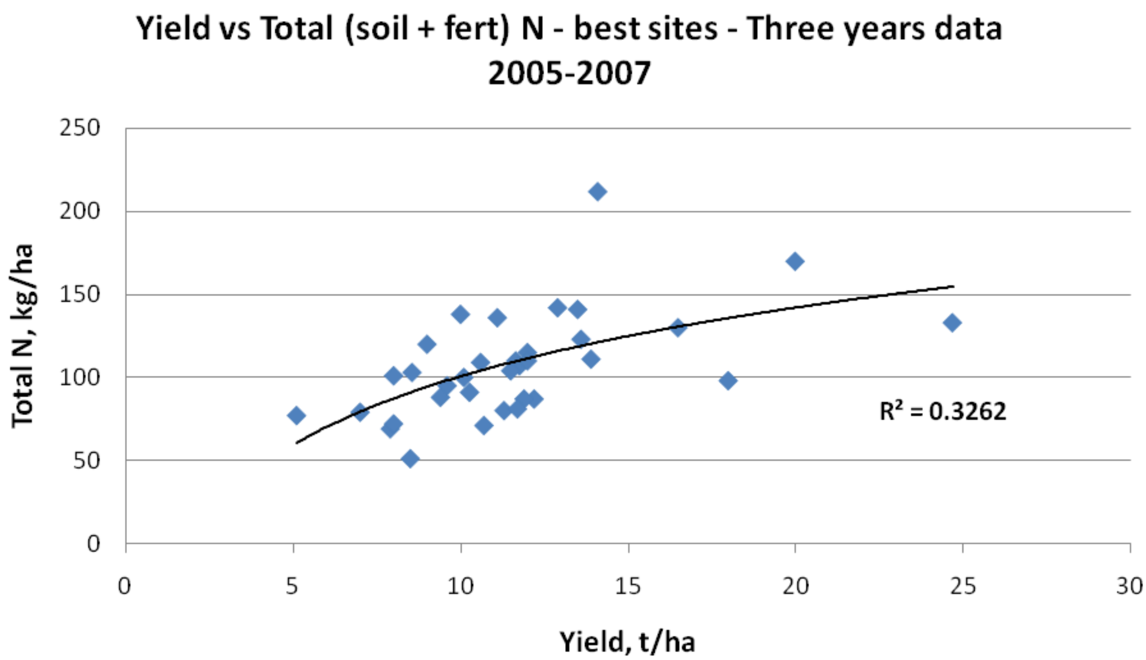
Hence to grow a 10-12 t crop requires 80-85 kgN, 15 kgP and 50 kgK/ha. Although 'Magnus' may yield lower than the 'Ben' varieties they are often larger bushes so have a similar N requirement. Their K requirement may be lower as fruit remove large amounts of potassium.

Year 3 nutrient usage and mean herbage concentrations, for all nutrients are given in Appendix 1. While roots contain more P and K, and shoots more Zn, levels of most nutrients are highest in the leaves despite many of them senescing at this point.

Photos 1-3: Plant height winter 2007, left to right, Magnus, Ben Ard, Ben Rua

SECTION 2. Yield and soil and Fertiliser Nitrogen

The previous study showed a loose relationship between crop yield and total N available to the crop (soil AMN at the start of the season and fertilizer N applied during the season), two years data, R^2 = 0.44. This was developed using only sites where a good yield response was given to N (80 kg fruit/kgN). This helped eliminate non nutrient factors such as pests, disease and frost as being the primary drivers of yield. In 2007/08 the relationship using the best sites was reasonably similar, R^2 = 0.35. As some areas had significant frost damage, the data used in 2007/08 was for a yield response of 65kg fruit/kgN or greater. All three years data has been combined to give the following relationship;



This means to achieve a 10-12 t/ha crop you require 100-120 kgN/ha to be available to the crop. If 75-80% of this nitrogen is utilized by the plant this means a reasonably mature crop must take up 80-90 kgN from soil and fertilizer to produce a fruit crop and adequate shoot growth for next season. This is approximately what was calculated as N usage in section 1.

Variances from this 'average' curve can be accounted for by soil and plant growth conditions. Where soils have high organic matter levels these reserves will replenish available soil N levels and so yields may be good at lower soil AMN and fertilizer applications. Similarly on light stony soils (which also have less organic matter), plants will be less efficient at utilizing N, as they are at cooler spring soil temperatures when N mineralization is slower. In these situations soil AMN and fertilizer N applications would need to be higher.

SECTION 3. Yield and Bush Growth

The remainder of this project seeks to examine various physical measurements that can be made in crops, to see if these can be related to yield. These may help fine tune grower recommendations.

In the 2007/08 season various measurements were made of plant growth to complement soil AMN and leaf N analysis. In total 41 crops were used, involving the varieties 'Ben Ard', 'Ben Rua' and 'Magnus' (plus one 'Murchison' crop). Most blocks had been previously monitored in the original project 05/008 so background data was available on the crops. In total crops on 18 grower's properties in Canterbury and Nelson were involved.

Crop measurements included crop height and width (spring and November), triangular area/volume of bush, the amount of extension growth prior to and the extra wood generated during the season, old vs young wood, light interception by the crop, leaf size, depth of fruiting through the canopy and yield. Data was also collected on fertilizer inputs and cultural practices such as pruning. In addition photographs were taken of bush growth in spring prior to budburst and in November.

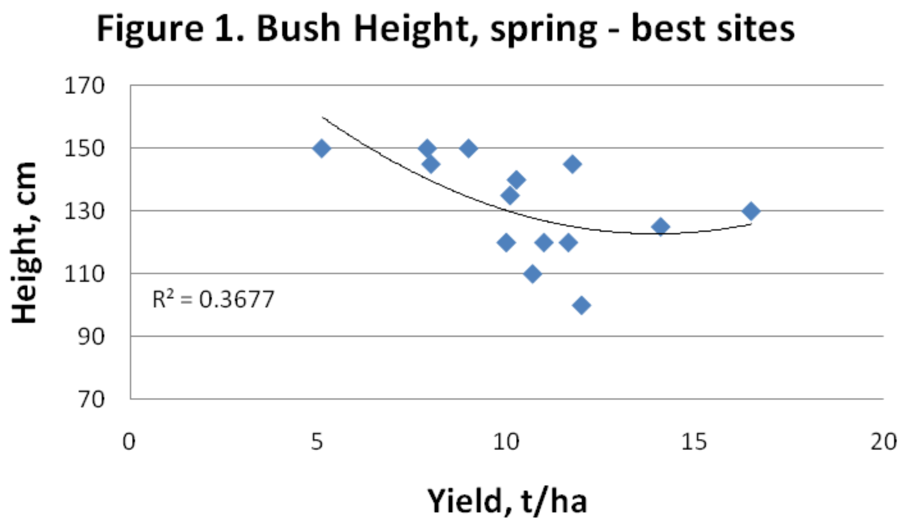
During the 2007/08 season many crops suffered frost damage mainly caused by a late frost in mid October 2007. This meant most crop measurements gave poor relationships to yield. Therefore data from more than half the sites could not be used with any confidence in yield relationships. To strengthen the data pool, where applicable information collected in previous work has been included.

Full data for the best sites is included as Appendix 2.

3.1. Spring Measurements/Relationships

Data from all varieties has been combined. Despite the different growth habit of 'Ben Rua' most relationships were similar, except for new growth.

1. Crop height – in spring crops (all sites) averaged almost 140 cm in height. 'Ben Ard' bushes were slightly above the average and 'Ben Rua' below the average. For the best sites there was a trend (R^2 = 0.37) for intermediate bushes to produce the best yield, Figure 1. There was no advantage in bushes being over 140-150 cm tall.



2. Crop width – crops averaged 150 cm in width with 'Ben Ard' averaging 160 cm and the others much lower. However there was no real relationship between width and yield.

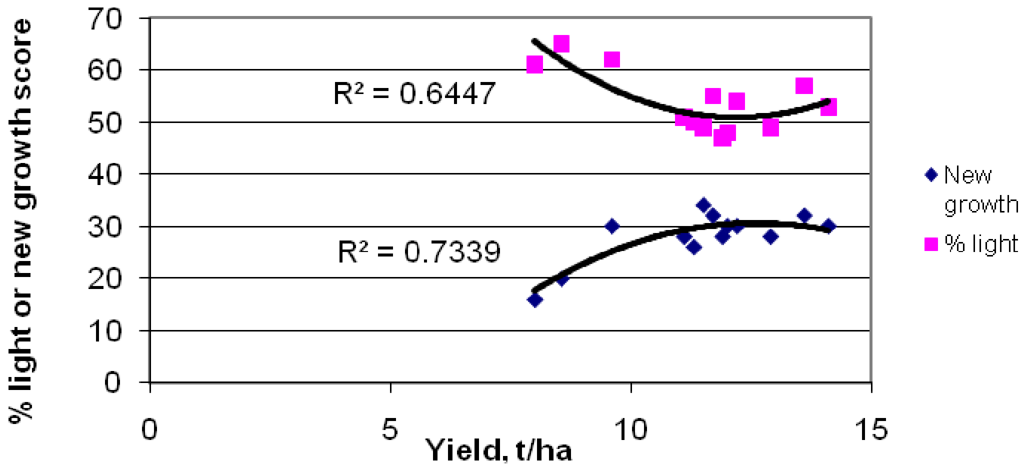
3. 'Ben Ard' tended to produce buds over a greater height of the bush although in general taller bushes usually produced buds higher up the plant.

4. Bush volume – 'Ben Ard' had the greatest volume of wood while 'Ben Rua' had the least. For the best sites there was little relationship. However the densest bushes were often lower yielding bushes. Crop density was better reflected in data relating to light interception. One guide was to look at the number of rows that could be seen by looking under the base of the rows. Where it was difficult to see beyond two rows bushes might be considered too dense and similarly where a fourth or even fifth row could be seen then bushes might be considered too thin. However this approach did not consider the age or the quality of the wood present (i.e. its ability to produce fruit).

Photos 4-6: Crop on left too thin, centre about right, right too thick

Light interception by the crop might be seen as a better measure but again the results were quite variable, range 45-65%. In the previous season, 2006/07, light interception gave a reasonable relationship with yield, $R^2 = 0.64$, Figure 2. Where over 60% light could be seen through the mid canopy yields were lower.

Figure 2. Blackcurrant yield vs % light seen through the crop or new wood produced, best sites 2006

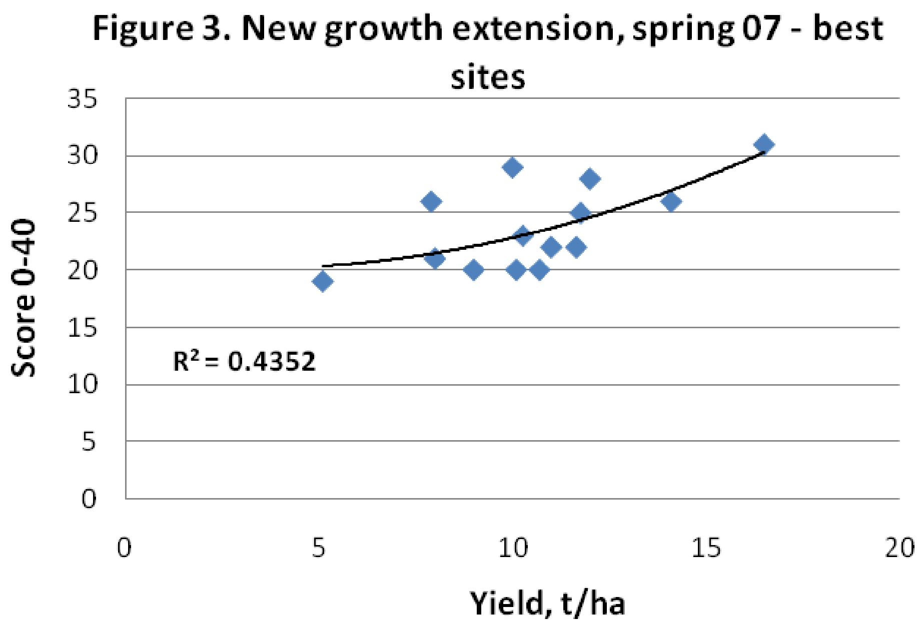


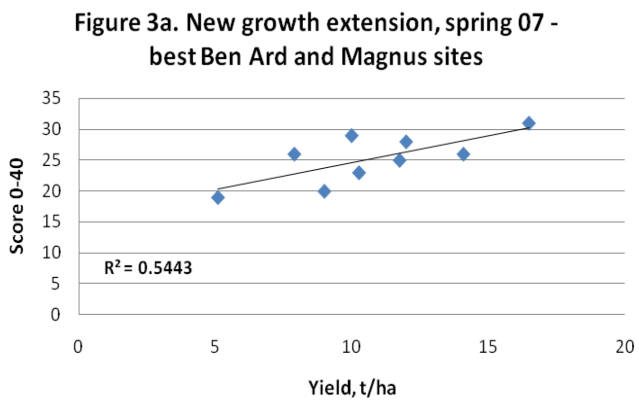
On crops yielding 10 t/ha or more, the best sites had between 45-55% light interception in both years (see photos for examples).

Photos 7-9: Light and new cane, left 60% light but young cane, centre 50% light, good cane, right <40% light, reasonable cane age but too bulky

5. Isolating older wood from younger wood proved difficult. Depending on the severity of side pruning and how early in the life of the stand pruning commenced, the older wood carried varying percentages of younger wood. Consequently the relationship between yield and % of older wood was fairly poor R^2 = 0.26. The trend was for the higher yielding crops to have less old wood. On average two thirds of all 41 crops received some pruning during the 2007 winter (of which all bar one were side pruned, the other being centre pruned).

   In 2006/07 scoring the amount of new growth in spring gave a good relationship to yield, R^2 = 0.73, Figure 2. Low yielding crops had less new growth compared to high yielding crops which had moderate or good new growth. In 2007/08 the data on the best sites showed a looser relationship, R^2 = 0.44, Figure 3 although this relationship was strengthened to R^2 = 0.55 by only including 'Magnus' and 'Ben Ard' data (Figure 3a). This highlights the importance of inputs being tailored to meet new cane for next season as well as to this season's yield. HortResearch have come to the similar conclusion for plant evaluation in their breeding program. We have endeavored in the guidelines to show growers how to measure this parameter in a quick and simple manner although it would be useful in the future to expand the scoring system and tie it in more closely with actual yield of the photographed or measured plants rather than the block as a whole.

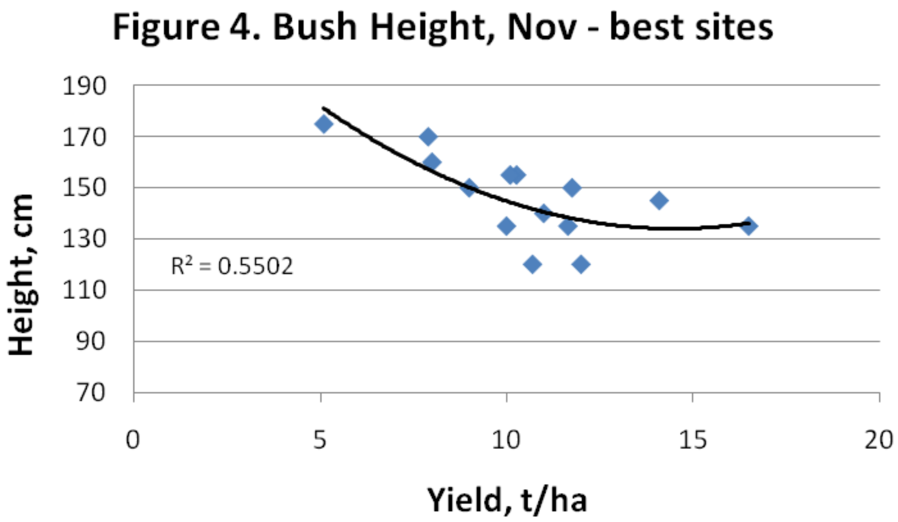




3.2. November (mid season) relationships

Data presented is for the best sites and relates to all varieties, however by eliminating 'Ben Rua' in many cases the relationships improve. Where it is considered relevant, relationships for only 'Ben Ard' and 'Magnus' are given in brackets.

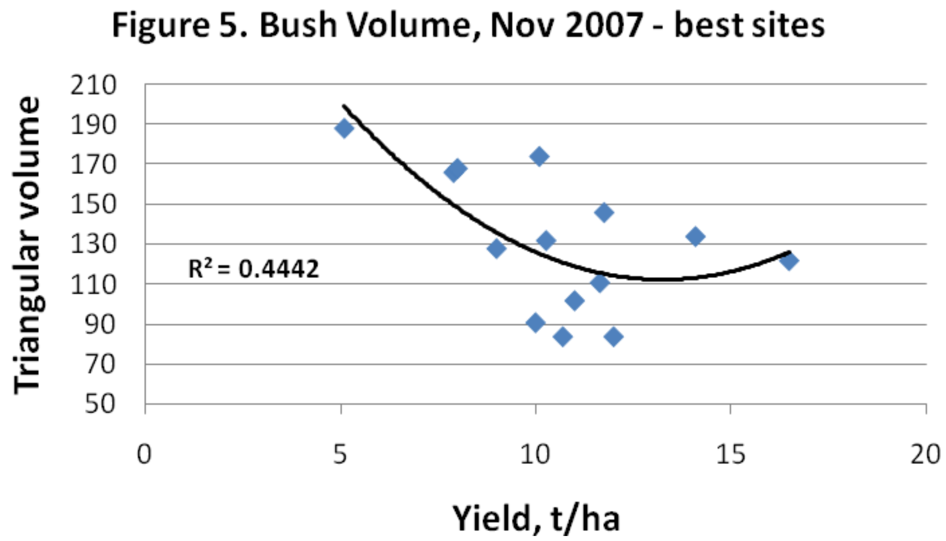
1. For the best sites crop height gave a stronger relationship than it did in the spring, R^2= 0.55 (R^2 = 0.60), Figure 4. Overall, most plants fell between 120-160 cm in height ('Ben Rua' were the smallest). There was no advantage in a bush being over 160 cm in height.



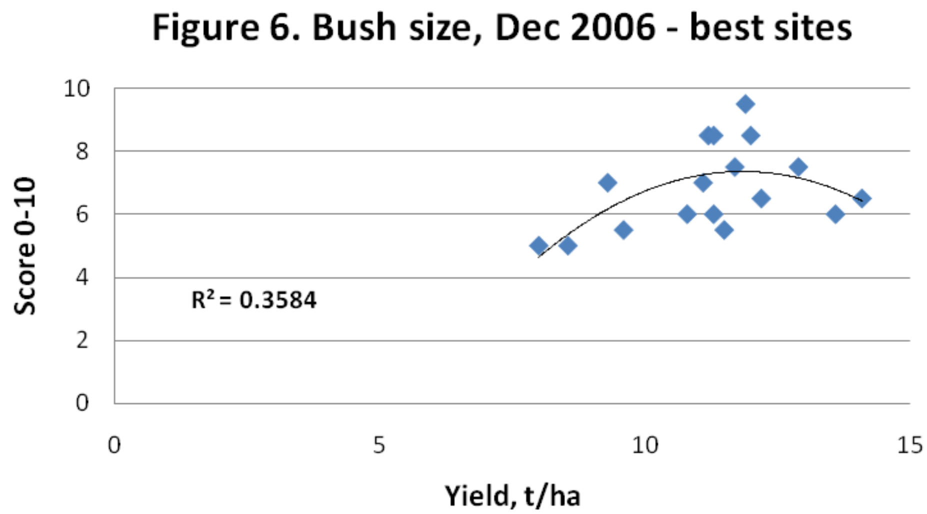
Photos 10-11: left is about optimal. Does the crop on the right need to be this high? (Red mark = 120 cm).

2. Crop width averaged 175 cm but was quite variable in relation to yield as some heavily laden branches flop out while others with intermediate yield, or more robust cane do not.

3. Bush volume was similar to that for spring data but was more strongly related to yield due to November height being a stronger parameter to measure, R^2 = 0.44 (R^2 = 0.55), Figure 5. Assuming there is no advantage in bushes being over 160 cm high then these bushes would not want to be more than 180 cm wide. However, in practice taller bushes are more likely to fall out so would be wider anyway.



4. General bush size was also scored with yield but showed little relationship. In the previous season, 2006/07 when bush size was also scored (early December) there was a slight relationship to yield, R^2 = 0.36, Figure 6. While this trend suggested the lower yielding crops came from smaller bushes, it also showed that bushes only needed to be of moderate size to ensure good yields.



5. Yield relationships with the current season's new wood which were measured in late November were poor whether it was scored or physically measured. Top growth on the best sites ranged from 6-17 cm but was highly variable. New base shoots were less variable, range 23-41 cm, R^2 = 0.34 (R^2 = 0.44). Generally the higher yielding sites had less new growth suggesting there was some partitioning of inputs between yield and growth. This is of concern as the requirements for both yield this season

and new shoot growth for next season are necessary. This not only could lead to some degree of biennial bearing, it could also have some implications as to the timing of N on crops. Early N (and even post harvest N the previous season may help the current season's fruit, while mid to late season N may help next season's buds and wood.

Delays in pruning in the early years of a bushes life probably have some effect as well. Bushes which have too much old wood then have to be pruned hard to give young wood a year out. A lighter pruning from the onset will lead to a mix of wood ages at any time.

6. Leaf size and leaf N concentration were poorly related to yield. 'Ben Rua' tended to have the smallest leaves. Leaf N also showed little relationship with new growth, leaf size or bush volume, reinforcing the view that leaf N alone is of limited use as a monitoring guide, if taken at the traditional mid December sampling time. The industry and analytical laboratories need to review the role and timing of leaf analysis in blackcurrants.

Photos 12-13: average size bushes with reasonable light interception and density developed on bushes with adequate young wood are likely to be the best yielding bushes

In summary the majority of bush parameters measured were poorly related to yield even when only the best sites were used. It was also difficult with some parameters to repeat trends observed in the previous season.

One of the simplest parameters to measure is crop height and to a lesser extent bush volume. There is no advantage in having tall bushes; >140-145 cm in spring, >160 cm in November (for 'Ben Rua' these could be lowered 10-15 cm). Relationships in mid season were stronger although perhaps less practical except for making recommendations for the following season.

Bush volume, density and light penetration are important but don't necessarily give good or repeatable relationships. In general three and sometimes four rows should be seen through the base of the crop in winter. If more rows can be seen or more than 60% light can be seen through the mid canopy indicate the crop is too thin. Equally where bushes are too dense (light penetration below 45% or it is difficult to see a third row through the crop), pollination may be poor, and too much older vegetative growth may be present leading to higher humidity and disease pressure.

Adequate new top and particularly basal growth is essential to provide healthy shoots on which to fruit next season. Although current season measurements were poor in both 2006/07 and 2007/08 scoring of new shoot growth, i.e. that produced the previous season, shows promise. The best yielding crops have average to above average amount of newer (one and two year) wood. This can easily be done in winter when it can aid with pruning decisions. A 0-10 or 0-40 scoring system where >6.5 or >26 are good, utilising photographs, is the best way to measure this. There is a need to further refine this system to improve its accuracy.

Regular side pruning will encourage new basal growth and preferentially take out the older and taller wood that was carrying more biomass and/or fruit the previous season. This wood is also likely to be more infested with clearwing which further reduces yield.

Conclusion and Recommendation

1. A set of grower guidelines has been produced to aid growers with pruning decisions to improve yield consistency. This combines height, light and new wood scoring information, with crop nutrient use, and soil and fertilizer N vs yield data collated over the previous three seasons. Photographs are an integral part of this and have been included in a two page set of guidelines to be sent to growers.

2. That the scoring system for newer wood be refined further to improve the guidelines.

Acknowledgements

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HortResearch

Sustainable Farming Fund
Ministry of Agriculture and Forestry
Te Manatū Ahuwhenua, Ngāherehere

nutrient solutions

Appendix 1. Crop Removal Data - nutrient usage in year 3, and mean herbage concentration (three years)

Usage		N	P	K	S	Ca	Mg	Fe	Mn	Zn	Cu	B
		kg/ha						g/ha				
Magnus	roots	16.8	4.0	6.5	1.8	6.4	1.5	406	17	46	12	21
	shoots	22.2	4.1	9.2	2.4	11.4	2.1	282	36	114	30	30
	leaves	23.2	2.4	5.0	2.7	36.8	5.3	728	53	46	32	86
	fruit	8.2	2.1	10.4	0.7	1.8	1.1	35	9	8	3	9
	Total	70.4	12.7	31.0	7.7	56.5	10.0	1451	116	214	77	145
Ben Ard	roots	12.6	2.9	4.6	1.3	6.2	1.1	390	20	34	8	13
	shoots	31.3	5.1	11.1	2.6	16.9	2.8	288	60	173	35	35
	leaves	16.8	1.8	3.6	3.2	39.0	5.6	518	73	47	27	75
	fruit	24.8	5.3	32.7	2.2	3.4	2.1	67	19	23	9	23
	Total	85.5	15.1	52.0	9.2	65.5	11.6	1263	172	277	80	145
Ben Rua	roots	21.4	4.6	8.0	2.4	8.1	1.7	815	33	52	14	23
	shoots	17.3	2.8	6.9	1.8	7.4	1.5	377	36	80	15	20
	leaves	18.7	2.5	4.5	3.0	47.3	6.6	1004	83	81	32	104
	fruit	21.2	4.6	29.7	1.6	2.9	1.6	54	10	20	7	21
	Total	78.7	14.5	49.1	8.9	65.7	11.4	2250	161	233	67	167

Herbage Conc.		N	P	K	S	Ca	Mg	Fe	Mn	Zn	Cu	B
		%						mg/kg				
Magnus	root	1.38	0.33	0.53	0.15	0.53	0.12	333	14	38	10	17
	shoot	1.02	0.19	0.42	0.11	0.53	0.10	130	17	52	14	14
	leaf	2.01	0.21	0.43	0.23	3.19	0.46	631	46	40	28	74
	Fruit	0.23	0.06	0.29	0.02	0.05	0.03	10	2	2	1	3
Ben Ard	root	1.42	0.32	0.52	0.14	0.70	0.12	439	22	38	9	15
	shoot	1.10	0.18	0.39	0.09	0.59	0.10	101	21	61	12	12
	leaf	1.61	0.18	0.34	0.31	3.75	0.54	497	70	45	26	72
	Fruit	0.24	0.05	0.32	0.02	0.03	0.02	6	2	2	1	2
Ben Rua	root	1.61	0.34	0.60	0.18	0.61	0.13	612	25	39	11	17
	shoot	1.20	0.20	0.48	0.12	0.51	0.10	261	25	55	10	14
	leaf	1.53	0.20	0.37	0.25	3.88	0.54	824	68	67	26	85
	Fruit	0.20	0.04	0.27	0.02	0.03	0.02	5	1	2	1	2

Appendix 2. Spring and November bush measurements best blackcurrant sites only, 2006/07

Spring Data												
Cultivar	Soil N	Fert N	Total N	Yield	Height	Width	Bud Depth	Bush Vol	light thru rows	old wood	light thru bush	new wood
	Kg/ha	Kg/ha	Kg/ha	t/ha	cm	cm	cm	cm3		%	%	0-40
Ben Ard	95	20	115	12	100	130	60	65	3	33	52	28
Ben Rua	51	20	71	10.7	110	140	75	77	3	33	47	20
Ben Ard	98	32	130	16.5	130	160	85	104	3	40	51	31
Magnus	111	27	138	10	120	120	60	72	3.5	50	57	29
Ben Ard	170	42	212	14.1	125	180	55	112	3	65	47	26
Ben Ard	69	0	69	7.9	150	180	80	135	3	50	48	26
Magnus	77	0	77	5.1	150	155	80	116	3	50	50	19
Ben Rua	37	55	92	11	120	120	80	72	4	33	60	22
Ben Ard	71	20	91	10.27	140	120	90	84	3	40	54	23
Ben Rua	90	20	110	11.65	120	125	70	75	3	50	54	22
Ben Ard	93	27	120	9	150	135	95	101	3.5	40	65	20
Ben Rua	101	0	101	8	145	160	75	116	3	40	57	21
Ben Ard	107	0	107	11.76	145	160	75	116	3	55	45	25
Ben Rua	100	0	100	10.1	135	185	80	125	2.5	80	47	20
November Data												
Cultivar	Height	Width	Bush Vol	young wood	leaf size	Leaf N	young wood	top growth	base growth	mean growth		
	cm	cm	cm3	0-10	0-10	%	0-10	cm	cm	cm		
Ben Ard	120	140	84	5.5	6	2.9	6.9	10	28	19		
Ben Rua	120	140	84	5	5	2.5	6.9	10	26	18		
Ben Ard	135	180	122	5	5.5	2.8	6.3	6	23	14.5		
Magnus	135	135	91	5	5	2.8	7.2	8	23	15.5		
Ben Ard	145	185	134	6	6	3	6.2	6	25	15.5		
Ben Ard	170	195	166	8	7	3	5.7	9	41	25		
Magnus	175	215	188	7	5.5	2.8	6.2	8	32	20		
Ben Rua	140	145	102	7.5	8	3.1	6.5	9	34	21.5		
Ben Ard	155	170	132	6.5	7.5	3.3	5.5	13	33	23		
Ben Rua	135	165	111	6	6.5	3.1	6.3	14	30	22		
Ben Ard	150	170	128	6	6	3.1	4.9	12	31	21.5		
Ben Rua	160	210	168	5	6.5	3	4.3	17	28	22.5		
Ben Ard	150	195	146	5.5	7	3	5.6	14	30	22		
Ben Rua	155	225	174	5	6.5	2.5	3.5	13	32	22.5		