4

Differences of maturity within the bunch

The interest in this chapter is firstly to record the variations that we see. Secondly, it is to wonder, in the word of Professor Julius Sumner Miller, why is it so?

Those who cultivate the vine commonly hold the view that the smallest berries are the sweetest. Is berry size per se the key to differences in maturity? Is it the case that the smallest bucket fills faster than the larger or does the act of filling stop the bucket stretching as much? Does the bucket have a mechanism to attract the water or is it just a receptacle that happens to be in the right place. Do the buckets closest to the tap fill faster? Is the pipe size important? Does gravity play a role as it does in many other hydrological and physical systems? Is evidence of large variation in solute strength prima facie evidence for deficiency in supply in relation to the number of berries/buckets to be filled?

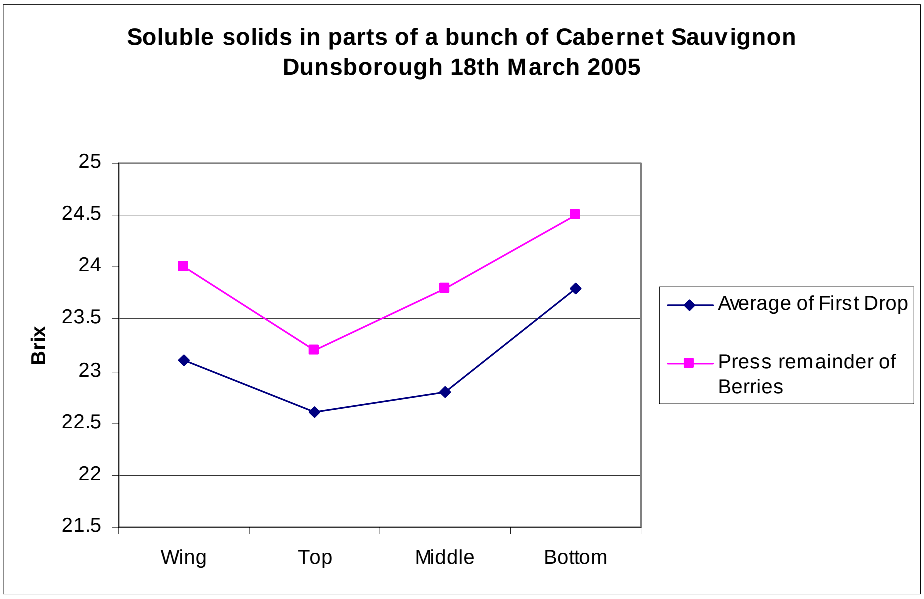
We want to know whether important variations manifest in the fruit within the bunch. We do not expect to arrive at universal laws that relate to berry development in all circumstances but if large variations do exist it would be nice to have some ideas as to the source of the variation and how we might go about producing fruit of more uniform maturity.

There is a difficulty in establishing the size of a berry. A sugar solution has a higher specific gravity than water. The weight of a berry is due to its volume and secondly to the strength of solute within it. We could establish its volume by displacement or by calculation, if the berry were a sphere. In the special case where solute strength is exactly the same in all berries differences in weight will be due entirely to differences in volume.

However, there is no real need to complicate the issue. If it is found that the smallest berries by weight have the greatest solute strength, the proposition 'the smallest berries are sweetest' is confirmed. This is so because the actual volume of the smallest berry by weight will be smaller than its weight suggests. Superior sweetness increases its specific gravity. Hence we can test the proposition that the smallest berries are the sweetest quite satisfactorily using weight as an indicator of volume.

Figure 4-1 records the average solute strength of the first drop expressed from each berry according to origin in wing, top, middle or bottom of the bunch. The solute strength of the remainder of the berry in each part of the bunch is also recorded.

Figure 4-1

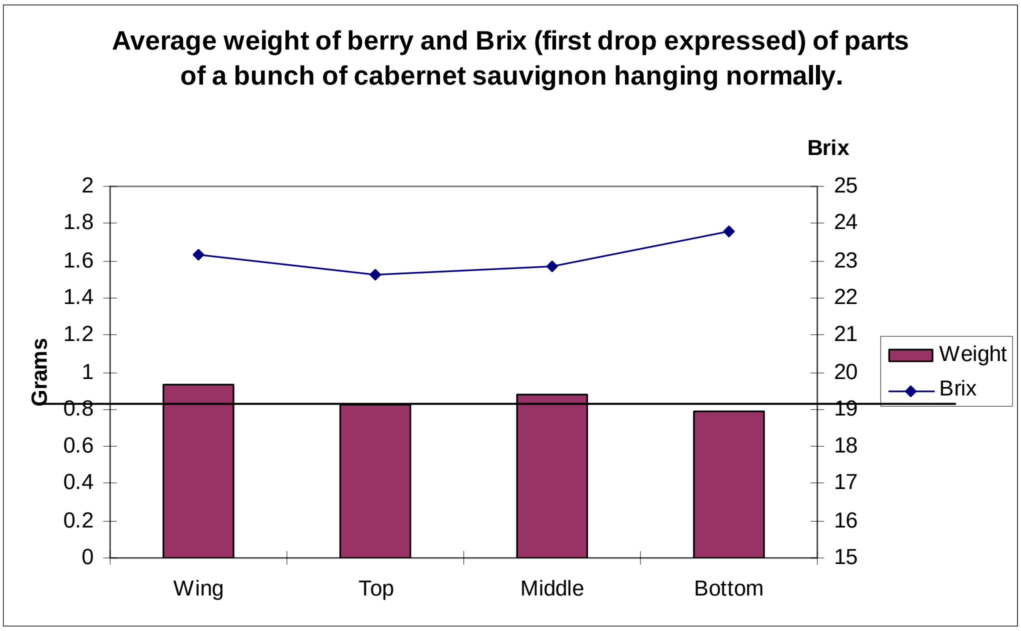


Observations:

- The soluble solid level of the remainder of the berry is greater than that of the first drop expressed by about 1.5 Brix regardless of origin. The relationship between the two is consistent. It follows that it is possible to obtain an idea of the degree of dispersion of soluble solid levels by sampling the first drop rather than squeezing the berry as a whole and mixing the contents with its associated problems of degree of pressure to apply, container to use and possible contamination of one sample by another.
- The wing and the lowest part of the bunch recorded the highest solute levels and the top of the bunch the least.

Figure 4-2 records the average weight of the berries in each location together with solute strength of first drop expressed from each berry.

Figure 4-2



Observations:

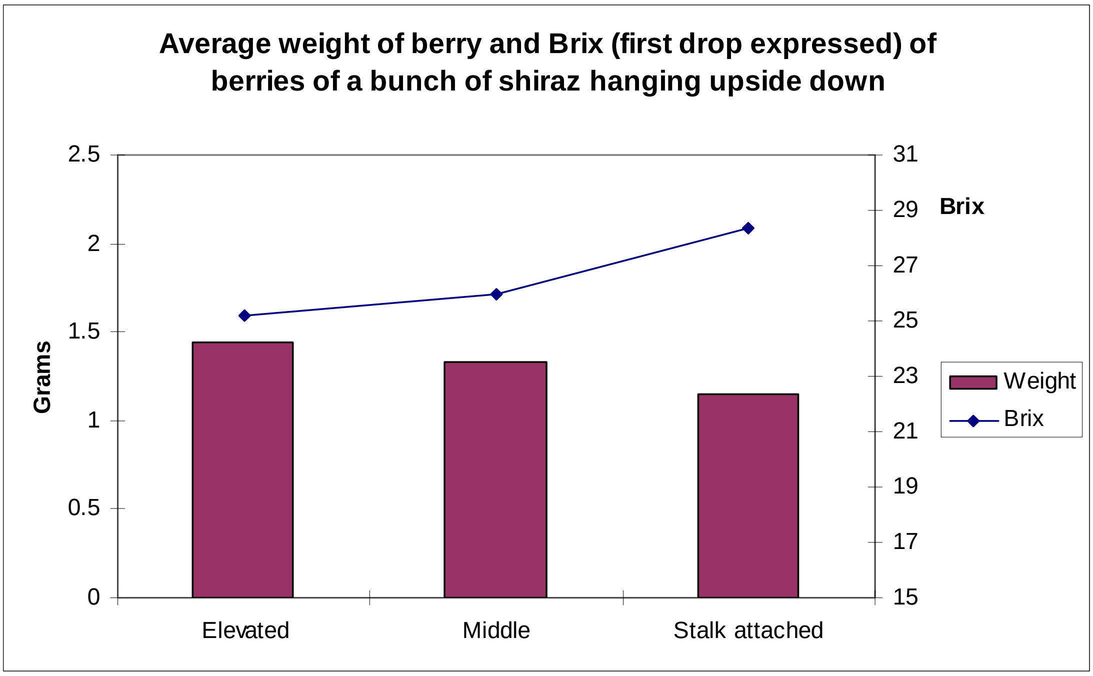
- The weakest solute strength occurs at the top of the bunch. The middle of the bunch has a higher solute strength but the greatest is seen at the bottom of the bunch. The wing has a higher solute strength than the top or middle of the bunch despite its elevation.
- The basal berries are approximately 15% lighter than the berries in the wing despite their higher solute strength. The basal berries are the smallest in the bunch by weight despite their higher solute strength. They must then be the smallest by volume.
- The next highest solute level is in the berries located in the wing that are the heaviest berries in the bunch. Berries in the wing with 15% more weight than the berries at the base of the bunch have only 3% less solute strength (23.1 Brix versus 23.8 Brix respectively).

Although the sweetest berries are the lightest and smallest it is apparent that sink size is not the only factor driving solute strength in berries in this bunch because the heaviest berries located in the wing have the next highest solute level. The wing has its own branch connection from the bunch stalk. That is a bit like having a good water supply because you are close to the main. The smaller diameter garden hose delivers a flow in inverse proportion to its length. As to why the greatest solute strengths are in the bottom of the bunch, then, perhaps gravity plays a role.

There is evidence in this data that sugar is in shortage and the sinks are filling unevenly. Perhaps, if we waited a little longer the solute concentration might even out? On the other hand, if we reduced the number of berries / buckets to be filled, they might fill more evenly? Alternatively, we might increase the factories for sugar production, the leaves. Still another alternative would be to put sugar aside prior to ripening so that it can be rushed to the berries when required.

Let us further explore the notion that gravity plays a part in determining solute strength. Figure 2 records the solute strength and berry weight seen in a bunch of Shiraz that developed hanging *upside down*.

Figure 4-3



Observations:

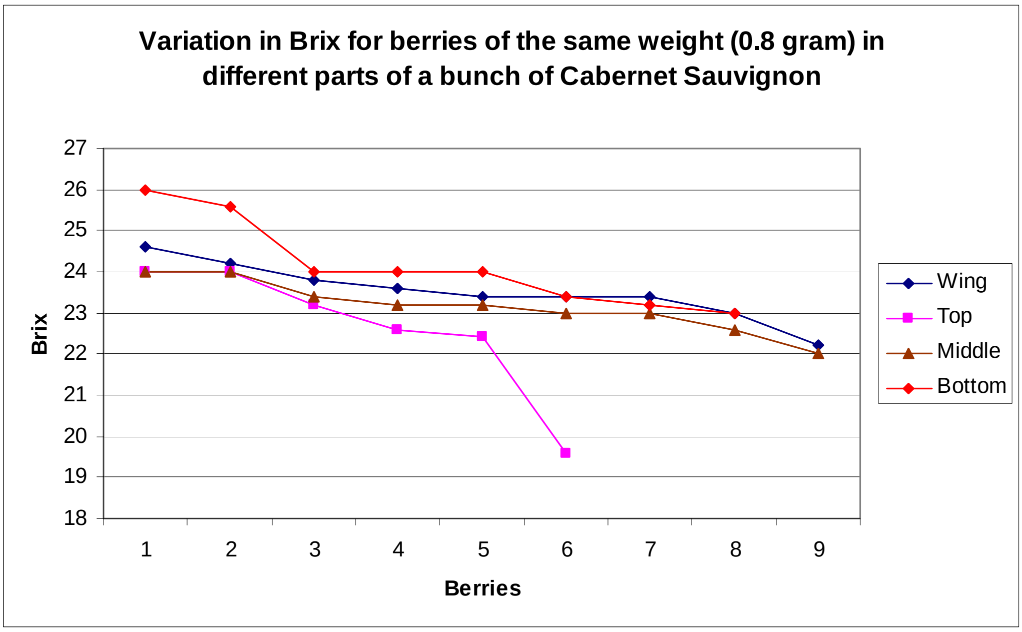
- Berries on this bunch of Shiraz are heavier at 1.2 to 1.5 gr. than the Cabernet at .8 to .9 gr. and the spread of weights is greater.
- There is a similar distribution of sugar between parts of the bunch except that the part of the bunch that is attached to the cane is now the lowest portion and has the highest solute levels. It also has the lightest (and smallest) berries. The lowest solute level is now at the most elevated part of the bunch where the heaviest berries are located. This suggests that the gravity effect is indeed influential.
- The heaviest berries are the most elevated whereas the heaviest berries on the cabernet bunch were in the middle and the wing.
- The difference between the extremities in the upside down bunch is 3 Brix, rather more than the 1 Brix difference between the extremities of the Cabernet bunch. This occurs despite the much more elevated sugar levels in the bunch as a whole. (Later in the study we see that differences in solute strength tend to diminish as solute strength increases). Could it be that one of the mechanisms for solute strength increase in the bunch is via escape of low solute strength material via the xylem and that this process is inhibited when the bunch is hanging upside down? Another possible mechanism for displacement of low solute strength material would be via evaporation. If that were the mechanism then the smallest berries with the highest surface area to volume should be the sweetest.

The difference in the pattern of solute accumulation in the upside down bunch tends to suggest that *sink size and position* is one factor in determining sugar concentration since the largest berries have the least sugar concentration. The wing in the Cabernet bunch had a relatively high concentration of solute despite its relatively large berries pointing to a *'proximity to source'* factor. That is reinforced by the presence of the highest solute strength in the stalk attached section of the bunch of Shiraz. Since it is always the smallest berries that are sweetest we can not rule out the possibility that high solute strength might inhibit berry expansion. (The act of filling stops the bucket growing?)

Apart from all these interesting possibilities the critical thing to notice is that there is a marked variation in solute strength between parts of the bunch. This is a big issue because berry flavour may vary even more than solute level. What a winemaker wants is uniformly ripe fruit. If there is a variation within the berry and between parts of the bunch our interest as grape growers should be in reducing that variation. Let us explore that variation a little further.

Figure 4 records the variation of solute concentration in berries weighing .8 gram in the same part of the bunch. For ease of observation the berries are arranged in order of decreasing solute strength from left to right. It is better to represent all the individual berries than to rely upon an average solute strength for the group and record the range or standard deviation. More statistics does not necessarily yield a plainer understanding.

Figure 4-4



It should be appreciated that although these berries weigh the same amount their volume may not be the same. Some of the higher solute strength berries might in fact be smaller. Differences in Brix could be disguising differences in volume. However, at this point we are simply interested in variations in solute strength for berries of a roughly similar size.

Observations:

- The range in soluble solid concentration is 18 to 26 Brix and this is rather less than over the bunch as a whole as will be reported in fig 4-5.
- The least variation occurs in the middle (2 Brix), followed by the wing (2.4 Brix) the bottom (3 Brix) and the top of the bunch (4.4 Brix). *The greatest variation in solute concentration for berries of the same weight occurs where it is least, at the top of the bunch.*

Interpretation:

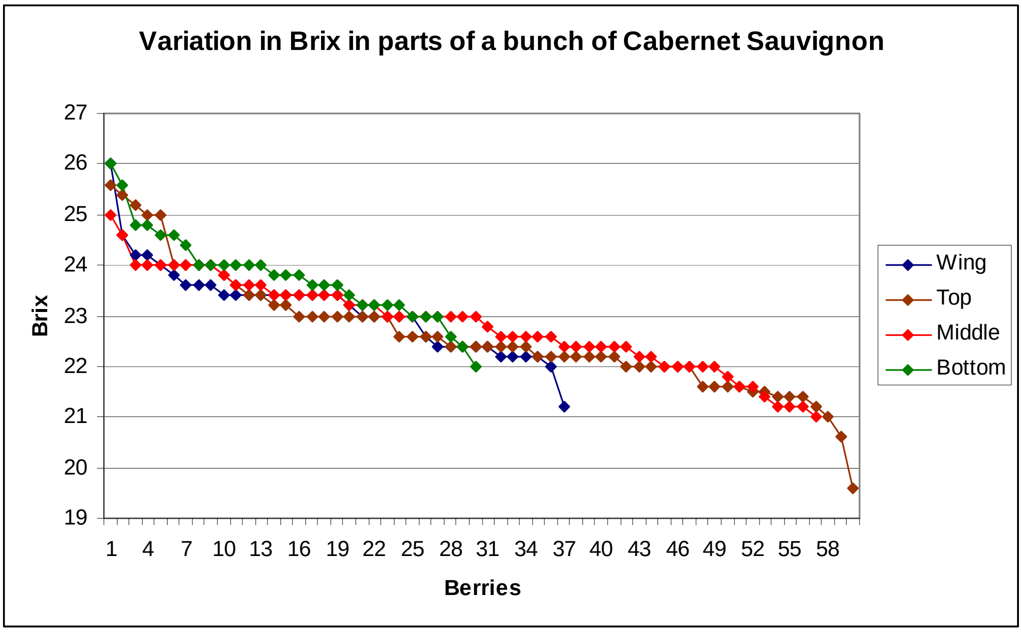
- The range of solute strengths seen amongst berries that are identical in weight and similar in size suggests that high sugar content is not an impediment to berry size increase.
- Given the variation in solute content amongst berries of a similar size in the same part of the bunch other factors than position in the bunch and berry size must be influential in determining berry solute strength. Perhaps these factors might include *seed number* and differences in the

stage of developmental reached by individual berries relating perhaps to *differences in the timing of berry softening and colouring up*. **Ollat 2002 Ollat Nathalie et al Grape Berry Development : A Review. J. Int. Sci. Vigne Vin, 2002, 36, no 3, 109-131** reported a relationship between seed number and berry size. Gibberellin is released by seeds and promotes cell enlargement. Berries with more seeds show no response to gibberellin applications. However, as we have seen, the heaviest berries are usually the least developed in sugar concentration. Perhaps the relationship between seed number and sugar concentration is antagonistic. Perhaps this is simply related to the size of the berry in relation to the limited flow of substrate. Perhaps the seeds utilize sugar in their development. Perhaps the presence of seeds delays verasion.

- It is possible that the variations that we are witnessing are simply the result of a shortage in supply in relation to demand and that the larger and more distant sinks are disadvantaged. To discover whether this is the case we need to know more about the vine that produced this fruit.

Figure 5 presents the range in solute strength recorded for berries of *all weights* in different parts of the bunch.

Figure 4-5



Observations:

- Berries at the base of the bunch range from 22-26 Brix, (4 Brix) in the middle from 21 to 25 Brix (4 Brix) and at the top from 19.5 to 25.5 (6 Brix).
- If we look at the weight distribution of the berries in different parts of the bunch we discover that berries of a weight 0.6 to 1.1 gram inclusive (covering the bulk of the fruit) represent the following proportions of the total. Middle 84% (4 Brix variation), Wing 75% (4.8 Brix variation), bottom 73% (4 Brix variation), and Top 65% (6 Brix) variation. It is probable that a low variation in Brix in the middle of the bunch is associated with relative uniformity in berry weight whereas the greater dispersion in Brix at the top of the bunch is associated with a similar dispersion of berry weight. This data tends to support the proposition that sink size (as reflected in weight) influences the rate of solute concentration.

Questions:

1. What factors determine berry size? Is seed number the key to berry size? Is seed number associated with low solute strength?

2. If a winemaker is to taste berries in the vineyard to assess whether green flavours have disappeared, is the place to look at the top of the bunch where solute level is least and dispersion greatest? Later we learn that berries at the top of the bunch tend to have more seeds but fewer green seeds.
3. Variation in Brix between different circumstances could be assessed by calculating the proportion of berries that lie within 2 Brix of the average Brix level. Could this measure identify fruit from superior vineyards? Would this measure assist winemakers in determining the allocation of fruit to different end purposes? Are these vineyards characterised by a better relationship between source (leaves) and sink (fruit volume)?

The way forward: The scope for variation in the harvest begins at the level of the individual berry. The evidence suggests that the range in solute concentration that can exist is dramatic. It is obviously vital to search for the factors responsible for this variation. In the sections and chapters that follow we look at bunches from different parts of the vine and the entire vine for factors that might be responsible. We also look at bunches at different stages of development. In doing so we ask whether the difference in solute concentration within and between bunches is the result of particular viticultural circumstances like:

1. Seed number in a berry
2. Bunch size.
3. Bunch length.
4. Number of bunches on the cane.
5. Bunch position on the cane.
6. Cane position on the vine.
7. Method of pruning.
8. Bunches supplied by leaves well exposed to early morning sunlight versus bunches supplied by leaves exposed only in the afternoon.
9. Weight of permanent part of the vine (as it reflects carbohydrate storage capacity) in relation to crop.
10. Differentials in entry to budburst, flowering and verasion.
11. Vine moisture relations and irrigation practices.
12. Exposure of the berries to sunlight.
13. Berry temperature.
14. Vines with deficient, adequate or luxuriant leaf area in relation to crop.

Anatomy of a bunch at mid verasion

The effort to make the observations below was driven by an interest in the following questions:

1. Does berry seed number drive berry size?
2. Where in the bunch are the berries that carry more seeds. Is the distribution of many seeded berries a result of nutrition factors at the pre flowering stage of development of the bunch or simply light and heat at flowering time as commonly suggested in the literature?
3. Is there a relationship between seed number and the time of verasion in a berry? What accounts for the slower development of some berries on the bunch that gives rise to a difference of soluble solid level of the order of 6 Brix between one berry and another at maturity?
4. Is there evidence in the way in which verasion begins that it starts in a particular part of a bunch. Does the answer to that question suggest a way that the process is initiated in the grape berry and the type of forces that lie behind it?
5. Are the immature green flavours in fruit associated with multiple seeded berries more than single seeded berries?

Table 4-6 gives some details relating to the population of berries in a single bunch of Merlot harvested in Dunsborough at mid verasion on 10th February 2006. The population is classified according to the number of seeds in the berry. The table provides the average berry weight, average soluble solid level of the first drop expressed from the berry, the number of berries that fell into the category, the proportion that number bears to the total number of berries in the bunch and it further divides the population according to whether the berry has colour or not.

Table 4-1

Bunch of Merlot at mid verasion						
No seeds in berry	Berry weight gr.	Brix	No berries	% Total	No coloured berries	% Coloured
1	0.65	9.88	114	71.25%	64	56.14%
2	0.90	8.49	39	24.38%	14	35.90%
3	0.97	6.73	6	3.75%	1	16.67%
4	1.03	7.60	1	0.63%	0	0.00%
			160	100.00%		

Observations:

- 71.25% of the berries are single seeded, with two seeded berries accounting for almost 25% of the total.
- Berries with three or four seeds together accounted for just over 4% of the total.
- The greater the number of seeds per berry the heavier is the berry, the lower is the brix of the first drop expressed and the smaller is the proportion that is coloured.

Interpretation:

The presence of seeds is associated with increased berry weight. The berry weight associated with a two seeded berry is almost 40% or .25 grams greater at this stage of development. This is five times the average weight of the extra seed in the berry since the seeds in two seeded berries weigh approximately .05 grams. Given the lower soluble solid level in two seeded berries the true stimulus to average berry *size* due to the extra seed is closer to 50%. On the same basis the four seeded berry is almost double the *size* of a single seeded berry. These differences are apparent before verasion and probably reflect increased cell numbers in the pulp of multiple seeded berries rather than cell size. It is likely therefore that these differences will persist.

The distribution of weight between berries suggests the presence of seeds intensifies the process of cell division in the post flowering berry and, or the nutrition advantage that accounts for extra seed number at flowering continues into the immediate post flowering period of cell division.

This difference in seed number and berry weight is prima facie evidence of deficiency in substrate supply and that the period up to the end of cell division in fruit is characterised by inhibiting deficiencies in substrate supply to the developing fruit.

Despite an apparent advantage in development (as reflected in berry size) possessed by multiple seeded berries, it is the single seeded berries that colour up first. At time of picking this bunch more than half of the single seeded berries had coloured up reaching an average soluble solid level of 9.88 brix by comparison with 36% of the two seeded berries and 17% of the three seeded berries that had coloured up.

Some questions that are of particular interest are:

- Where the multiple seeded berries are located in the bunch.

- Whether the presence of multiple seeded berries on a bunch segment inhibits the colouring up of single seeded berries on that segment.

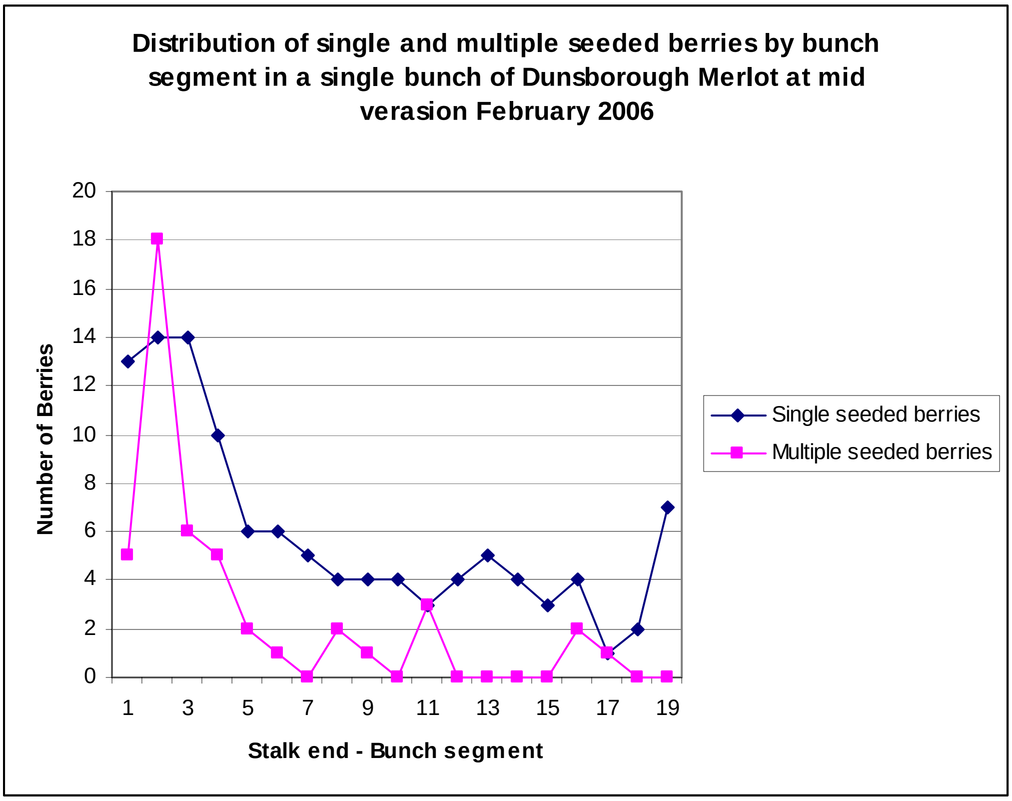
Table 4-7 presents an analysis of the bunch segment by segment for the 19 segments on this bunch. There are 113 single seeded berries and 46 multiple seeded berries on the bunch.

Figure 4-6 shows graphically where the berries were located.

Table 4 -2

Distribution of berries on a bunch of Merlot by segment. Stalk at segment 1.								
Segment	Single seeded berries	2	3	4	Total multiple seeded berries	Total no berries	Red single seeded berries	Red multiple seeded berries
1	13	5			5	18	0	0
2	14	13	4	1	18	32	6	2
3	14	5	1		6	20	8	1
4	10	4	1		5	15	5	3
5	6	2			2	8	3	2
6	6	1			1	7	6	
7	5				0	5	4	
8	4	2			2	6	3	1
9	4	1			1	5	4	1
10	4				0	4	3	
11	3	3			3	6	3	3
12	4				0	4	4	
13	5				0	5	3	
14	4				0	4	3	
15	3				0	3	2	
16	4	2			2	6	3	
17	1	1			1	2	1	1
18	2				0	2	2	
19	7				0	7	1	
	113				46			

Fig 4-6



Observations

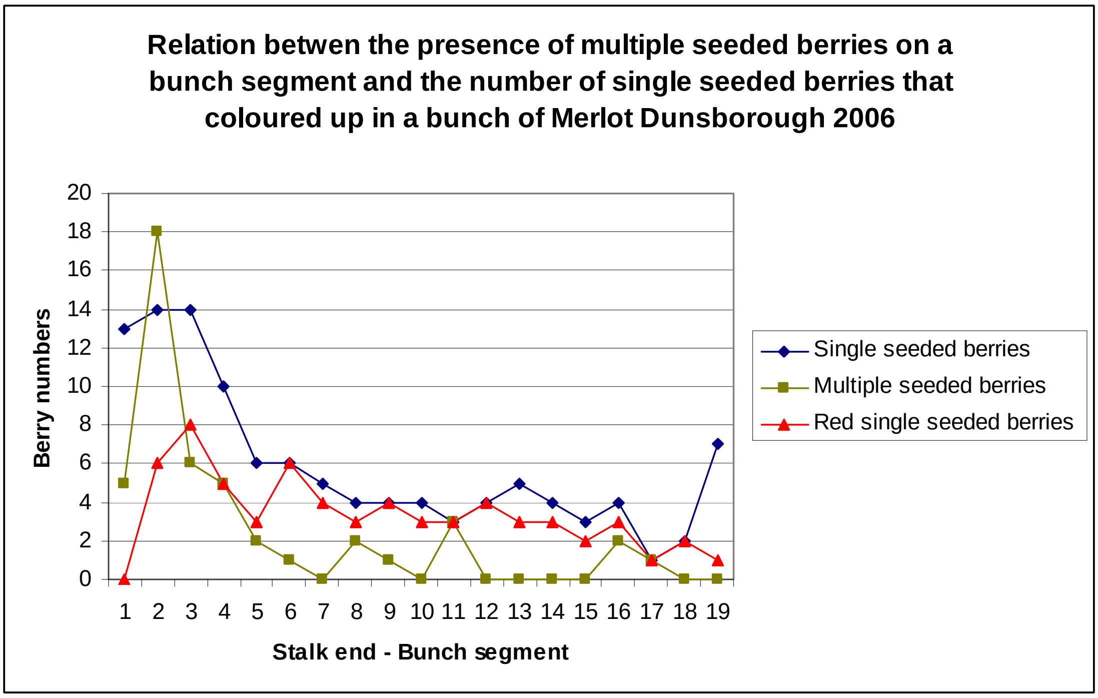
- Segments 1-4 on this bunch contain 74% of the multiple seeded berries in a berry population that is 53% of the total on the bunch.
- The first segment or wing bore some resemblance to a tendril with the berries located a significant distance from the main stalk. The first and third segments had a similar proportion of berries that were multiple seeded.
- Whereas single seeded berries dominate all other segments there are actually more multiple seeded berries in the second segment than single seeded berries.
- Beyond segment 4 multiple seeded berries tend to be less well represented in the population of berries in each segment. The exceptions to this generalization are in segments 8, 11, 16 and 17,

Interpretation

The developing inflorescence is inverted prior to flowering. The superior rate of fertilization at the base (stalk attached) part of the bunch is probably associated with better nutrition at that point rather than heat or light at flowering that tends to advantage the elevated part of the bunch. Bunches only descend to their maturation position after the berries actually begin to form and gain some weight. Cool springs, notorious for poor set, inhibit the rate of carbon creation by the leaves so that the contribution to plant growth from stored carbohydrate must be greater. Since stored sources of carbon are not inexhaustible it is understandable that carbohydrate deficiency at flowering will affect the distribution of seed number in this way. In the very cool 2006 season in Margaret River when the vines appeared a month behind at the end of December poor set was noticeable on many varieties, notably Merlot and Chardonnay. As the season warmed up the vines partitioned more material to shoot growth which continued until verasion an adaptive response tending to increase the leaf area to fruit ratio on the one hand and utilize substrate on the other. Notably verasion in mid to late February was only ten days to two weeks later than normal suggesting that the increased leaf area to fruit ratio assisted the speed of development.

Does the presence of multiple seeded berries on a bunch inhibit colouring up?
We have already seen that it is the single seeded berries that colour up fastest. Is it possible that the presence of multiple seeded berries can inhibit development in a bunch segment? Alternatively, can the presence of many single seeded berries on a segment advance the rate of development of multiple seeded berries?

Figure 4-7



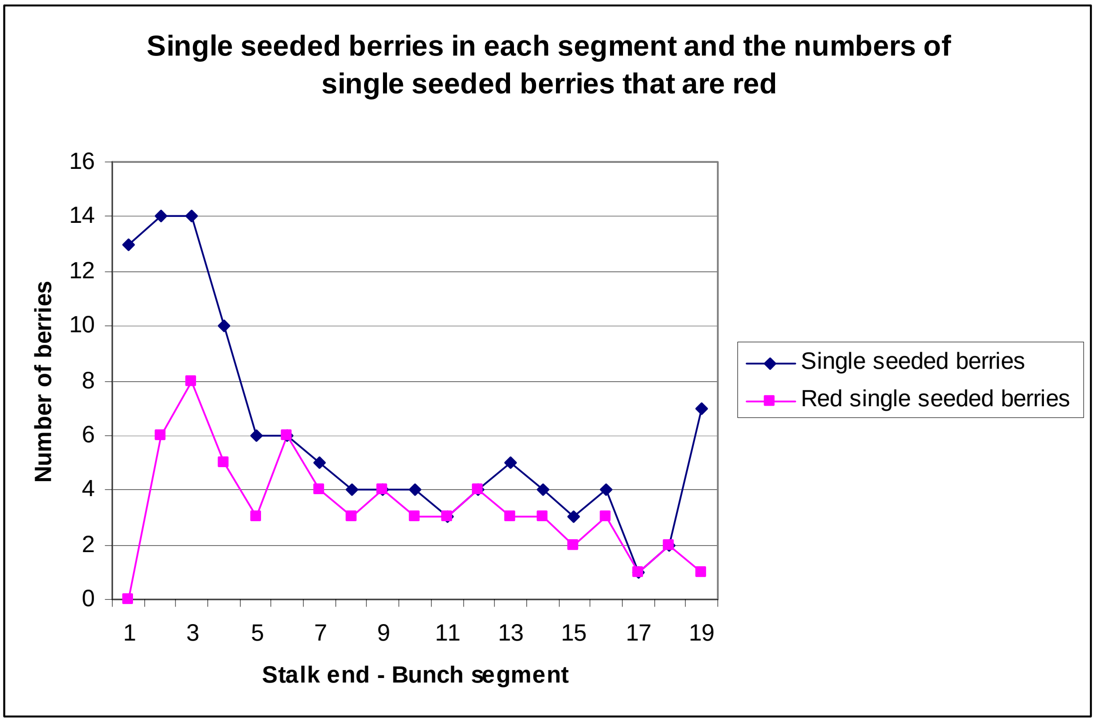
Observations

- Colouring up of single seeded berries is almost complete in segments 6 to 18.
- Relatively small numbers of multiple seeded berries in segments 6, 7, 9, 10, 12, 13, 14, 15 and 18 are associated with colouring up of a large proportion of the single seeded berries in those segments.
- Low ratios of single seeded berries colouring up appears to be associated with the presence of large numbers of multiple seeded berries. This is in evidence in segments 1, 2, 3, 4 and 5.
- The presence of relatively large numbers of multiple seeded berries that is associated with a high proportion of single seeded berries colouring up is in evidence in segments 8, 11 and 16. In each case the multiple seeded berries themselves are either colouring up or are in the post softening stage of development indicating a relatively advanced stage of development in those segments.
- The remaining segments are 17, where all berries are coloured and 19 where few berries are coloured regardless of seed score.
- It is notable that there are few coloured berries in segments 1 and 19 which are segments at the extremities.

Conclusion
The presence of multiple seeded berries in a segment appears to inhibit the progress of verasion in single seeded berries. The presence of single seeded berries advances the development of multiple seeded berries. It appears that verasion proceeds from the middle of the bunch, towards the perimeter and is not driven by seed number alone although seed number is obviously a very strong factor.

How important is seed number as a factor driving the progress of berry softening and colouring up?
The progress of colouring up in the single seeded berries is revealed in Figure 4-8.

Figure 4-8



Observations

- Segment 1 closest to the supporting cane has few coloured berries.
- Segment 19 has few coloured berries.
- Progress of colouring in segments 6 through to 17 is almost complete despite the presence of multiple seeded berries in segments 6, 8, 9, 11 and 16.

Interpretation

1. It is probable that the inception of verasion is unrelated to the flow of carbohydrate to the berry given the lack of colouring of many single seeded berries in segments 1 and 19. However, it is possible that once the process is initiated the rate of flow of carbohydrate to the berry may be a factor in colouring up.
2. It appears that verasion begins in the middle segments where there is a dominance of single seeded berries and proceeds to the perimeter. This is consistent with the notion that ethephon plays a strong role in the initiation of berry ripening.

Further research

- Do the single seeded berries maintain their advantage in terms of soluble solid content as maturation develops?
- Is the weight relativity between the berries with different seed content similar at harvest time?
- Will the single seeded berries mature their seeds faster than the multiple seeded berries given their better pulp to seed ratio and smaller berry size? Berry size probably influences reactions in the seed that are driven by light, heat and oxidation.
- What is the influence of seedless-ness on the pattern of development of berries in a bunch? Do the seedless berries show less IBMP and green flavour?
- What are the impacts of millerandage (grape cluster where one or two normally sized, seeded berries are formed along with numerous small seedless berries which normally ripen) on soluble solid development in the bunch?
- Is millerandage associated with chronic carbohydrate deficiency prior to flowering?

From http://lenewa.netsync.net/public/CP20895.htm

Millerandage Jim Kamas

Although we are still searching for a cause to this disorder there are a few observations that most believe are relevant:

* The problem is aggravated by machine pruning or high node number.
* It occurs most commonly on heavy or shallow sites.
* Soil pH's in affected vineyards range from 4.0-6.5.
* The disorder is more severe in years following very dry falls.
* Affected vines show a number of leaf symptoms including holes in basal leaves, malformed leaves resembling growth regulator (2,4-D) exposure, zigzag growth habits and often show terminal leaf chlorosis late in the season.
* Large crops the preceding year may play a role in taking vines over the edge the following season.
* The disorder appears to be confined to American varieties and has been observed on 'Concord', 'Niagara', 'Delaware', 'Catawba' and 'Elvira'.

What perhaps is most disturbing is that affected vineyards are most commonly very well managed sites.

Hypothesis: low carbohydrate reserves at budburst are related to difficult ripening conditions in the previous year….or an inability of the vine to recover carbohydrate reserves after harvest. Low carbohydrate reserves up to fruit set can also be related to cool springs where growth is disproportionately funded out of reserves and relatively much less via photosynthetic processes that depend upon temperature. Hence, carbohydrate will be relatively scarce during the development of infloresences and this will effect embryo fertilization and seed development after flowering.

Millerandage

Millerandage is the situation where a small number of normally sized, seeded berries are found in each segment of a cluster along with numerous small berries that are seedless. All berries ripen. The bunch is sometimes described as exhibiting ‘hen and chicken’.

The study of this bunch of is driven by a desire to understand questions like:

- The causes of millerandage.
- Influence of seedless-ness on the pattern of soluble solid development in a bunch.
- Impacts of the presence of seedless berries on development of seeded berries.

Table 4-3

	Normal bunch of Merlot				
	Berries	%	Av. Berry Wt.	Total Berry Wt.	%
Seedless					
1 seed	114	71.25%	0.65	74.14	63.87%
2 seeds	39	24.38%	0.90	35.17	30.30%
3 seeds	7	4.38%	0.97	6.77	5.83%
4 seeds			1.03		
Total	160	100.00%		116.07	100.00%

	Merlot with Millerandage				
	Berries	% total	Av. Berry Wt.	Total Berry Wt.	%
Seedless	198	80.82%	0.14	28.27	34.22%
1 seed	43	17.55%	1.06	45.74	55.37%
2 seeds	3	1.22%	2.09	6.27	7.59%
3 seeds	1	0.41%	2.33	2.33	2.82%
4 seeds					
Total	245	100.00%		82.61	100.00%

Observations

- The bunch affected by millerandage has more than 80% of its berries without seeds. These berries are much smaller and account for only 34.22 % of total berry weight
- Single seeded berries account for only 17.55 % of the total number of berries but 55.37% of total berry weight in the bunch affected by millerandage, slightly less than in the normal bunch where 63.87% of the weight was accounted for by single seeded berries.
- Seeded berries are individually much heavier than they are on the bunch that is unaffected by millerandage.

A bunch of Merlot showing segments in the order that they were detached from the main bunch stalk at right and the seeds belonging to each segment.

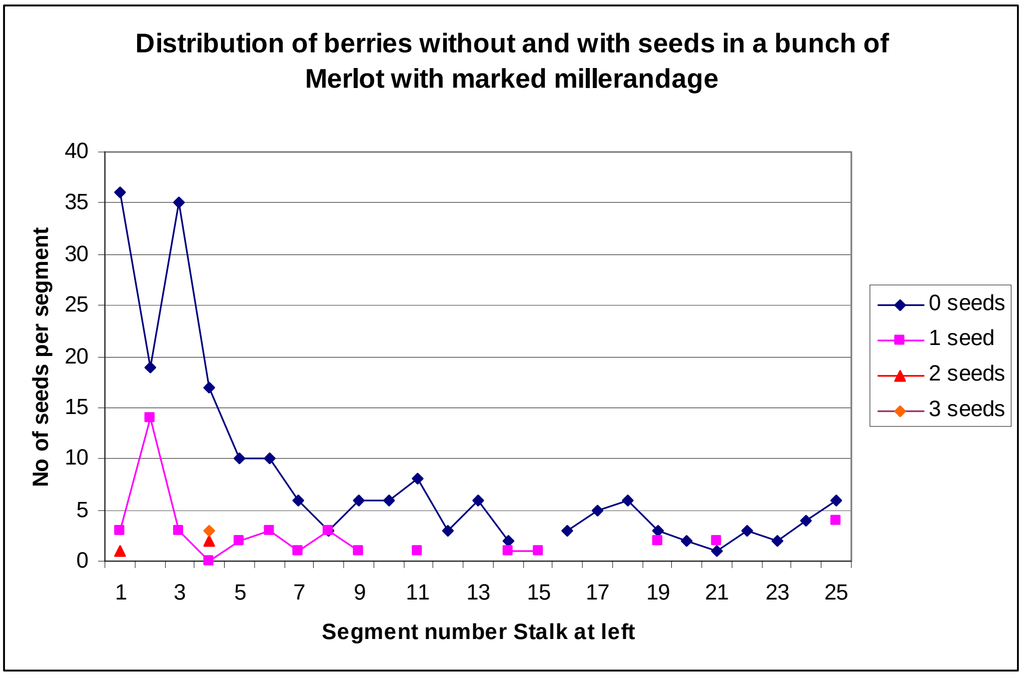
Table 4-4 and Figure 4-9 documents the location of berries on the bunch in terms of the bunch segment in which they occur.

Table 4-4 Location of seedless and seeded berries

Millerandage Merlot Bunch						
Segment	Berries per segment	0 seeds	1 seed	2 seeds	3 seeds	Seeds per segment
1	40	36	3	1		5
2	33	19	14			14
3	38	35	3			3
4	20	17		2	1	7
5	12	10	2			2
6	13	10	3			3
7	7	6	1			1
8	6	3	3			3
9	7	6	1			1
10	6	6				0
11	9	8	1			1
12	3	3				0
13	6	6				0
14	3	2	1			1
15	1		1			1
16	3	3				0
17	5	5				0

18	6	6				0
19	5	3	2			2
20	2	2				0
21	3	1	2			2
22	3	3				0
23	2	2				0
24	4	4				0
25	10	6	4			4
Totals	246	202	41	3	1	50
Segment 1-4	131	107	20	3	1	29
Seg. (1-4)/all segments.	53.25%	52.97%	48.78%	100.00%	100.00%	58.00%

Figure 4-9



Observations

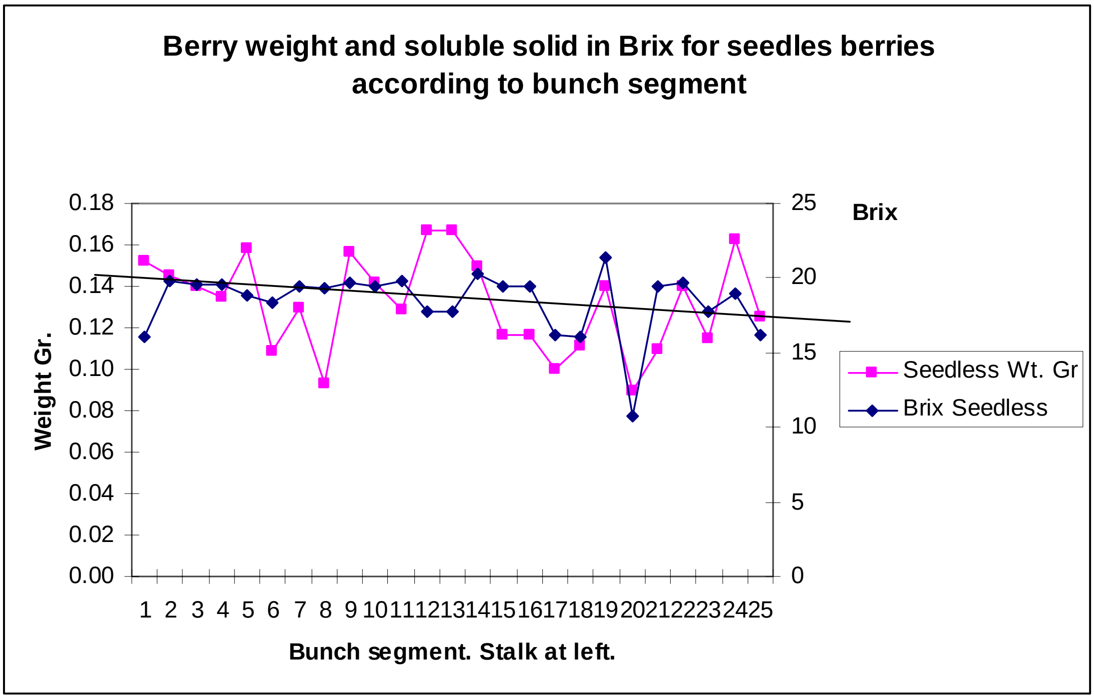
- More than 50% of berries in all categories and 58% of all seeds are found in segments 1-4.
- The first segment or ‘wing’ is disadvantaged in its very low proportion of seeded berries with only 5 seeds in 40 berries.
- The second segment has an unusually high proportion of seeded in relation to unseeded berries with 14 seeded berries and 19 unseeded berries in a total of 33 berries. Segments 1 and 3 have more berries than segment 2 but very few seeded berries.

Interpretation

The lower absolute berry load on segment 2 (less competition) by comparison with segments 1 and 3 and the particular form of segment 1 where berries are located at the end of a long tendril like attachment to the bunch explains why segment 2 is favoured with more seeds. The relatively high number of seeds in segments 1-3 also probably reflects an early advantage in nutritional status. The stalk attached end of the bunch is best located to take advantage of depleted flows of carbohydrate in the pre flowering stage of berry development when carbohydrate derived from the old wood has to be shared between many growing points. This likely yields a more perfect state of development of flower parts or better pollen viability. That in turn gives rise to more seeded berries. It is highly unlikely that a generalised environmental circumstance like low light intensity or temperature could produce the particular pattern of development that can be seen in this bunch.

Figure 4-10 documents the average berry weight and level of soluble solid content in seedless berries across all bunch segments.

Figure 4-10



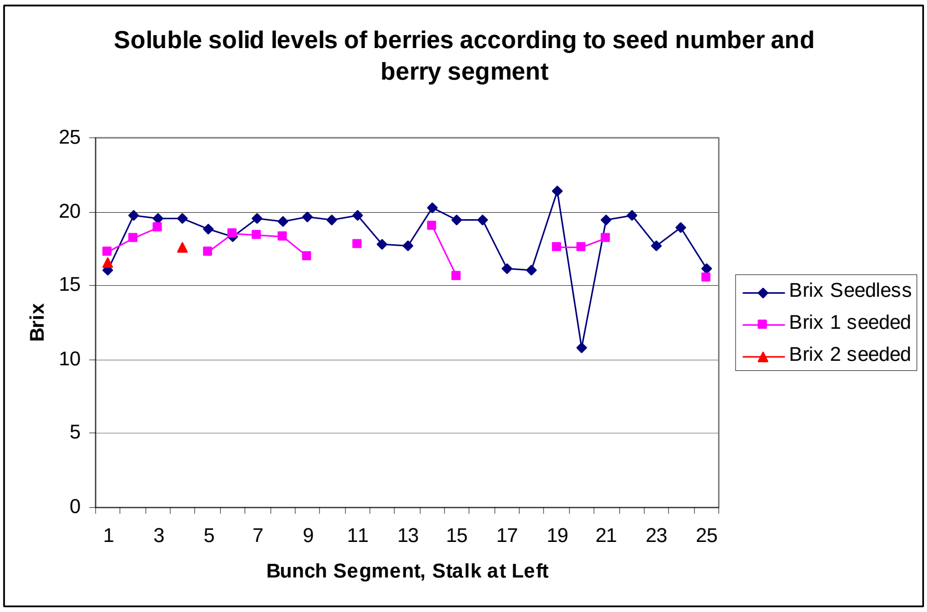
Observations

- There is a weak trend for both berry weight and soluble solid levels to fall the further a berry segment is located from the point of attachment to the shoot.
- Soluble solid level ranges from 10 to 20 Brix.

Interpretation:

The pattern of development seen here is consistent with a sugar flow that is impacting more strongly at the end of the bunch where it is attached to the shoot than at the distal end. This pattern may develop differently as ripening proceeds and sugar levels rise. The opportunity to examine berries that are very close in size in all parts of the bunch helps to get a better idea of the potential for differences in maturity to develop in different bunch segments due to location at different points of the supply pipe.

Figure 4-11 Distribution of soluble solids



Observations :

- Seedless berries have a marginally higher soluble solid content in almost all berry segments than seeded berries.

Conclusions:

1. There is a great deal of evidence here of disparate rates of development within the bunch.
2. It is apparent that a study of bunch form and development can give clues as to the nature of the processes operating during berry development and ripening.
3. Marked differences in berry development are prima facie evidence of a source inadequacy in relation to sink demand. There is plenty of evidence of this state of affairs in bunches described in this chapter.

Differences in berry maturity in a bunch of Pinot Noir

In this study the interest was to discover the variation that existed in aspects of fruit ripeness between the berries in a bunch of Pinot Noir. Clones of Pinot Noir exhibit some variation in bunch size and tightness. The 'droopy' clone is an early ripener with small bunches of about 130 berries weighing about 100 grams. The packing of the berries is so tight that some are commonly detached by the pressure of other berries as the fruit expands. Individual berries then show the indentations caused by pressure from adjacent fruit and have an elongated shape similar to a hot air balloon.

Bunch segments were detached working from the shoot attached end. Each berry was weighed. The soluble solid level of the first drop was established by refractometry. Then, the seeds were expressed and separated from the pulp. The number of seeds per berry was recorded along with a score based upon seed colour. The score was given according to the following schema. 0 = wholly green, 1 = green and yellow, 2 green and brown and 3 = wholly brown. The results in terms of averages for each of 19 berry segments is presented in table 1.

Table 4-5
Parameters of a bunch of Pinot Noir by bunch segment.

Segment	Berry number	Berry Brix (first drop)	Berry Weight gr.	Seed number	Seed Score
1	5	23.88	0.67	1.20	2.80
2	5	23.44	0.85	2.40	2.00
3	15	21.65	0.72	1.47	1.87
4	11	22.80	0.67	1.36	1.95
5	13	22.29	0.69	1.62	1.88
6	11	21.73	0.71	2.09	1.45
7	7	22.43	0.62	1.57	1.57
8	11	23.25	0.70	1.45	1.64
9	10	22.76	0.76	1.50	1.20
10	5	23.36	0.53	1.40	2.40
11	3	23.27	0.52	1.67	1.50
12	5	24.40	0.87	2.20	1.70
13	4	22.10	0.81	2.00	1.75
14	6	22.20	0.94	1.50	0.75
15	4	21.60	0.64	1.75	1.25
16	4	21.50	0.88	1.75	1.63
17	4	22.65	0.79	1.75	1.38
18	5	22.24	0.84	2.00	1.20
19	5	22.20	0.68	1.60	1.00

The distribution of fruit according to soluble solid of the first drop expressed from each berry is presented in table 4-6. Since the soluble solid level of the first drop expressed is lower than would be obtained by crushing and pressing the entirety of the berry/bunch these figures can not be taken as representative of the entirety of the juice within the berry.

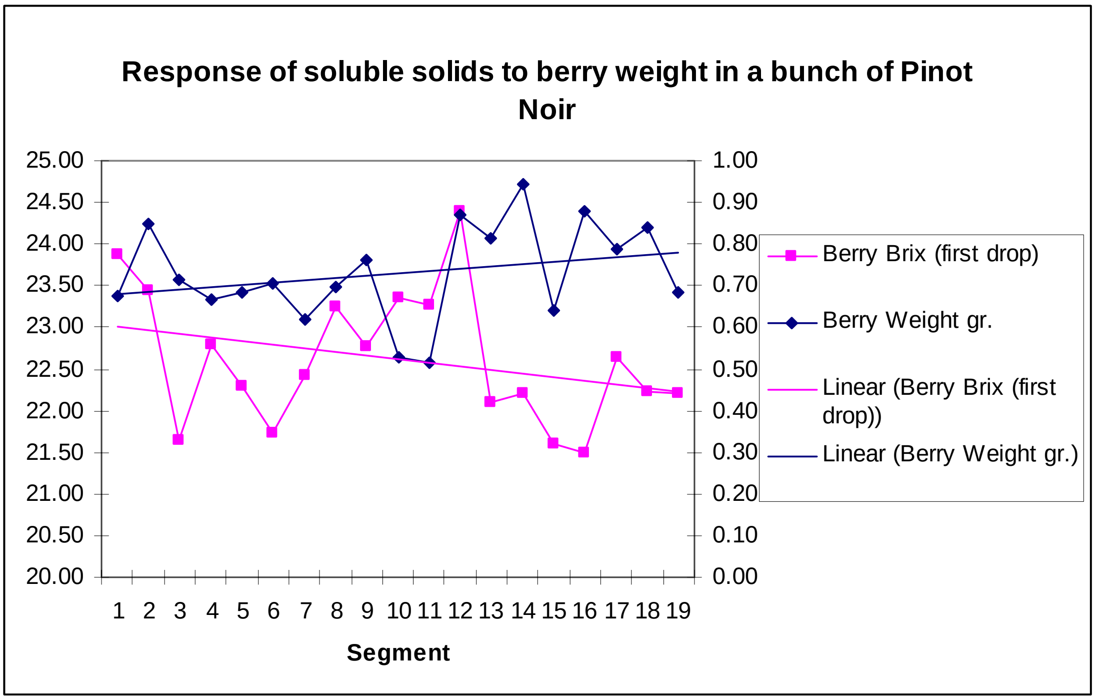
Table 4-6
Distribution of berries at different soluble solid levels.

Brix	No's of berries	Percent
19-20.9	12	8.70%
21-22.99	79	57.25%
23-24.99	32	23.19%
25-26.99	6	4.35%
27-28.99	3	2.17%
29+	6	4.35%
	138	100.00%

It is apparent that 80% of the berries lie in a range between 21 Brix and 24.99 Brix. The 7% that have a Brix above 24.99% are probably all in a state of relative detachment from the pedicel and are in a process of dehydration. Only 9% have a soluble solid level of less than 21 Brix. According to soluble solid levels the bunch is therefore well and truly ripe.

In the figures below the relationship between the various entities in table 4-5 are explored. In all of these figures the point of attachment of bunch to shoot is adjacent to segment 1 at the left hand end of the diagram. The tail or bottom of the bunch is therefore segment 19.

Figure 4-12



Observations

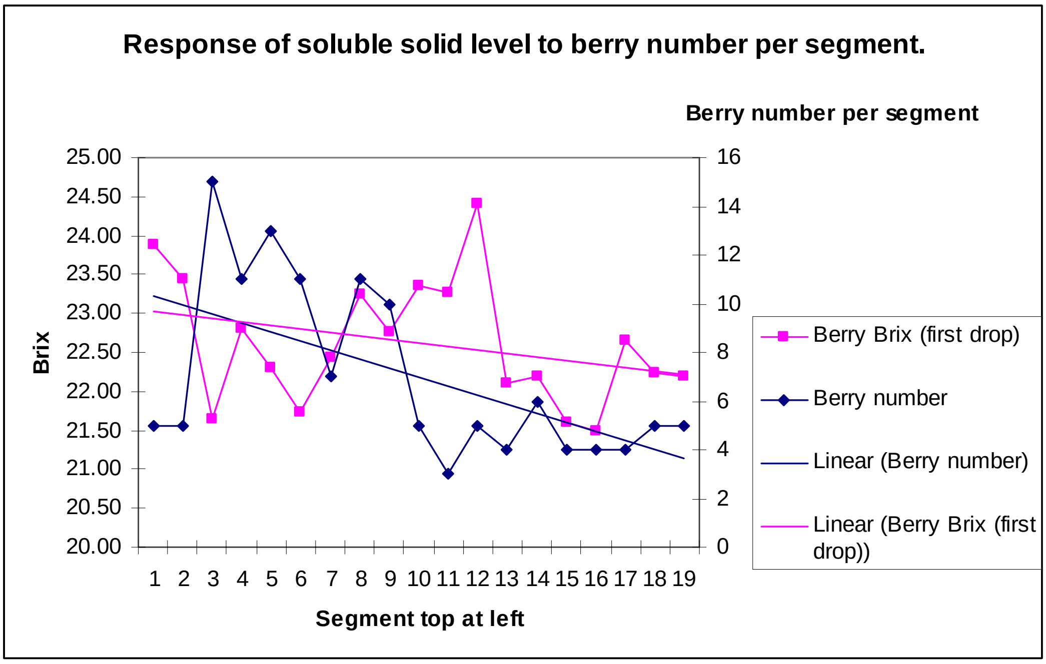
- Average berry weight increases with segment number.
- Soluble solid levels tend to fall slightly with increasing berry weight.

Interpretation

Increase in berry weight with segment number probably reflects the extra space available for berry expansion as the number of berries per segment diminishes. Berry size is also commonly related to seed number per berry. Figure 4-13 demonstrates that seed number per berry increase with segment number.

The fall in average berry soluble solid level from left to right probably reflects a proximity to source factor (bunch stalk) a sink size factor (berry size) and a time of verasion and development factor (more seeds per berry is associated with a later entry to verasion). However, given the departure from the trend line in some segments other influences must also be at work.

Figure 4-13



Observations

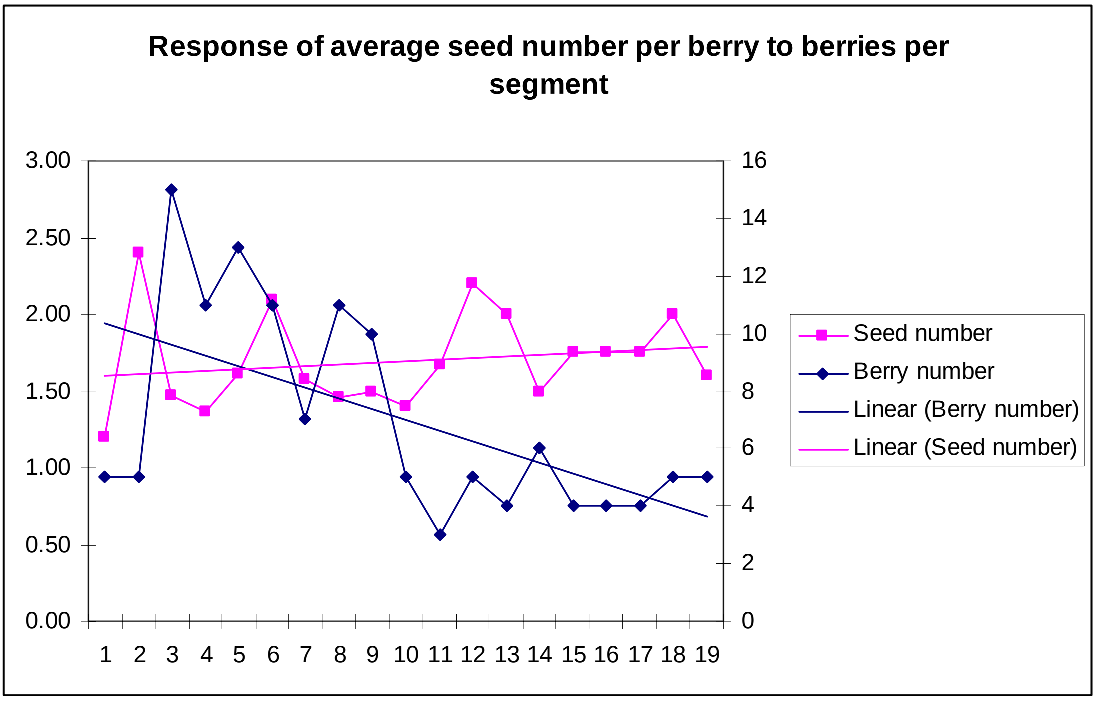
- Where berry number per segment exceeds the trend line soluble solids tends to be depressed below the trendline and vice versa.
- There appears to be a general depression of soluble solid level in the tail of the bunch because even though berry number per segment is less than the trend line there is little response in soluble solid level.

Interpretation

The sink closest to the source has a higher soluble solid level. This phenomenon is evidence of carbohydrate deficiency in relation to sink demand.

Where sinks compete more strongly because of high berry numbers per segment the soluble solid content is below trend line for that position on the bunch and vice versa. Here is the yield quality relationship working in microcosm.

Figure 4-14



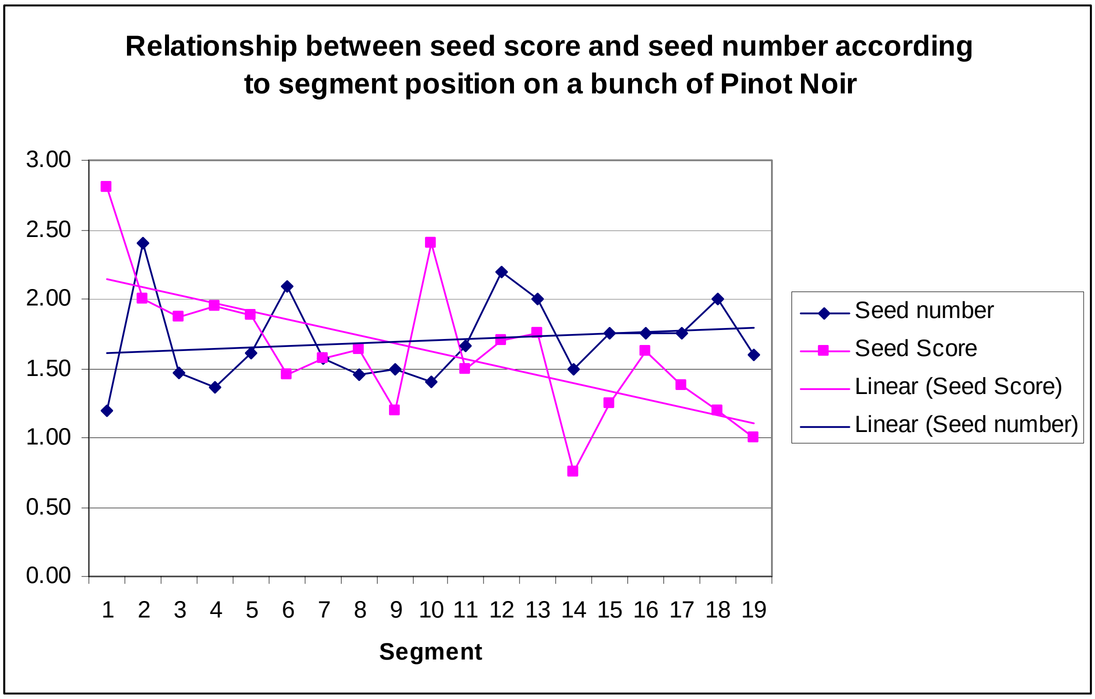
Observations

- Where berry number per segment is above trend line for that part of the bunch the seed number per berry is depressed and vice versa.

Interpretation

This phenomenon is evidence of a competition factor resulting in reduced embryo fertilization in segments that contain large numbers of berries. This may be due to nutritional factors affecting the formation of the structures upon which fertilization depends, including perhaps the viability of the pollen and the embryo itself. It points to carbohydrate deficiency during structure formation. This in turn may be related to inadequate vine carbohydrate reserves, structural damage that inhibits carbohydrate flows from the permanent wood or the inability of the developing fruit to compete for nutrient flow against other sinks which include developing shoots and leaves. Since current leaf area and activity is responsible for a portion of total carbohydrate supply, carbohydrate deficiency may also relate to deficient shoot leaf area during the phase where cell differentiation is occurring in the infloresences. The latter might be due to temperatures too low to sustain the required level of carbohydrate production by new leaves. In cool springs shoot and fruit development is slower and more reliant on non structural carbohydrate reserves in the permanent parts of the vine. In such circumstances the production of berries with fewer seeds or even entirely without seeds is to be expected representing an extreme form of carbohydrate starvation of the developing fruit that is responsible for failure of the berries to develop seeds a phenomenon called millerandage.

Figure 4-15



Observations

- Average seed number per berry tends to increase with segment number.
- Seed score declines as segment number increases.

Interpretation

Declining seed scores with increasing seed number per berry is explicable because seed score depends upon oxidation and light penetration to the seed both of which will decline with increased berry size. Increased seed number is responsible for increased berry size and since seeds are tightly packed some surfaces of the seed are not as well exposed as in single seeded berries. Assuming that the bunch hangs normally, the best illuminated part and the smallest berries will be at the stalk end at segment 1. Confirming the point, the highest individual segment seed score is in segment 1 which is best illuminated and has a relatively low incidence of multiple seeds.

Lessons from the study of this bunch

- Soluble solid level is not always greater at the distal end of a bunch. In this case high seed numbers promote large berry size and are likely to be associated with a late start to verasion at the distal end the bunch.
- Average seed number per berry provides a window into the carbohydrate status of the vine during fruit development.
- The Pinot Noir vines studied are regularly fruit thinned and cropped moderately. The dispersion of soluble solid score in the bunch was slight. There were a relatively large number of seeded berries in the bunch confirms the point. Nevertheless there is evidence of nutrient starvation in those parts of the bunch where berry numbers per segment is large. This evidence is in the form of fewer seeds per berry.
- It is apparent that vine carbohydrate status during fruit formation has a potent influence on aspects of berry set and seed development.