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STUDIES ON FORECASTING THE MOST SUITABLE DATE FOR HARVEST OF PINOT NOIR IN THE VALLE SCUROPASSO (OLTREPÒ PAVESE)

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INTRODUCTION

In the decision-making process aimed at improving the quality of grapes for wine production, the timing of the harvest is particularly important.

This takes on an even greater importance with regards to grapevines for the production of sparkling wines *méthode traditionnelle*. In fact, because of the particular processes involved in the production of these wines, and to a certain extent, also for fresh white wines, the choice should fall to musts that, besides a sufficiently high sugar content, should have good acidic levels.

Traditionally, grape cultivation in the Oltrepò Pavese is destined for the production of sparkling white wines (Pinot Noir, Pinot Gris, Riesling italic and Chardonnay). The last phases of maturation of the grapes frequently take place at quite high temperatures (end of August-beginning of September). Since the breaking down of the acidic component of the grapes, particularly its malic component, is favored by high temperatures, the timing of harvest should avoid obtaining musts with very high pH. However, it is also important not to harvest too soon because if on the one hand this maintains acid levels high, on the other it does not allow the grapes to completely mature in terms of adequate sugar content which is always related to good quality harvested grapes. Timing of the harvest is, therefore, extremely important, above all for the chemical composition of the grapes, and to obtain the balance required to allow the grape grower to reach his qualitative enological objectives.

In the context of grape growers in general, and in particular in the Oltrepò Pavese, such decisions are not always based on strictly technical-agronomic considerations. Very often other factors come into play. These include farm management and organization, availability of labor, the size of the farm, or when the co-operative wine growers' associations or the producers of sparkling wines *méthode traditionnelle* who depend on the Oltrepò Pavese require that the grapes be delivered to them. Given this, problems often arise with the technical assistance available in the field, because there is often a lack of the equipment, manpower, expertise and adequate working methods necessary to follow the maturation of the Pinot Noir grapes in the various areas involved. Therefore, it would be particularly interesting to control the time needed for the process of maturation of the grapes destined for the production of sparkling wines *méthode traditionnelle* in order to be able to follow the development of the principal components of the grapes and consequently to forecast the correct time to harvest sufficiently in advance.

Growth and maturation of the grapes from their formation to harvest

From its formation (setting) to harvest, the grape goes through a series of significant changes easily perceptible visually, by taste and by touch. As the vegetative season advances, the immature grape considerably increases its volume and weight while changing in consistency, color and taste. In fact, as the grape continues to increase in weight, the internal structure of the pulp also changes significantly (softening) and the grape then turns red or yellow, deepening over time, becoming sweeter and less astringent to taste.

The grape goes through a first phase of herbaceous growth (PHASE I, up to 50-60 days after flowering) in which its increase is mainly due to the division of cells and during which there is an increasing

organic acidic component (up to 35-45 g/L of titratable acidity, measured in equivalents of tartaric acid). The grape is hard, and sour with only approximately 2% of sugar content; in fact, there has been almost no change in sugar content since the beginning of the herbaceous phase. At the end of this phase, the grape has grown to around half its final weight (from 0.6 to 1.0 g, according to the variety). There is a brief halt in growth (PHASE II) at the end of which hormones set off the process through which the berry is transformed from a green body similar to a leaf in a colored and mature fruit. Changes in the balance of hormones are mainly the result of a repeated increase in abscisic acid (ABA) and in ethylene. In fact, this is accompanied by a rapid variation in the sugar-acidic content and of the coloring substances (anthocyanins in red grapevine variety). The grape starts to increase in weight again (PHASE III, maturation) and this is due to a swelling of the cells up to approximately 1 or 2 g. The titratable acidity decreases approximately up to 5-8 g/L and sugars increase up to 200 g/L at the vintage.

Maturation process and forecast of the best timing for the harvest

The development over time of some of the principal characteristics of the grapes (weight, sugars, acidity) during maturation can be described as polynomial functions (second, third or fourth degree with or without a plateau), by multiplicative regressions or also, in well-defined periods, by linear regressions (MAUJEAN, 1983; FREGONI, 1985; IACONO *et al.*, 1985; VERCESI *et al.*, 1989). These functions can show the type of maturation offered by the various species of wine in the different areas of cultivation, particularly if examined for decrease in acidity and increase in sugar content. The speed of the decrease in acidity and increase in sugar content during the maturation process, along with the time at which these take place, characterize the interaction of the variety with its environment and changes the meeting point date, where titratable acidity (%) and sugar level (%) are equivalent. This represents an identifiable moment in the final phases of the veraison for the different varieties in the different areas (LIUNI, 1989; VERCESI *et al.*, 1989; ORTIZ-VILLAIOS, 1991) (FIGURE 2). Methods have been tried in different environments and for different varieties to forecast the best timing of the harvest in relation to evaluations developed through the study of the maturation of the grapes. These methods refer to: i) changes in temperature in the periods between March or April and June at the moment of flowering; ii) the speed (linear regressions) of the decrease in acidity from the start of veraison onwards (forecasts made 2-3 weeks in advance); and iii) the date on which the meeting point between the decrease in acidity and the increase in sugar content takes place (MAUJEAN, 1983; IACONO *et al.*, 1985; BARILLERE, 1988; VERCESI *et al.*, 1989).

In order to raise our awareness of the potential for study of the maturation of the Pinot Noir grape in different production areas of the Valle Scuropasso so as to forecast the best timing of the harvest, with particular reference to the use of the harvested grapes in the production of sparkling wines *méthode traditionnelle*, the Department of Viticulture of the Università Cattolica del Sacro Cuore of Piacenza, together with the Technical Viticultural and Enological Center of the Valle Scuropasso, is developing an ongoing study, already in its third year, in some of the more important grape growing areas for the production of Pinot Noir.

MATERIALS AND METHODS

The study considered 6 vineyards of Pinot Noir grapevines, situated at different altitudes and exposures, and considered sufficiently representative of the different contexts in which Pinot Noir is cultivated within the Valle Scuropasso (FIGURE 1 and TABLE 1). In the vineyards under study, Pinot Noir is cultivated according to the double Guyot training system with 2 canes with a number of buds *per* vine of between 30 and 40. The grapevines were spaced 1.6-2.2 m in the rows with 2.5 m between them. Grapevine density (number of vine *per* ha) was approximately 2,300-2,900. Soil samples were taken for analysis at depths of 15 and 60 cm. Analyses of these samples showed the following

variables: sand (%), silt (%), clay (%), pH, cationic exchange capacity (C.E.C.), and active limestone (Table 2).

Within each vineyard, we studied 30-40 reference vines in the center of the vineyards over two rows, 2 to 5 grapes were taken from each group of reference vines approximately every seven days from 20th July to 3rd September. These were considered representative of the overall level of maturation reached by the grapes. The average weight of grape was estimated by weighing two subsamples of 100-150 berries each. The grapes were then pressed and the following evaluations were made on the must (fresh, non-frozen must):

- sugar level (°Brix);
- titratable acidity (g/L, expressed in equivalents of tartaric acid);
- pH;
- tartaric acid (g/L);
- malic acid (g/L).

The following vegetal-productive characteristics were checked on a sample of 12-15 grapevines:

- number of buds *per* vine;
- number of grape clusters *per* vine;
- fertility (number of grapes/number of buds *per* vine);
- yield of grapes *per* vine (kg/vine);
- average weight of grape clusters (g).

The method used to estimate the level of maturation of the grapes and the best timing of the harvest was that relating to the meeting point understood to be the date at which the percentage of sugar level (degrees Brix) equaled acidic levels (titratable acidity in g/L, expressed in tartaric acid) (VERCESI *et al.*, 1989) (FIGURE 2).

A study was made of the correlations between the meeting point and the maturation characteristics of the grapes on harvest, i.e. the number of days between the meeting point and the harvest, and the ratio of sugars : titratable acidity of the grapes on harvest. For the quality evaluation, precise reference was made to the priority given to obtaining sufficient acidic levels in the musts on harvest, this being the enological objective in the production of sparkling wines *méthode traditionnelle*.

RESULTS AND DISCUSSION

General considerations

The vineyards studied were characterized by different soil types (TABLE 1). The two vineyards situated in the north of the Valle Scuropasso, near to the River Po (vineyards 1 and 2) were at lower altitudes. These were characterized by almost equal levels of silt and clay (approx. 30% each). The highest values of soil pH were reached in this area, while here exchangeable potassium values were the lowest (296 and 253 ppm in vineyards 1 and 2, respectively).

The remaining vineyards, situated at higher altitudes (200-400 m a.s.l.) in the central-southern part of the valley had more clay than silt. Clay made up just over 50% compared with almost 20% silt. In these cases, pH was slightly less and exchangeable potassium levels reached the highest values (503-636 ppm). Active limestone was always over 20%, except for vineyard 3 with only 7.5%. Cationic exchange capacity varied between 20.8 (vineyard 1) and 36.2 (vineyard 2) (FIGURE 1 and TABLE 2).

In the three years studied (1989, 1990, 1991), the climatic conditions with regards to temperature and rainfall could be considered overall as drought. In the vegetative period from April to September, overall rainfall decreased from the first to the last year of study (392, 300, 254 mm in the period April-September of the years 1989, 1990, 1991 respectively) (TABLE 3). No snow fell in the winter of 1989-1990 and there was no heavy snow in the winter of 1990-1991.

Furthermore, it should be noted that the winter of 1989-1990 was exceptionally mild. April was the wettest month for the period under study, except for 1991 when the rainiest month was May. The highest maximum temperatures were recorded in the period June-July-August, always over 30°C with particularly high peaks of 36°C in July 1991. July 1989 was significantly wetter and cooler (TABLE 3). Average yields *per vine* were approximately 5.5 kg/grapevine (range 3.07-7.41 kg/vine). Average weight of the grape cluster in the different locations for the different years was close to 110 g. Sugar content was between 15.73 and 22.58 (°Brix) with pH between 2.97 and 3.28. Titratable acidity was between 6.93 and 11.61 g/L, with constantly higher levels in 1989 (TABLE 4).

Maturation of the grapes

The maturation of the Pinot Noir grapes studied in the various locations varied over the three years. Both the decrease in acidity and the increase in sugar content were recorded at different times, even though speed and curve were similar (FIGURES 3, 4, 5, 6, 7 and 8). More precisely, 1990 saw much earlier fundamental maturation phenomena (sugar-acidity development), while maturation was later in 1989 and in 1991.

Titratable acidity reached its maximum peak in the last days of July and started to decrease appreciably more often at the beginning of August, when the sugar concentrations in the grape began consistently to increase and the first grapes clearly changed color (start of veraison). In almost all cases, the titratable acidity fell from a maximum 40-45 g/L (last week of July) to less than 10.0 g/L on harvest (first or second week of September). Of the two principal organic acidity components of the musts, malic acid shows the more consistent breaking up, during maturation this decreased 6-8 fold (from approx. 25-35 g/L to 2-4 g/L), while in the same period tartaric acid halved from 10-15 g/L at the end of July to approximately 5-7 g/L on harvest. The average weight of each grape on harvest was usually between 1.1 and 1.6 g, and near the start of veraison amounted to approximately 55-65% of its final fresh weight. In 1989, grapes were on average heavier, probably due to the higher overall rainfall of the months before harvest, above all in July.

Forecast of the best timing of harvest using the meeting point

Estimates of the best date of harvesting considered not only the date on which the farms responsible for harvesting the vineyards under study but also the level of maturation of the harvested Pinot Noir grapes. In fact, frequently the date of harvest corresponded to organizational and market factors and not to an evaluation of the composition of the grapes according to the pre-determined objectives regarding the production of sparkling wines *méthode traditionnelle*, the climatic and phenological evolution for the year. This was due to a lack of available labor on the farm and to organization criteria imposed by the local co-operative associations or by the producers of sparkling wines *méthode traditionnelle* from outside the Oltrepò Pavese who buy these grapes for use in their production processes. In order to avoid any possible errors in evaluating the results we measured the sugar : titratable acidity ratio of the grapes on harvest and tried to develop forecasting models based on, above all, the levels of acidity in the harvested grapes.

In the 3-year period 1989-1991, the Pinot Noir grapes in the vineyards under study were harvested between 4th and 11th September. There was a big difference in sugar (°Brix) and titratable acidity (g/L) ratios among the musts: from 1.46 (with 16.93 sugar content and 11.61 acidity in vineyard 4 in 1989) to 3.03 (with 20.8 sugar content and 6.86 acidity in vineyard 2 in 1991). In all cases examined, this ratio was always lower in 1989 compared with other two years (TABLE 4). The meeting point, understood as the date on which acidity levels (‰) equal sugar content (°Brix), was considered a first marker of the level of maturation of the grapes; this fell between 11th and 30th August (the end of veraison). The number of days between the meeting point and the harvest varied between 8 and 28 days. The grapes, therefore, were not harvested at the same levels of maturation (TABLE 4). There

was a highly significantly positive linear correlation between this time gap and the sugar : acidity ratio recorded in the grapes ($r=+0.800$; $F=24.82$; $P<0.01$). Acidity levels of the Pinot Noir grapes had a highly significant negative correlation with the time gap between the date of harvest and the meeting point ($r=-0.895$; $F=56.48$; $P<0.01$). Including the average weight of the bunch in the model as a second independent variable in estimating sugar : acidity ratio of the grapes according to a multiple regression model, we saw that this variable takes on a significant negative coefficient (TABLE 5). Therefore, the relationship between the sugar: acidity ratio of the harvest and the number of days since the meeting point changed in relation to appreciable variations in the bunch weight on harvest. For example, for the same time gap between meeting point and harvest, heavier bunches correspond to a lower sugar : acidity ratio. For an average grape clusters weight, grape acidity fell below 8.5‰ of titratable acidity (to be considered a critical level) approximately 20 days after the meeting point (FIGURE 9).

On average we can see that sugar content (%) and acidity (‰) were around 12-14, respectively, after which titratable acidity lost approximately 0.2 g/L *per* day from then onwards.

CONCLUSIONS

The Pinot Noir grapes cultivated in the vineyards under study and coming from the different viticultural areas of the Valle Scuropasso (at altitudes from 187 to 460 m) on harvest (1st -10th September) almost always showed an adequate sugar level in relation to the enological objectives. On the contrary, in some cases, acidity values were even lower than 8‰ of titratable acidity with pH over 3.2, above all at the lowest altitudes in the vineyards with the best aspects (TABLE4).

The tartaric : malic acid ratio was almost always over 1 and acidometric profiles of the musts often revealed a maturation of the grapes that was probably excessive for the production of sparkling wines *méthode traditionnelle*. However, these considerations refer to the three years under study that were on the whole quite hot and dry, with seasonal conditions that favored high sugar levels and maturation of the grapes. It should be noted that greater attention should be given to the choice of location of the vineyard and timing of the harvest in order to obtain adequate acidic compositions of the musts so as to provide high quality sparkling wines *méthode traditionnelle*.

The correlation of the meeting point with the level of maturation of the grape in that year can be used to estimate the timing of the harvest by programming the sugar-acidity level of the harvested grapes. More precisely, the grapes should be harvested 17 or 20 days after the meeting point to obtain sugar : acidity ratios of 19/9 or 20/8.5, respectively (pH 3.00-3.20) values that can be considered 'good' for the production of sparkling wines *méthode traditionnelle*. These ratios also seem to be influenced by the productive habitat of the grapevines. In fact, in cases in which larger sized grape clusters were observed, maturation seemed to be slower. In addition, this suggests that clones with smaller grapes are probably not suitable for the production of sparkling wines *méthode traditionnelle*, above all at lower altitudes or at better exposures. The methods used to estimate the timing of the harvest should also be modified according to the considerable variation in the productive yield of the grapevines. Further studies on climate are required in order to evaluate a possible connection between seasonal conditions (using data obtained from the agrometeorological network), meeting point and the timing of harvest, in relation to the characteristics of maturation of the grapes in the different cultivation areas of the Pinot Noir.

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Table 1 – Some characteristics of the vineyard studied (No. = number, m = meters on the sea level).

vineyard	locality	Altitude (m)	Exposure	Training system	n. of vine / ha	No. of buds /vine
1	Vallescuropasso	107	West	Guyot	2,500	31
2	Scorzoletta	120	East	Guyot	2,300	40
3	Pragone	200	North-West	Guyot	2,600	40
4	Finigeto	300	South-West	Guyot	2,500	31
5	Rocca de Giorgi	425	South-West	Guyot	2,600	33
6	Canevino	460	South-East	Guyot	2,900	35

Table 2 – Some characteristics of the soils.

vineyard	Clay (%)	Silt (%)	Sand (%)	pH	C.E.C.	K exchangeable (mg/kg)
1	32	28	40	8.13	20.8	296
2	32	30	38	8.11	24.5	253
3	50	18	32	8.02	36.2	636
4	50	18	32	7.90	30.7	548
5	54	20	26	7.81	26.0	570
6	48	28	24	7.71	24.6	503

Table 3 – The monthly rain (R, mm) and the monthly maximum temperature (T.M., °C), measured by the meteorological station in Cigognola, in the period April-September.

year	April	May	June	July	August	September	Σ of the rain (mm)
1989							
R	173	15	32	87	10	76	393
T.M.	22	28	30	31	32	26	
1990							
R	172	28	35	5	44	16	300
T.M.	23	29	31	32	32	30	
1991							
R	39	93	20	21	3	78	254
T.M.	22	31	35	36	34	33	

Table 4 – The parameters of the ripening of the grapevine, evaluated in the different localities; mp = meeting point, ΔmpV = distance from meeting point and the vintage (V), S/A = sugar /titratable acidity, G.A.V. = grape cluster average value

No.	year	mp (dd/mm)	V (dd/mm)	ΔmpV (days)	S / A (°Brix/g/L)	pH (must)	G.A.V (g)	kg / vine
1	1989	20/8	5/9	16	17.97/9.97	3.15	131	4.68
	1990	11/8	4/9	24	19.25/7.96	3.10	108	6.16
	1991	24/8	11/9	28	19.58/6,93	3.28	117	5.08
2	1989	-	-	-	17.73/9.08	2.97	118	7.41
	1990	15/8	4/9	20	20.91/8.19	3.02	77	3.07
	1991	16/8	10/9	25	20.80/6.86	3.24	120	6.80
3	1989	25/8	4/9	10	20.85/10.15	3.14	95	6.08
	1990	14/8	4/9	21	20.70/9.27	-	107	5.58
	1991	15/8	6/9	22	21.39/7.40	3.11	92	3.85
4	1989	27/8	4/9	8	16.93/11.61	3.12	116	6.77
	1990	16/8	4/9	19	22.58/7.65	3.24	72	5.50
	1991	21/8	6/9	17	19.30/8.76	2.90	124	6.72
5	1989	18/8	11/9	23	19.08/8.22	3.10	107	4.99
	1990	12/8	4/9	23	20.80/8.28	3.07	-	-
	1991	24/8	16/9	23	19.08/8.22	3.18	-	-
6	1989	28/8	4/9	7	15.73/10.78	-	-	-
	1990	14/8	4/9	21	20.57/8.30	-	114	4.90
	1991	30/8	11/9	12	17.50/8.07	3.17	105	6.11

Table 5 – The characteristics of the equation of regression, simple and multiple, calculated. A = titratable acidity (g/L), S = sugar (°Brix), ΔmpV = distance from meeting point and the vintage (No. of days), r = regression coefficient; F = Fisher test, * = significant for p<=0.05, ** = significant for p<=0.01, R2 = coefficient of determination.

$$A = 12.48 - 0.1976 \Delta mpV$$

$$r = -0.895 \quad F = 56.48 \quad **$$

$$S/A = 1.13 + 0.0627 \Delta mpV$$

$$r = +0.80 \quad F = 24.82**$$

$$S/A = 2.46 + 0.5870 \Delta mpV - 0.011G.A.V.$$

$$R^2 = 0.678**$$

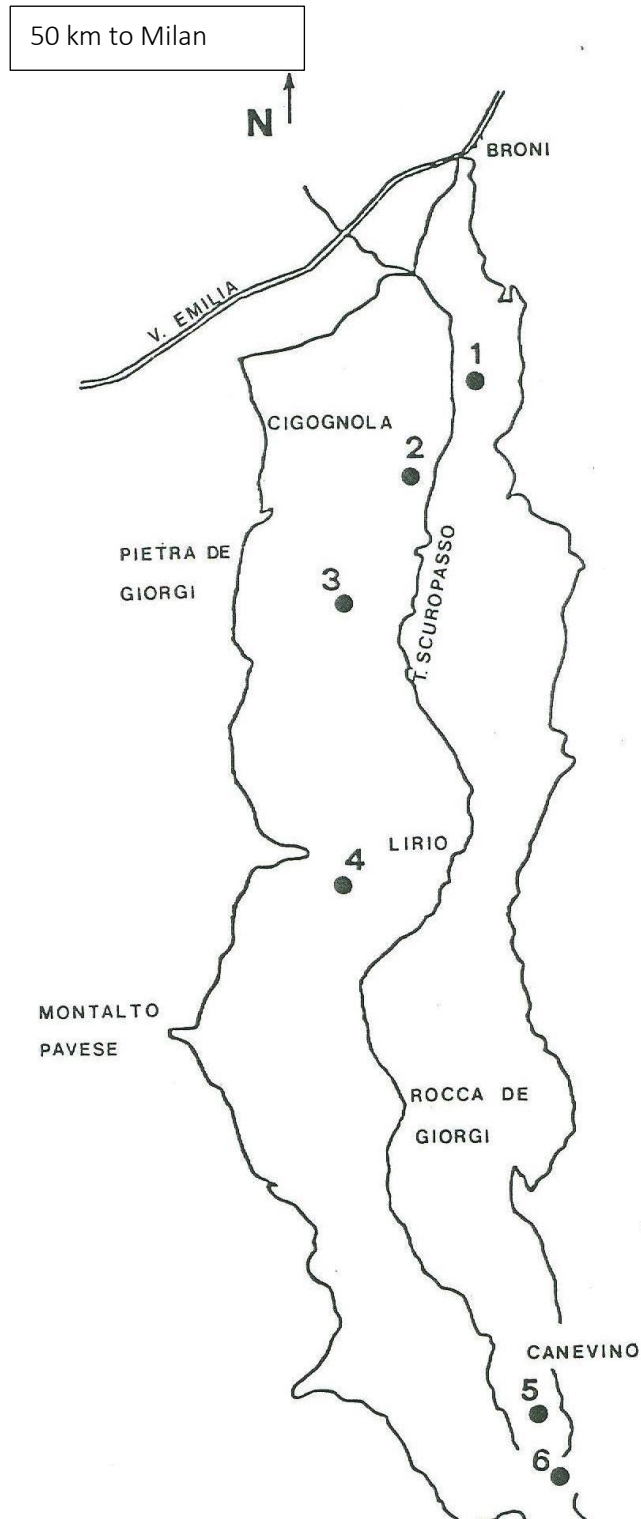


Figure 1 – Limits of the Scuropasso Valley with indicated the experimental vineyards (from 1 to 6) and the main localities (rural Centers). (T. Scuropasso = Scuropasso stream).

1 = 1°Brix
of sugar =
1 g/L of
titratable
acidity

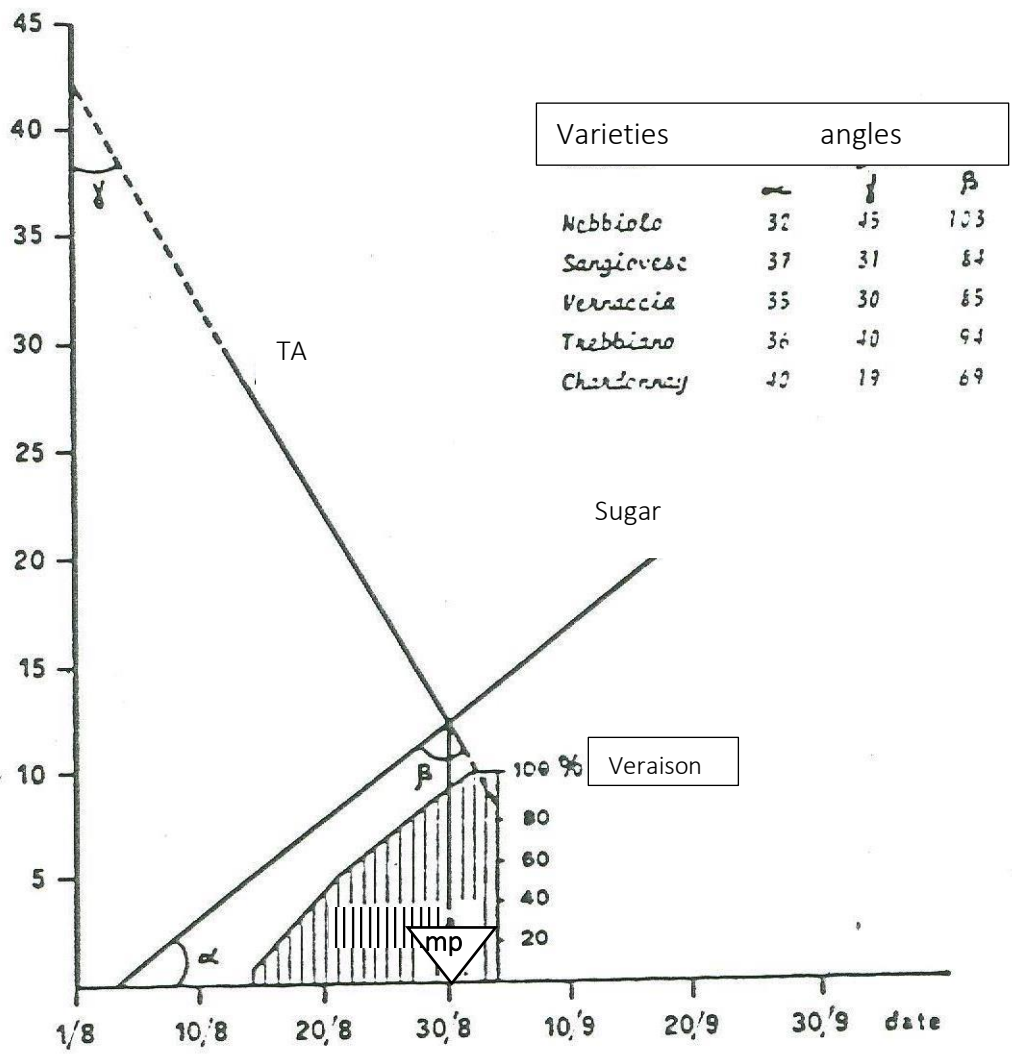


Figure 2 – The graphical representation of the “meeting point” (mp), the day when the content of sugar and of titratable acidity (TA) in the juice of the berry, are equal (Vercesi et al., 1989).

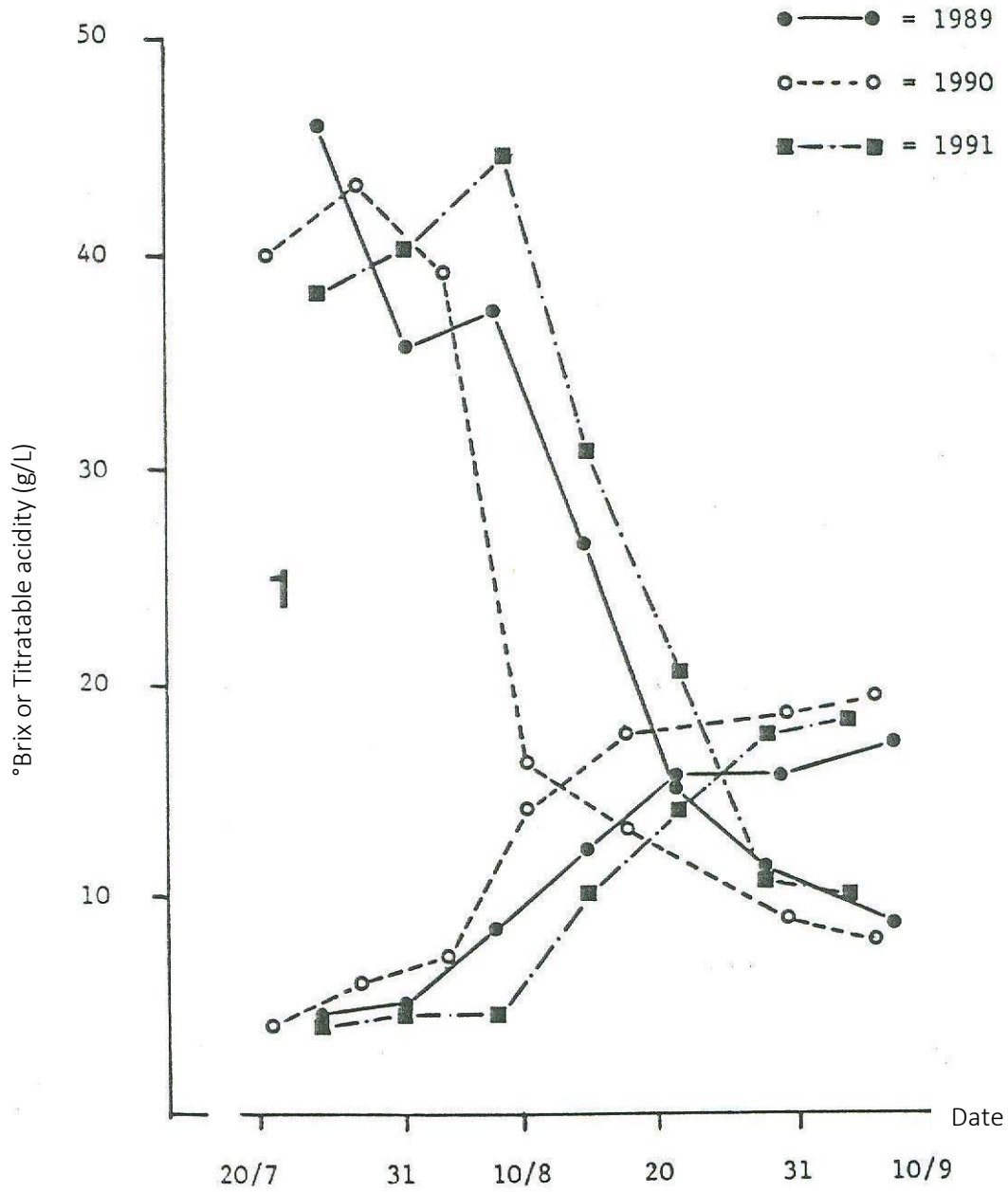


Figure 3 – Pinot noir, Vineyard No. 1. Graphic representation of the rise in the sugar content of the berries and the reduction of those in titratable, during ripening (1 ° Brix = 1 g/L).

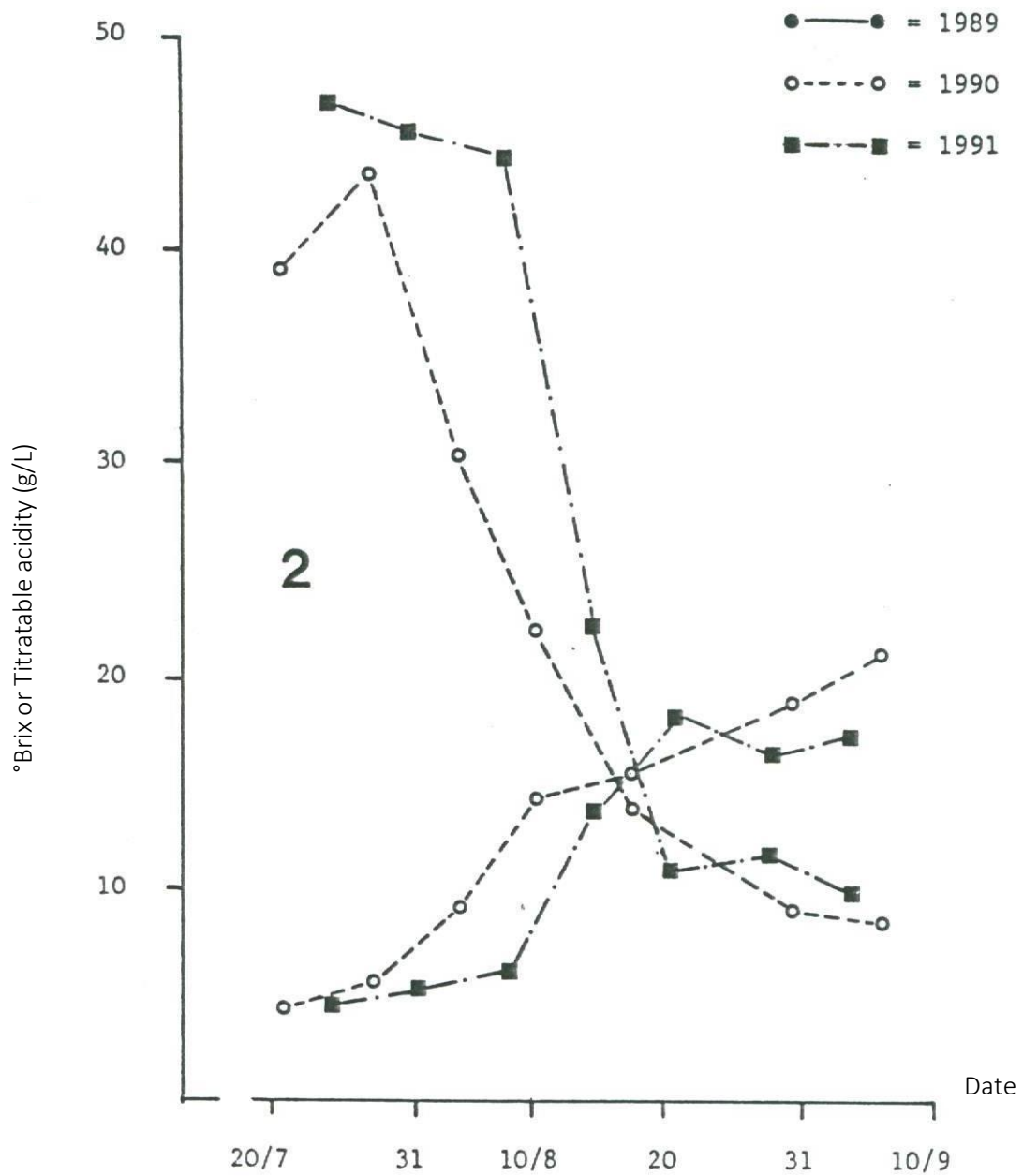


Figure 4 – Pinot noir, Vineyard No. 2. Graphic representation of the rise in the sugar content of the berries and the reduction of those in titratable, during ripening (1 ° Brix = 1 g/L).

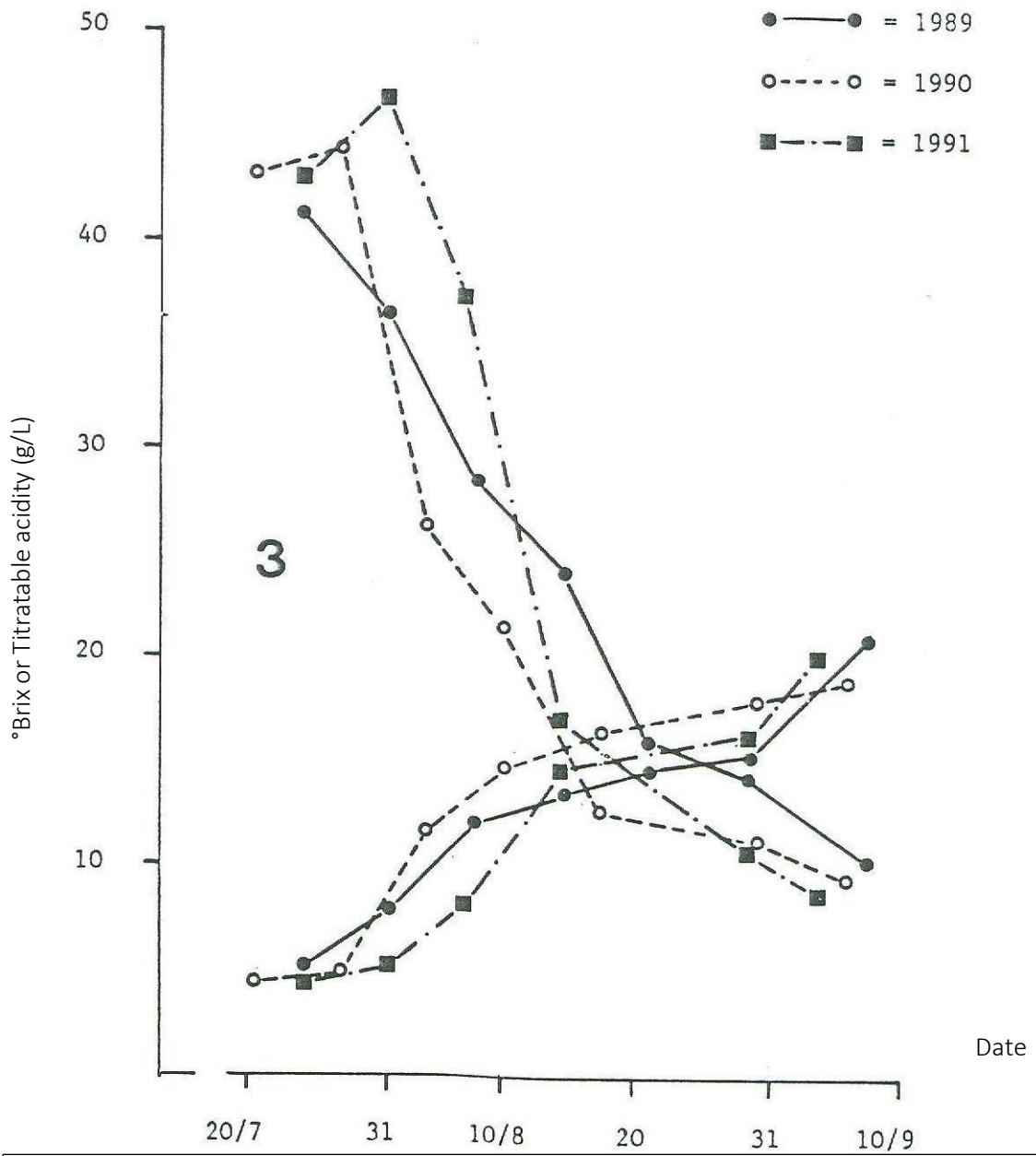


Figure 5 – Pinot noir, Vineyard No. 3. Graphic representation of the rise in the sugar content of the berries and the reduction of those in titratable, during ripening (1 ° Brix = 1 g/L).

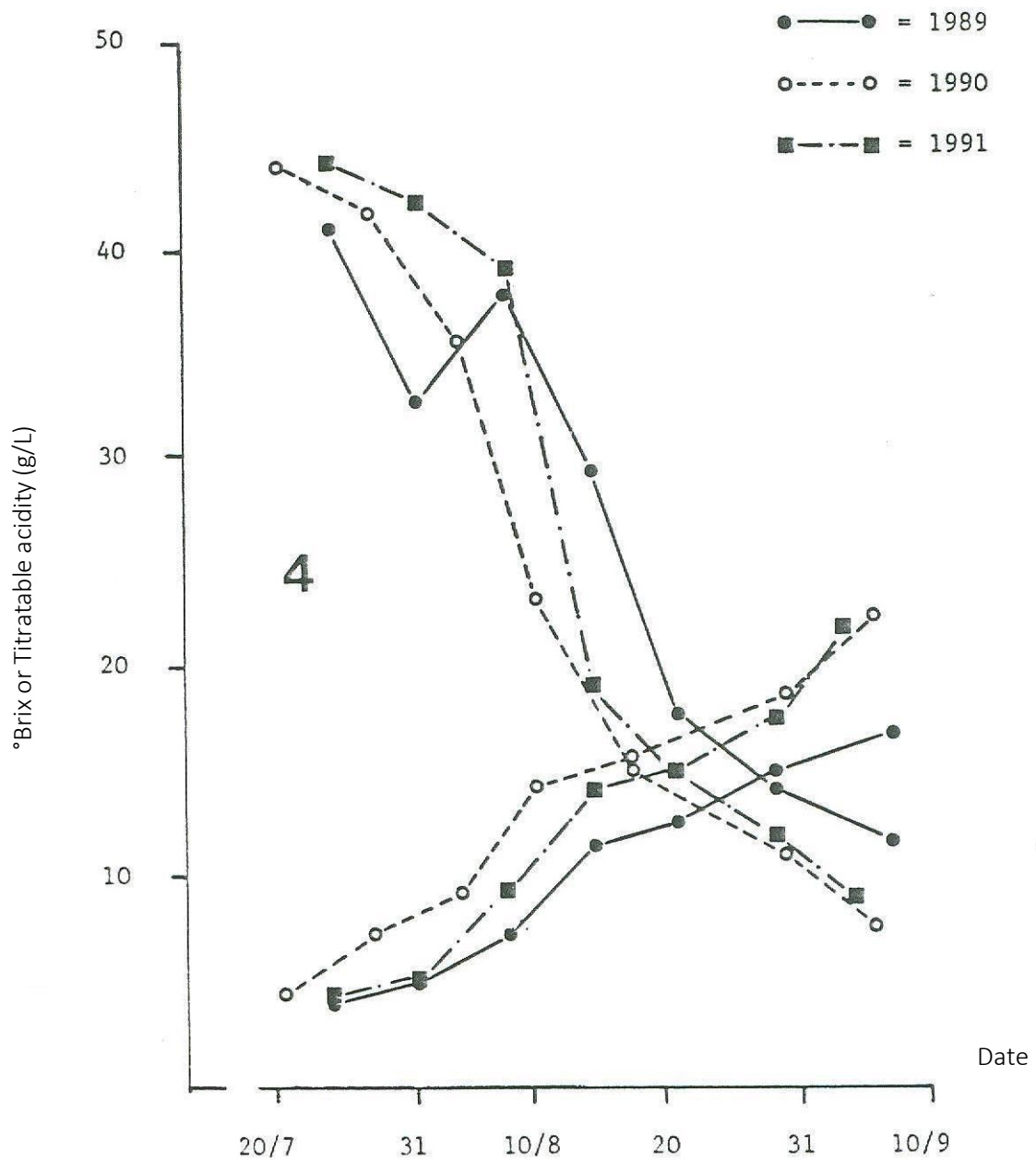


Figure 6 – Pinot noir, Vineyard No. 4. Graphic representation of the rise in the sugar content of the berries and the reduction of those in titratable, during ripening (1 ° Brix = 1 g/L).

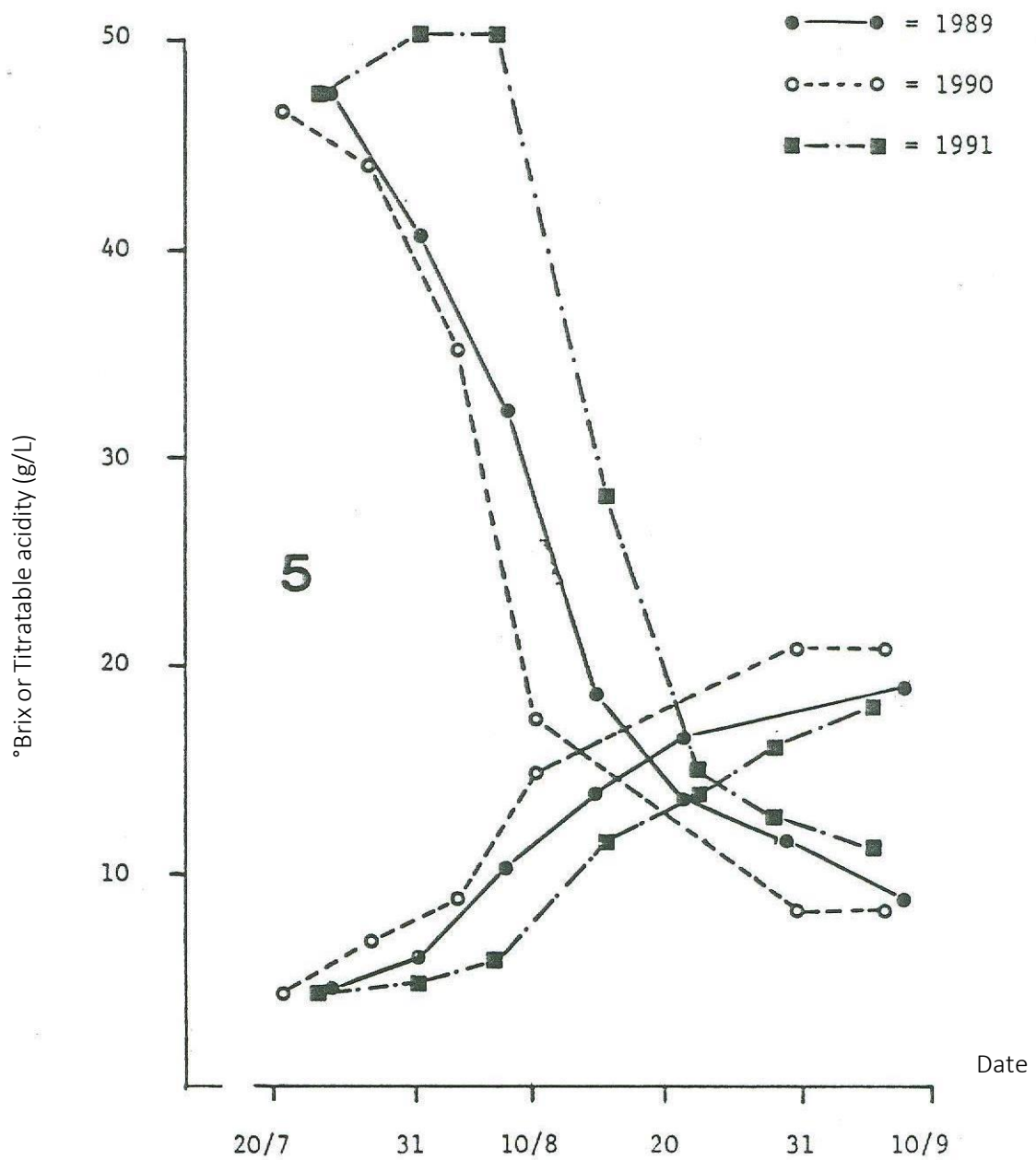


Figure 7 – Pinot noir, Vineyard No. 5. Graphic representation of the rise in the sugar content of the berries and the reduction of those in titratable, during ripening (1 ° Brix = 1 g/L).

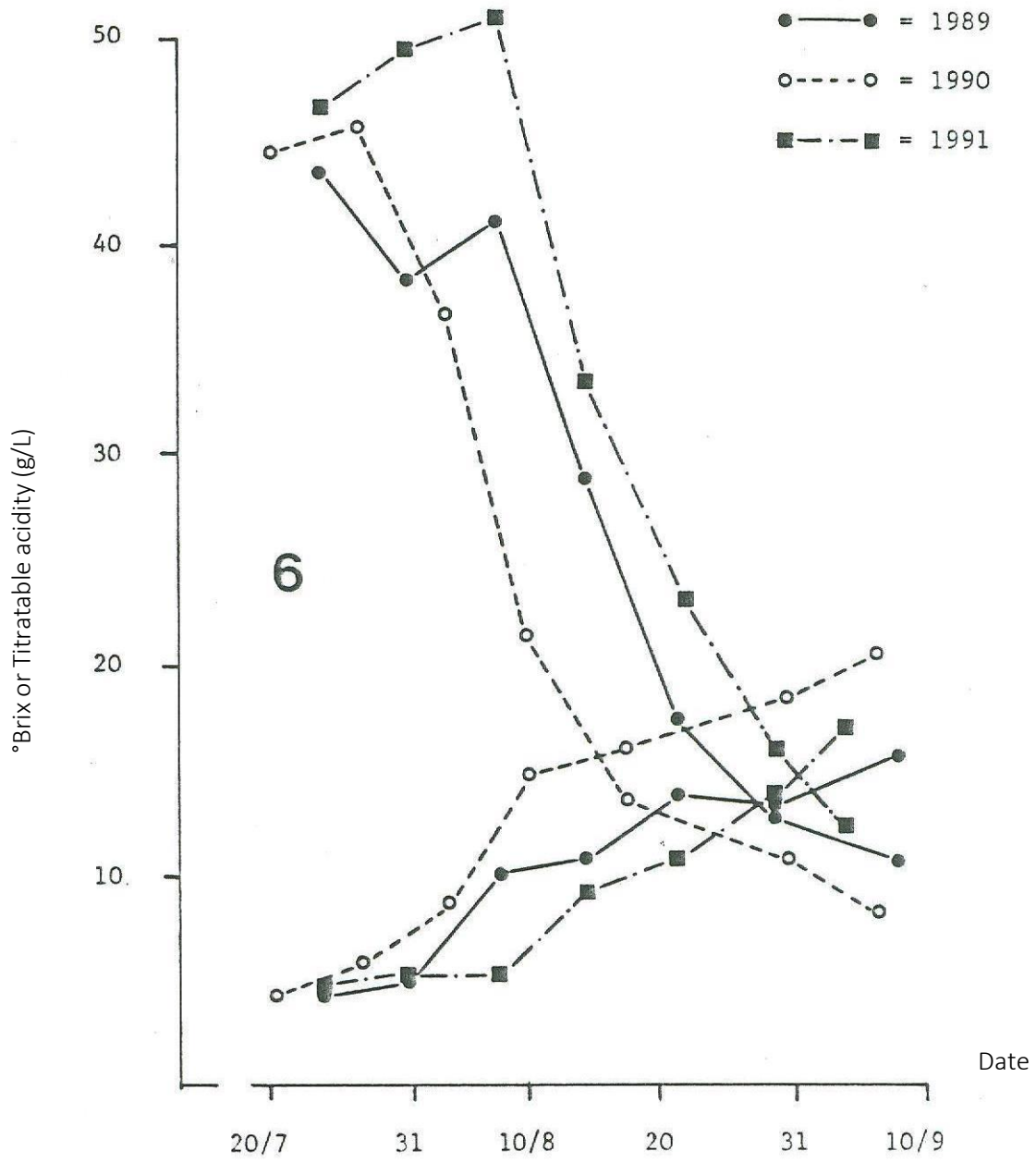


Figure 8 - Pinot noir, Vineyard No. 6. Graphic representation of the rise in the sugar content of the berries and the reduction of those in titratable, during ripening (1 ° Brix = 1 g/L).

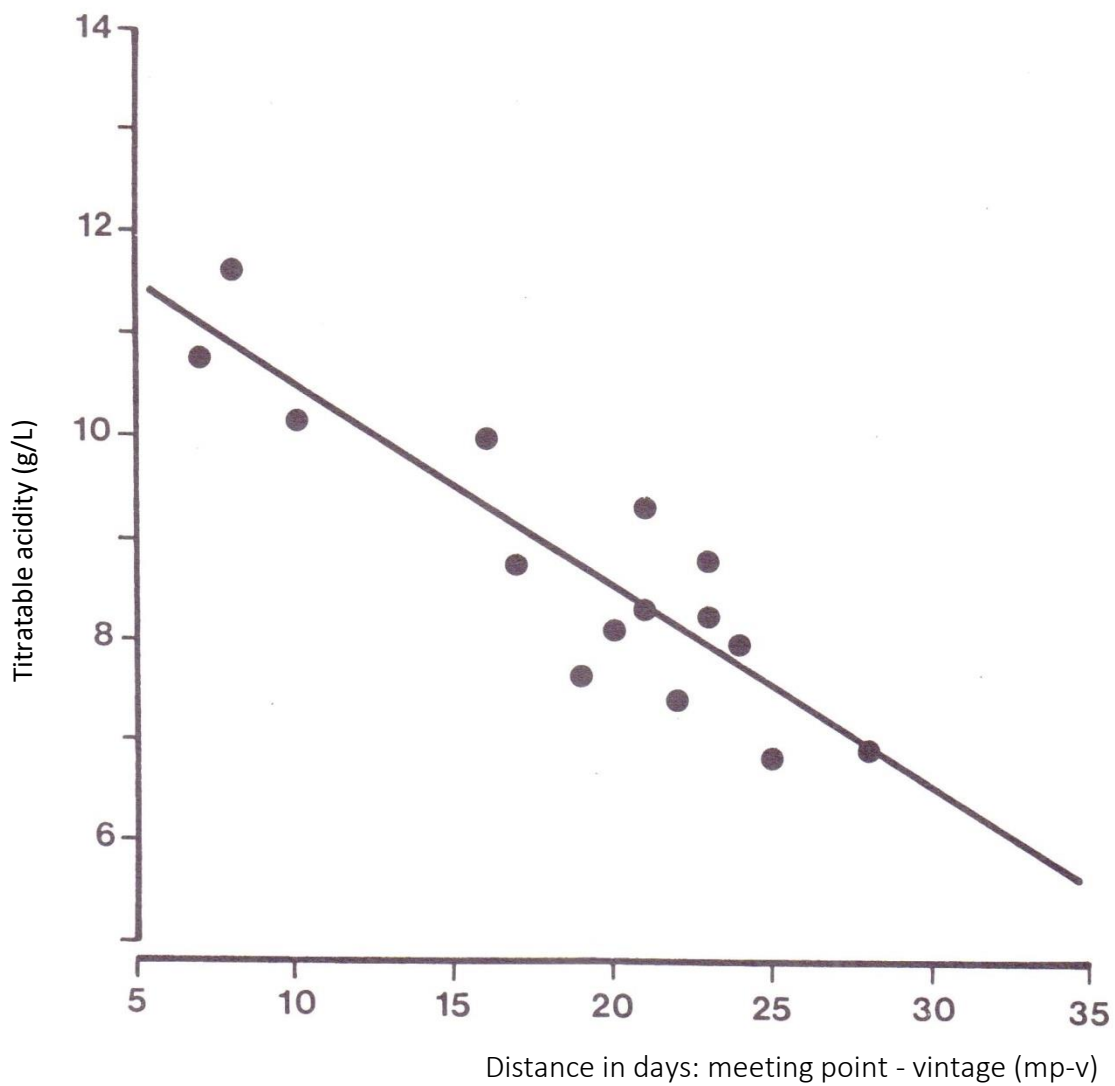


Figure 9 – Linear regression (1989, 1990 and 1991) between titratable acidity (g/L) and the number of days between mp (date of “meeting point” of sugar and titratable acidity) and the date of vintage (mp-v). Increasing distance in days between mp and harvest, decreases must acidity; after 17 or 22 days from mp, titratable acidity of musts is 9 or 8 g / L, respectively, reasonable minimum for the sparkling wine production.