

First steps in the grape mechanization process in Brazil: quantitative features

Wilson Valente da Costa Neto^{1*}, Miguel Garrido-Izard¹, Pilar Barreiro Elorza¹,
Fabrício Domingues²

(1. *Department of Agroforestry Engineering, Laboratory of Physical Properties and Advanced Technologies in Agri-food (LPP_TAGRALIA) ETSI Agrónomos, Technical University of Madrid, Avda. Complutense, 3. Madrid, 28040 Spain;*

2. *Miolo Wine Group Vitivinicultura S.A, General Manager of Almaden, 97578-831Brazil.*)

Abstract: Grape harvest is still fully manual in the majority of farms in Brazil (above 99%), yet the structure of the fields and the vine trellis are already prepared for being mechanized in a 24% of the cases. Besides, only the large-size farms are prepared for performing a detailed analysis of working capacity, product quality and losses; data of great value when trying to quantitatively address the incorporation of machinery. The fact that grape harvest in South America (and South Africa) be complementary in season compared to Europe, or North America, makes this potential market of Brazil an interesting option for European manufacturers. In this work, we have supervised a whole grape harvest season, in a 552 ha farm, where both, mechanical (trailed) and manual harvest, are performed. Harvest performance is assessed by means of digital field notebooks and using georeferenced data, Differential Global Positioning System (DGPS). A large variety of incidences have been found for the mechanized procedure due mainly to a deficient maintenance of the equipment, being reflected in a clearly reduction of the work capacity. Also in this study an analysis of juice losses due to mechanized harvest is performed. The quantitative features are defined and have been compared to evaluate the difference among both procedures, together with a technical discussion in the prospective of the grape (harvest) mechanization in the near future in Brazil.

Keywords: farm management system, must, viticulture in Brazil, grape harvest, lost grape

Citation: Neto, W. V. D. C., M. Garrido-Izard, P. B. Elorza, and F. Domingues. 2017. First steps in the grape mechanization process in Brazil: quantitative features. *Agricultural Engineering International: CIGR Journal*, 19(2): 110–119.

1 Introduction

Grape harvest mechanization started in California in the 1960s by designing trellis that would allow the mechanized process. It continued in Europe, mainly in France, in the 1970s fostered by the petrol crisis. Ever since, France reflects a large manufacturing expertise in the subject: Braud (first commercialized model in 1975, currently CNH Industrial), Gregoire (first model in 1978) and Pellenc (at the beginning of the 1990s). In general terms, an hour of mechanized work equals to the labour of a team of 10 people on a full-dedicated day (8 h)

(Barreiro, 2009).

In Spain it is by 1990 that grape mechanization starts due to the need of adapting the vine into the new trellis system (Barreiro, 2009). The latest data available (December 2014) indicate that there are 1980 harvesters in Spain (MAGRAMA, 2014), being an order of magnitude lower than France.

The vast majority of marketed grape harvesters work on the basis of horizontal vibration and are classified into: trailed, self-propelled and multi-purpose machines. Trailed harvesters represent the lowest cost of acquisition and maintenance, requiring a tractor power take-off (PTO) above 56 kW, while self-propelled machines (offered in a range of 75-100 kW), have an acquisition cost substantially higher than trailed ones (more than double). Self-propelled machines are ideal for contractors while trailed harvesters are preferred by individual farmers.

Received date: 2016-09-14 **Accepted date:** 2017-04-26

* **Corresponding author: Wilson Valente da Costa Neto**, Department Agroforestry Engineering, Technical University of Madrid, Avda. Complutense, 3. Madrid, Spain. Email: wilson.vdacostaneto@alumnos.upm.es

Since South America (the South Hemisphere) has a complementary harvest season compared to Europe (the North Hemisphere), international transport of harvesters has become a new active business, which allows duplicating the available working time (from about 500 h to nearly 1000 h per year). Chile is the main depository of this interchange due to cultural similarities (language among all), and several Spanish contractors are placing a significant effort to offer grape harvesters all along the year.

In 2015, Brazil reported 79094 ha for wine growing (Figure 1), distributed in 9 states with an overall production of 1.5 Mt; 50% for table grapes consumption, and the rest for processing wine, juice and derivatives.

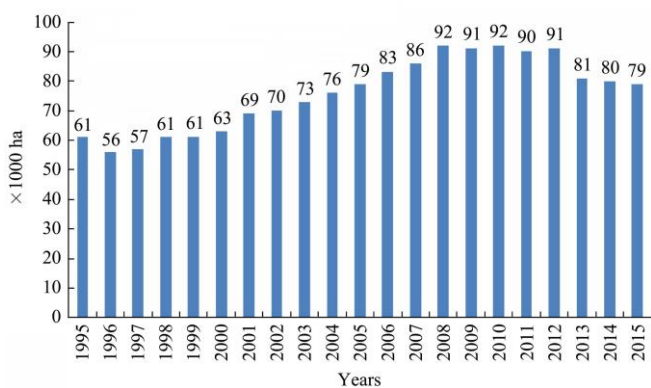


Figure 1 Cultivated area of vineyard in Brazil

The area planted with vineyards in Brazil (Figure 1) has shown a steady increase from 1995 to 2008, and a plain situation until 2013, while decreasing from 2013 until 2015. In 2015 an overall reduction of 1.83% has been found, affecting most of the nine producing states; only two showed a small increase in area, while the rest had a reduction of 0.1% to 12.79%. This reduction may be due to weather issues, poor hand availability and high valuation on the land.

In 2015, 1.5 Mt of grapes were produced in Brazil (Figure 2), which represents an increase of 4.41% compared to 2014. Production decreased in 2015 in Bahia (0.13%), São Paulo (3.22%) and Paraná (1.12%). These states represent 22% of national production (Mello, 2015).

The production of grapes for wine, juice and derivatives was 781 kt in 2015, accounting for 52.12% of national production. The remaining production (47.88%) was destined for fresh consumption in table grapes.

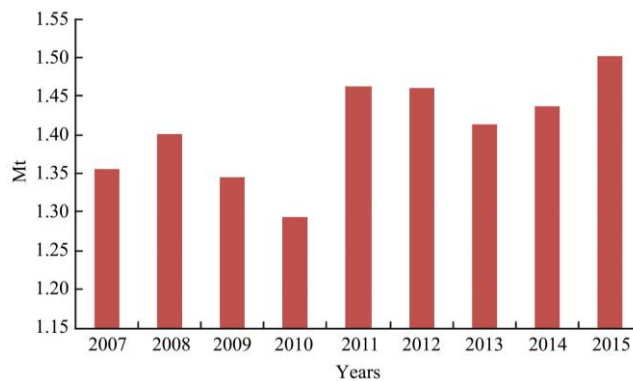


Figure 2 Grape production in Brazil

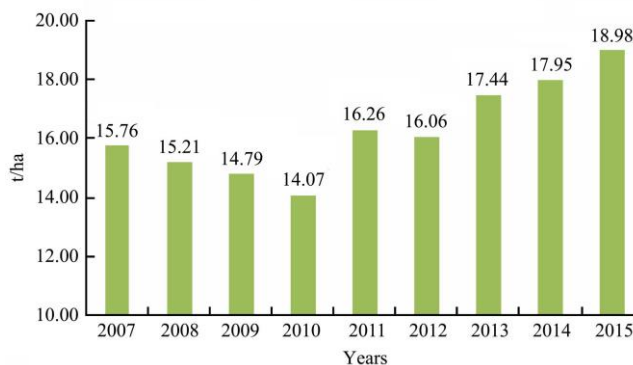


Figure 3 Mean production of grapes per ha in Brazil

It is estimated that among the total area of vineyard in Brazil, a 24% is conducted in trellis system. Trellis system has shown an increasing tendency due to the lower cost of implementation and its suitability for mechanization. Still, in 2015 only three grape harvesters were available in Brazil: 2 trailed machines and one self-propelled device.

Recently, precision agriculture techniques have been adopted by few winegrowers in Brazil by considering the correlation between the soil and the production and quality of the grapes. On the other hand, researchers as Sarri et al. (2016), go beyond this precision agriculture concept, analysing parameters related with the vegetative vigour by the use of specific technology (infrared sensors, ultrasound, georeference, etc.)

There are a limited number of scientific papers related to the evaluation of grape harvester performance. Pezzi and Caprara (2009) presented a study on the transmission of vibrations in vines of the variety Lambrusco Grasparossa collected with a Braud VL6060. They performed an analysis of losses (unharvested berries, must release and must retain in vegetation, or expelled by the cleaning system) as a matter of the setting parameters of the harvester (vibration frequencies of 380 to

460 min^{-1}). The main results indicate that the transmission of vibration to the plant only reaches 100% for the higher frequencies (460 min^{-1}); the losses of berries on the ground are not influenced by the frequency of vibration but by the characteristics of the constitution of the machine and the vineyard. A higher frequency of vibration decreases the number of uncollected berries while increasing the liberated must losses, as well as the number of detached leaves. Therefore better regulation is one in which both aspects are minimized, in this study corresponded to 440 min^{-1} . The authors warn that losses due to uncollected fruit easily visualized, and tend to favour the use of excessive frequency since the must losses are not obvious.

In 2011, Caprara and Pezzi (2011) performed a similar analysis comparing two Gregoire grape harvesters: trailed versus self-propelled. According to this study, there is a significant reduction of unharvested berries, and berries in the ground in the self-propelled (1.06% and 2.7%) compared to the trailed machine (1.7% and 3.9%), that is to say a 33% reduction is obtained in self-propelled compared to trailed machines, with similar must release values (26.5% in self-propelled compared to 28.2% in trailed machines). In spite of previous results, defoliation index was lower for trailed than for self-propelled (17.8% compared to 20.8%). These authors also performed vibration analysis with both types of machines with results pointing to a lower energy requirement for detachment in self-propelled compared to trailed machines, probably due to a lower transversal component (of little detaching effect).

Nowadays there is a growing interest in carrying out selective harvesting (Bramley, 2005; and Bramley, 2009). In the case of side discharge harvesters (no hopper), the unloading conveyor has a bidirectional movement that sends the grapes towards two different trailers depending on the quality (Báguena, 2011). In the case of rear discharge harvesters (with hopper), there is a patent (Berthet et al., 2010) by CNH Industrial that redirects the flow to either hopper (left or right depending on the quality). Báguena (2011) provides a large review of precision viticulture evolution. The incorporation speed of such innovations may be much faster than the previous

ones since they do not require further adaptation of the vines.

The objective of this work was to evaluate the possibility of implementing mechanized operations in Brazilian vineyards, identifying the agricultural units that own grape harvesters and evaluating their field capacity, yield, grape production and grape losses. Moreover, some field manual data were analysed, obtained from the field notebooks, as structure and cultivated varieties, area of cultivation, losses, and the way of harvesting used (manual or mechanical).

2 Materials and Methods

In Brazil, agricultural machinery is exempted from licensing for circulation (Brasil, 2015), then from a study carried out by Costa Neto et al. (2014), contacted the owner of the only grape harvester in Brazil until then, to carry out this work. Thus, the methodology adopted consisted in: a field performance assessment by the installation of a centralized DGPS antenna on the machine; an evaluation of the field notebooks data and an estimation of grape and must losses.

2.1 Field performance assessment with Diferencial Global Positioning System (DGPS)

For the evaluation of the performance of the grape harvester (Pellenc model 3052/Smart système), operating with frequency of the shaker from 500 beats min^{-1} and amplitude 850 mm, a DGPS antenna (Garmin modelo H-17) was installed and configured at 1 Hz. Data were recorded during a single day of harvest in a property location in Santana do Livramento municipality in the state of Rio Grande do Sul, Brazil (latitude 30°47'00"S and longitude 55°22'09"W), in an area of 4.5 ha (Alma3 and Alma4), cultivation density 2.777 plants per hectare (3.0 m \times 1.2 m), estimated yield 11100 kg ha^{-1} corresponding to Alicante Bouchet.

The tractor trailing the harvester was Massey Ferguson model 291 with a nominal power of 72.2 kW. National Marine Electronics Association (NMEA) codes were recorded by means of free-code software (Visual GPS Application®). Later, the data were processed in Matlab® with dedicated routines for extracting: time, latitude, longitude, the Universal Transversa de Mercator

coordinates X and Y (XUTM, YUTM), global positioning system fix data '\$GPGGA' and track made good and ground speed '\$GPVTG' messages. Data were organized as exemplified in Table 1. The methodology used for the processing was similar to that used in B águena et al. (2009).

Table 1 Transformation of NMEA codes for dimensional parameters

Time	Latitude	Longitude	XUTM	YUTM	Speed, km h ⁻¹	Altitude, m
153928	-30.785705	55.36845	343885	-3406990.91	2.5	213.2
153929	-30.78570833	55.368445	343884.5	-3406991.286	2.5	213.3
153930	-30.78571	55.3684383	343883.9	-3406991.48	2.3	213.3

The routines developed considering the Bodria et al. (2006) formulas allowed the identification of crop rows, headlines, and stops, in other words, the determination of the total working and effective time was made possible for the first time in Brazil; evitable dead time is computed as stops inside rows. The main parameters and formulas used are explained below:

In-row time (*In_row*), in seconds (s), is duration while the machine was inside the row.

Evitable dead time (*TME*), in seconds (s), is the identification and sum of the times in which the machine stops inside the row.

Accessory time (*TA*), in seconds (s), is the sum of all the unavoidable times spent on the evaluated portion, such as manoeuvring on the headland, unloading and fuel replenishment.

Effective time (*TE*), in seconds (s), is considered operating time, when the machine is not stopped inside the row.

$$TE = In_row - TME \quad (1)$$

Effective Capacity (*WC_e*), in hours per hectare (h/ha) was calculated by:

$$WC_e \text{ (h/ha)} = 1 / Te \quad (2)$$

Theoretical capacity (*WC_t*) was calculated using the following formula:

$$WC_t \text{ (ha h}^{-1}\text{)} = b * v * 10^{-1} \quad (3)$$

where, *b* – distance between lines (m); *v* – theoretical forward speed (km h⁻¹).

Actual field efficiency (*Act_FE*):

$$Act_FE = \frac{\sum(TE)}{\sum(TME + TA + TE)} \times 100 \quad (4)$$

Actual work capacity (*WC_a*):

$$WC_a = \frac{WC_t \times Act_FE}{100} \quad (5)$$

Optimal field efficiency (*Opt_FE*):

$$Opt_FE = \frac{\sum(TE)}{\sum(TA + TE)} \times 100 \quad (6)$$

2.2 Field notebook

Field notebook has been organized with respect to the following items: plot, variety, surface, plant density, production, harvest losses (grapes on ground), mold losses and type of harvest (manual or mechanized).

From this information it is possible to extract a series of data, as follows, such as the use of the machine and its performance against manual harvesting.

2.3 Loss grapes and must release

Besides, an additional determination of grape losses was performed whenever mechanized harvesting took place. It was defined an area of 18 m² centred in the production line before harvest, where grapes on the soil were removed (not performed in the standard notebook data) shows sampling rectangle, in this case with 6.0 m × 3.0 m. After harvesting, grapes on the soil were counted and weighed.

To evaluate the occurrence of mold, a number of plants growing in the contiguous line (not yet harvested), was evaluated. The number and weight of rotten grapes were then evaluated. Therefore, grape loss evaluation consisted of in two parameters (losses in the soil and rotten grapes). Evaluation was performed by three replicates per plot.

As a qualitative test, water sensitive papers were used for evaluating must release during the harvest, since beaters remove the fruits from the wood, which is markedly different from manual harvest. The papers were arranged as shown in Figure 4, two being positioned on the ground away from 60-80 cm stem on the planting row (A-B); stem with a height of 40 cm (C); two in the production string (D-F); and two more in the canopy area, height 1.30-1.50 m (E-E1), as exemplified in Figure 4.

After the mechanical harvest, the papers were immediately collected and catalogued for further image acquisition and analysis by MatLab®, which allowed the determination of the percentage surface in blue (reacting

to moisture) in a similar way as Salem et al. (2014):

$$2B - R - G > 15 \tag{7}$$

where, *B* – blue channel; *R* – red channel; *G* – green channel, and the constant –15.

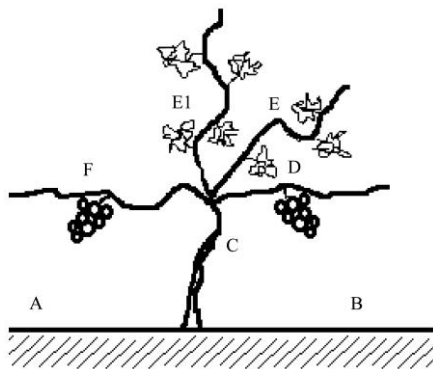


Figure 4 Positioning the hydro sensitive papers

3 Results and Discussion

3.1 Field performance assessment with GPS

Table 2 shows the time records and work speeds in each crop row for Alma 3 plot, according to DGPS. According to time records, the WC_t in Alma 3 was 0.695 ha h⁻¹, the Opt_FE was 90.6%, while the Act_FE was 39.7%. On the other hand, average work speed was rather low (2.32 km h⁻¹) with coefficients of variation (*CV*) nearly always above 20%.

Table 2 Time records and work speeds per crop row in Alma 3 according to DGPS

In-row, s	TME, s	TA, s	TE, s	Speed, km h ⁻¹	CV of speed, %
491	341	23	150	2.39	20.6
442	339	33	103	2.35	11.1
708	335	27	373	2.37	19.9
446	337	26	109	2.42	13.6
610	349	28	261	2.34	23.8
512	348	26	164	2.32	19.0
693	361	26	332	2.32	28.0
896	789	39	107	2.29	23.2
528	351	33	177	2.32	20.5
883	381	24	502	2.23	23.3
952	373	31	579	2.25	28.0
838	381	29	457	2.18	24.2

Figure 5a shows the work pattern in Alma 3 plot according to GPS records. Duration of every *TME* in a row is identified by a corresponding stop duration colour. The large spread in *TME* corresponds to several needs: adapting the work speed with the conveyor speed (synchronization did not work) few seconds, removing leaves whenever system was blocked 10 s, and replacing

the conveyor into the carrier platform above 40 s (Figure 5b). All of this clearly indicates the lack of proper maintenance of the machine.

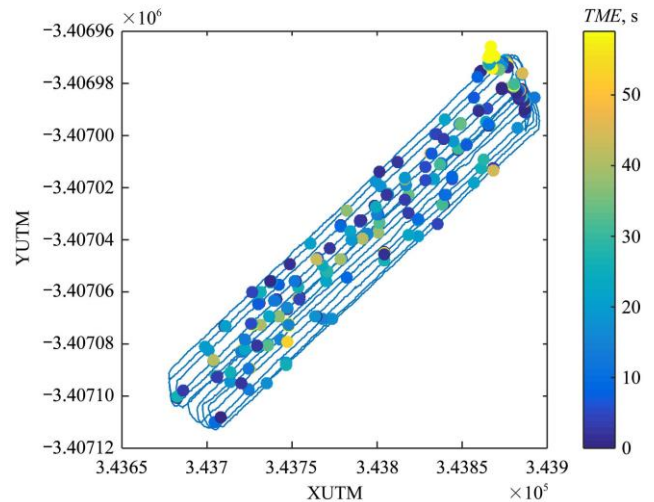


Figure 5a Work pattern in Alma 3 field according to GPS records

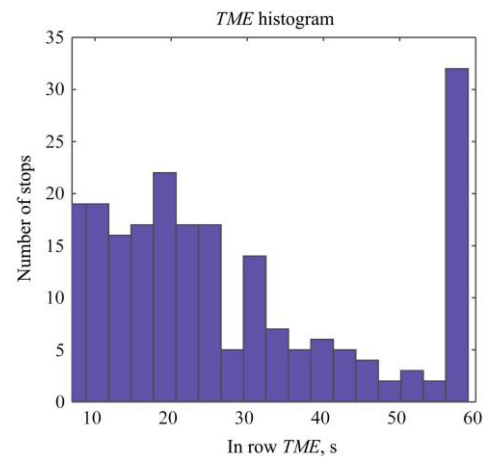


Figure 5b Histogram of in-row *TME*

Table 3 shows the time records and work speeds per crop row in Alma 4 plot according to DGPS. As before, *TME* is identified as time with null speed inside the row and it is labelled as evitable since this fact is totally abnormal. According to time records in Table 4, the WC_t in Alma 4 was 0.738 ha h⁻¹, the Opt_FE (miss regarding the *TME*) was 56.8%, while the Act_FE was 22.6%, that is to say considering the *TME*. On the other hand, average work speed was rather low (2.46 km h⁻¹ on average) with *CV* in above 20% (very high).

Table 4 compares the machine performance in both fields Alma 3 and Alma 4. In both cases the speed was similar (2.32 and 2.46 km h⁻¹). The Act_FE was extremely poor in both cases (39.7% and 22.6%). In case of Alma 4 many of the *TME* occurred at the headlines and so it has not been possible to isolate them from the *TA*,

drastically reducing the Opt_{FE} (from 90.6% in Alma 3 to 56.8% in Alma 4). The WC_t in Alma 3 and Alma 4 were 0.695 and 0.738 ha h⁻¹ respectively. Field efficiency, computed as described in material and methods, indicates a very poor field performance due to the existence of very long dead time (93.1% and 77.7% out of whole ineffective time).

Figure 6a shows the work pattern in Alma 4 field according to GPS records. Duration of every TME in a row is identified by corresponding stop duration colour, not being represented the TME occurred at the headlines. As before, the large spread in TME corresponds to several needs: adapting the work speed with the conveyor speed (synchronization did not work) few seconds, removing leaves whenever system was blocked 10 s, and replacing the conveyor into the carrier platform above 40 s (Figure 6b). As before, this clearly indicates the lack of proper maintenance of the machine.

Table 3 Time records and work speeds per crop row in Alma 4 according to DGPS

<i>In-row, s</i>	<i>TME, s</i>	<i>TA, s</i>	<i>TE, s</i>	Speed, km h ⁻¹	CV of speed, %
352	308	50	44	2.6	19.6
596	346	50	250	2.41	22.3
577	337	47	240	2.36	25.4
524	341	171	183	2.32	15.2
466	339	27	127	2.36	23.3
483	357	167	126	2.26	24.4
476	331	27	145	2.39	20.8
488	344	390	144	2.37	17.7
434	318	23	116	2.54	14.4
321	305	147	16	2.61	12.5
412	320	25	92	2.61	17.8
366	320	68	46	2.60	11.9
486	331	24	155	2.55	23.4
406	320	94	86	2.60	12.3
327	308	22	19	2.69	14.2
425	327	131	98	2.60	16.6
400	316	50	84	2.62	22.2
573	326	172	247	2.58	19.9

Table 4 Machine performance and field efficiency in both fields Alma 3 and Alma 4

Name	Speed, km h ⁻¹	Au, m	Sum (TME)	Sum (TA)	Sum (TE)	WC_t , ha h ⁻¹	WC_e , ha h ⁻¹	WC_a , ha h ⁻¹	Opt_{FE} , %	Act_{FE} , %
Alma 3	2.32	3	4685	345	3314	0.695	0.629	0.276	90.6	39.7
Alma 4	2.46	3	5894	1685	2218	0.738	0.419	0.167	56.8	22.6

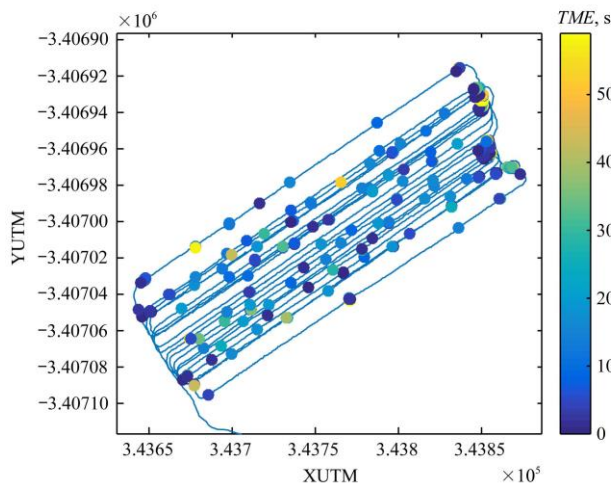


Figure 6a Work pattern in Alma 4 field according to GPS records

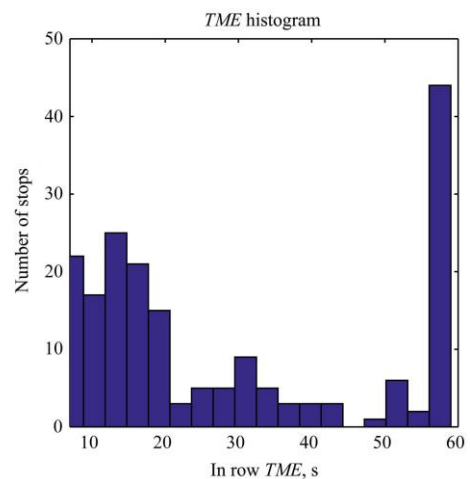


Figure 6b Histogram of in-row TME

Another interesting feature from DGPS is the possibility of addressing the work sequence, and thus the steering radius selected by the operator. In Alma 3 the typical steering diameter was 4 rows (ranging from 1 to 6). In Alma 4 the steering diameter was equally distributed between 4 and 5 rows (ranging from 1 to 8).

3.2 Digital field notebooks outcomes

Figure 7 presents the amount of vine varieties grown

in the farm under study (552 ha, 160 fields), all in trellis, that is to say harvest mechanization is feasible for the whole farm. According to the field notebook, 28 varieties were grown in 2015 which is a huge variety compared to standard production in Europe (approximately 20 varieties per farm). Among the varieties in use, the most relevant ones (as a matter of ha) gather 40% of red grapes: Cabernet Sauvignon (20%), Tannat (11%), Merlot (9%)

and Moscato (4%); 20% of white grapes: Riesling Italic (8%) and Sauvignon Blanc (6%), Chardonnay (4%); and 10% of surface without indication of variety in the notebook; the remaining 30% corresponds to varieties with field area below 3%.

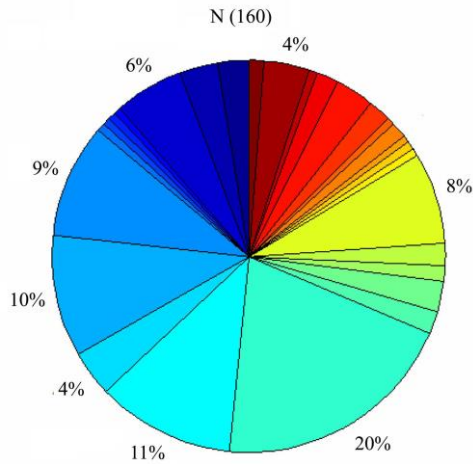


Figure 7 Plot for different variety

According to the field notebook, 77.3% of the field (115 plots) are harvested manually at current stage, while a 27.7% (44 plots) are harvested with mechanized harvesters, among them the main mechanized varieties are: Cabernet Sauvignon (14/32 plots), Riesling Italic

(6/12 plots), Merlot (5/15 plots), Tannat (4/18 plots), and Pinnot Noir (3/5 plots).

Figure 8 presents the proportion of the use of mechanical harvest in 28 most representative parcels of the property. In 10 cases there is no variability since a single field grows the corresponding variety. For the rest, we appreciate production rates for a single variety that range from 4 to 11 t ha⁻¹ (Semillon Blanc) will others are less variable (3 to 7 t ha⁻¹). It should also be highlighted that outlier fields (Red Crosses) appear for varieties (Cabernet Sauvignon and Chardonnay). In the case of Cabernet Sauvignon there are 2 plots that had nearly no production at all, while in the case of Chardonnay we find a field which doubles the production of the rest of fields.

Figure 9 shows a scatter plot of field production (t ha⁻¹) and grape losses (%) for the 160 plots harvested in 2015 as referred by the field notebook. Manual harvest is shown as squares (116) while mechanized harvested fields are shown as filled circles (44). Most of fields show losses below 2% (152/160), corresponding all of them to manually harvested fields.

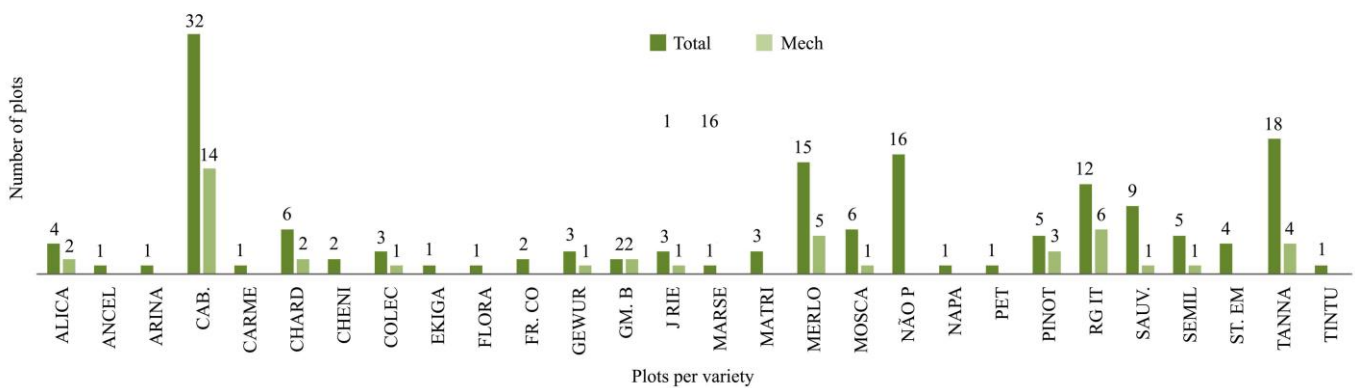


Figure 8 Mechanized plots and total

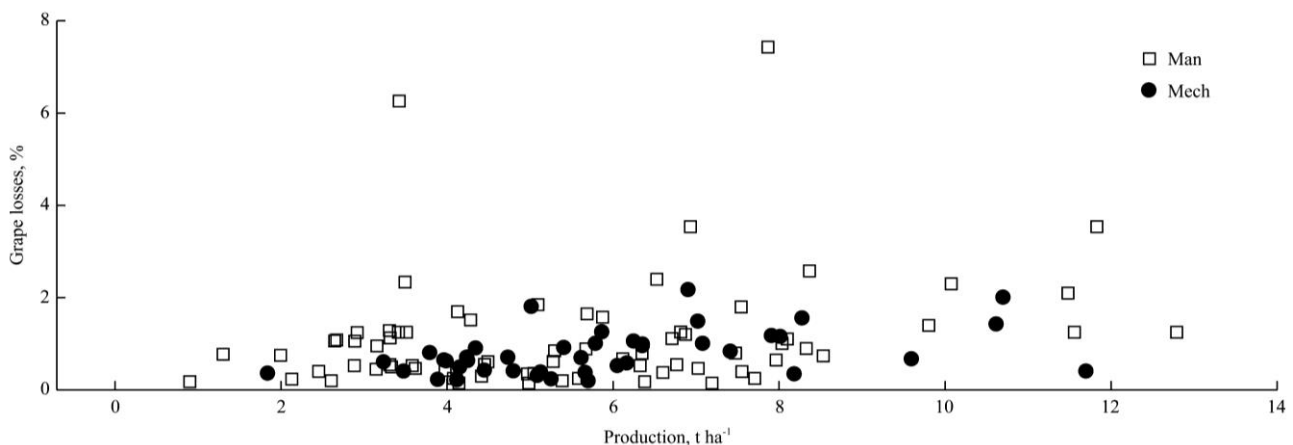


Figure 9 Scatter plot of field production and grape losses

The Figure 10 shows the amounts of grape harvest losses during three different portions for the variety Alicante Bouchet.

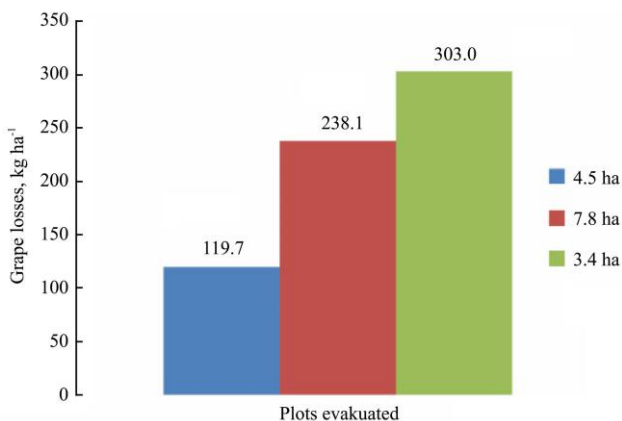


Figure 10 Third party versus property assesment

In Figure 10, the first column refers to the losses of grapes by the author after the mechanical harvesting. The other two columns were extracted from the notebook, in which records all uncollected grapes, already on the ground, after harvest not being cleaned the soil previously as in the case of the authors measurements.

Thus, a loss grape percentage of 1.24% was obtained for the author while by the notebook it was obtained a percentages of 2% and 6%.

The value found (119.7 kg ha⁻¹) only refer to losses in mechanical harvesting of grapes in the soil is below the values found by Pezzi and Caprara (2009).

The high quality of the notebook data constitutes a major tool for the design of a mechanization strategy which will be further discussed.

3.3 Must release

Five analyses were performed at the following times: 09:00, 10:30, 11:30, 12:30 and 13:00. The results are shown in Table 5. It can be seen that, in general, paper reaction decreased with time, due to the presence of early moisture in the morning; relative humidity in the zone decays over 40% from 8:00 to 12:00, while thermal amplitude exceeds 12 °C. The areas with highest paper reaction were “C” with an average of 77.7% followed by “D-F” (average of 44%), and “A-B” (41%), and finally “E-E1” (34.5%).

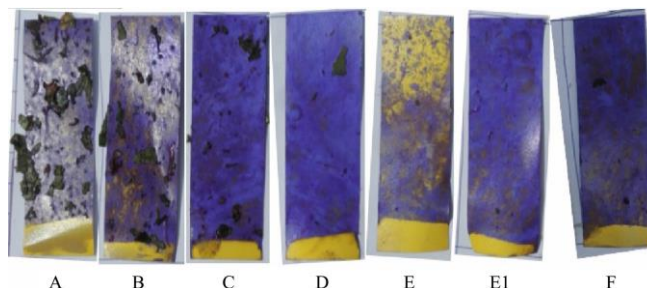
These values are higher than those disclosed by Barreiro et al. (2016), with values in the order of 22% and 34% for a similar “D-F” and “C” position.

Table 5 Recoating percentage of paper-water sensitive

Time	A-B, %	C, %	D-F, %	E-E1, %
09:00	98.85	N/C	12.81	98.83
10:30	42.57	96.95	97.18	68.57
11:30	9.49	77.81	44.88	1.31
12:30	2.40	48.23	47.18	1.69
13:30	50.55	87.91	17.85	2.07

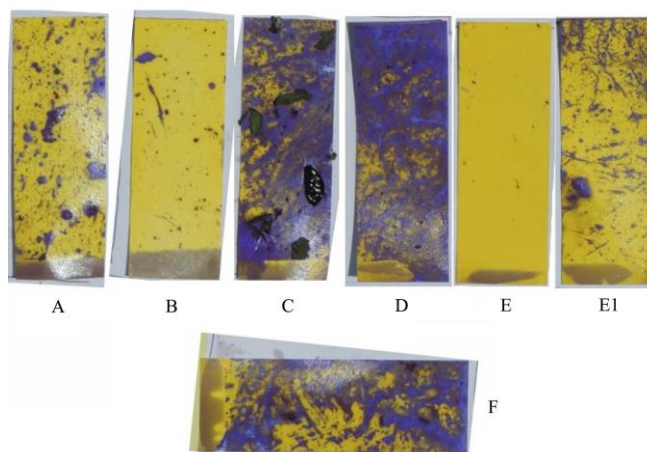
Note: N/C – Not Calculated.

Figures 11 and 12 are the sets of papers-water collected in 09:00 and 13:30. It can be visually perceived the difference in coverage between the two samples (98.85% and 50.55%). However, it has to be emphasized that some of the reaction of the water sensitive papers, could be due to the movement of the branches and leaves system sack (exhaust) of grape harvester and not to the direct impact of must drops. Still, it is noticed that the stem region, as well as the area corresponding to the first wire (location of bunches of grapes) are the ones that stood out by coverage.



Note: Reaction of the papers practically in all the points of the plant.

Figure 11 Sets of papers-water collected in 09:00.



Note: Reaction due to contact with must, stem (C), soil (A-B) and buches (D-F).

Figure 12 Sets of papers-water collected in 13:30.

4 Conclusions

Grape mechanization in Brazil is just about to start with few machines while 24% of the surface is already prepared for it. The non-existence of commercial services

in Brazil makes extremely difficult the maintenance of the machines in a proper status as verified in this study, and thus it is not easy to foresee the speed of mechanization in the following years.

The technical staffs of the farms use digital field notebooks in which detailed information per plot is included: production, type of harvest, grape losses and mold effects. The analysis of notebook data (160 plot, 552 ha) has shown that in all plots mechanically harvested (44) there was no significant increase in losses compared to manual harvesting (around 2%).

The analysis of grape harvesters requires the definition of a new concept (must release) that has never been used in manual harvesting. Must release may be important since fruits are detached from the wood which constitutes a totally new approach compared to manual harvesting, in an effect that will for sure be variety dependant. In this study a large variability in must release is found using water sensitive paper. Interestingly, this method also allows addressing water deposition in the early hours of the day since there is thermal amplitude of 12 °C and air relative humidity ranging from 22% to 90% in 4 hours.

In this study only 2 plots (4.5 ha) have been analysed with DGPS, as the first approximation for upcoming years. Machine performance was very poor due to evitable dead times. The trailed machine was not in proper status. As a consequence three types of dead times occurred inside the crop row: adapting the work speed with the conveyor speed (synchronization did not work) few seconds, removing leaves whenever system was blocked 10 s, and replacing the conveyor into the carrier platform above 40 s. Theoretical field efficiency could reach 89% which means that with proper maintenance, mechanization could be properly attained. However, actual field efficiency ranged from 22.6% to 39.7% due to in-row stops. Theoretical machine performance (ha h^{-1}) was also low compared to previous studies, as due to the low ground speed (below 2.5 km h^{-1}).

As a general remark, there is a need of an engineering profile to support farmers in this mechanization process with institutional (public or private) support and local technical consultancy from grape harvest manufacturers.

Works similar to this will be carried out with the other existing machines, which will allow the monitoring of the evolution of the mechanization of viticulture in Brazil, an area of importance for the agricultural engineering.

Acknowledgements

The author gratefully acknowledges the financial support of CNPq.

References

- Báguena, E. M., P. Barreiro, C. Valero, X. Sort, M. Torres, and J. M. Ubalde. 2009. On-the-go yield and sugar sensing in grape harvester. In *Proc. 7th European conference on Precision Agriculture Precision agriculture 273-278*. Wageningen, Netherlands, 6-8 July.
- Báguena, E. M. 2011. On-board system for yield and quality determination in grape harvesters: development and field validation. Ph.D. diss. Madrid, España: Escuela Técnica Superior de Ingenieros Agrónomos, Universidad Politécnica de Madrid.
- Barreiro, P. 2009. De la vendimia mecanizada a la mecanización total del viñedo. *Vida Rural*, vol. (297): 66–72.
- Barreiro, P., B. Diezma, M. Garrido-Izard, A. Moya, and C. Valero. 2016. Vendimiadora New Holland Braud 8030L, caminho de la perfección. *Vida Rural*, (404): 12–21.
- Berther, J. P., T. Le Briquer, and J. Berthet. 2010. Selective harvesting method for e.g. grapes, in agricultural plot, involves automatically activating supply system based on determined zone for storing harvest flows from zone into corresponding container. Patent FR2936682– A1 (in French)
- Bramley, R. G. V. 2005. Understanding variability in winegrape production systems 2. within vineyard variation in quality over several vintages. *Australian Journal of Grape and Wine Research*, 11(1): 33–42.
- Bramley, R. G. V. 2009. Lessons from nearly 20 years of Precision Agriculture research, development, and adoption as a guide to its appropriate application. *Crop and Pasture Science*, 60(3): 197–217.
- Brasil. National Congress. Brazilian. 2015. Traffic Code. Law 13.154, July 30th, n° 145. Brazilia. Official Diary of the Union.
- Bodria, L., G. Pellizzi, and P. Piccarolo. 2006. *Meccanica Agraria, vol. 2: La meccanizzazione*. Bologna, Italy: Edagricole.
- Caprara, C., and F. Pezzi. 2011. Measuring the stresses transmitted during mechanical grape harvesting. *Biosystems Engineering*, 110(2): 97–105.
- Costa Neto, W. V., R. B. Pires, and A. S. Meinerz. 2014. Characterization of mechanization used in viticulture region of

- the campaign of RS-Brazil. In *Proc. 37th World Congress of vine and wine*, 323-324 Mendoza, Argentina, 9-14 November.
- MAGRAMA (Ministerio de agricultura, alimentación y Medio Ambiente). 2015. Anuario de estadística 2014. Available at: <http://www.magrama.gob.es/es/estadistica/temas/publicaciones/anuario-de-estadistica/2014/default.aspx?parte=3&capitulo=15&grupo=6>. Accessed 18 April, 2016.
- Mello, L. M. R. 2016. Desempenho da viticultura brasileira em 2015. Available at: <https://www.embrapa.br/busca-de-noticias/-/noticia/9952204/artigo-desempenho-da-vitivinicultra-brasileira-em-2015>. Accessed 16 April, 2016.
- Pezzi, F., and C. Caprara. 2009. Mechanical grape harvesting: investigation on the transmission of vibrations. *Biosystems Engineering*, 103(3): 281–286.
- Salem, H. M., C. Valero, M. Á. Muñoz, M. Gil-Rodríguez, and P. Barreiro. 2014. Effect of reservoir tillage on rainwater harvesting and soil erosion control under a developed rainfall simulator. *Catena*, 113(1): 353–362.
- Sarri, D., R. Lisci, M. Rimediotti, F. Grandi, and M. Vieri. 2016. Introducing on the go selective harvest in wine grape vineyard: criticality and chance. In *Proc. CIGR-AgEng conf.* Aarhus, Denmark, 26-29 June.