Departamento de Fitotecnia e Engenharia Rural

VINEYARDS MECHANIZATION OF THE DEMARCATED DOURO REGION

Fernando A. Santos

www.utad.pt/~fsantos

UNIVERSIDADE DE TRÁS-OS-MONTES E ALTO DOURO

Douro *vs* Vineyard Mechanization

General characterization of vineyard installation of Douro Region

Standard agricultural equipments

Multifunctional traction unit

Tractors performance tests

Study and adaptation of a axial-flow fan sprayer to vineyard terrasses of Douro Region

Performance comparison of a axial-flow fan sprayer with and without a liquid sprayer control system

Pesticides application with centrifugal sprayers in Douro Region

Fungicides application with aerial sprayers in Douro Region

Departamento de Fitotecnia e Engenharia Rural

Douro *vs* Vineyard Mecanization

UNIVERSIDADE DE TRÁS-OS-MONTES E ALTO DOURO

Douro - a hillside vineyard region

- Big vineyard area with ± 45.000 ha;
- Vineyard planted, basically, in hillsides;
- Difficult accesses to the patches of ground and mechanization;
- Cultural system dependent of manual work (> 1.000 h/ha/year)

Reconversion and mechanization - a need

Considering that:

- **it is important to keep the vineyards in slopes, because this areas produce the best wines;**

- **the manual work is scarce, with a high cost and pain.**

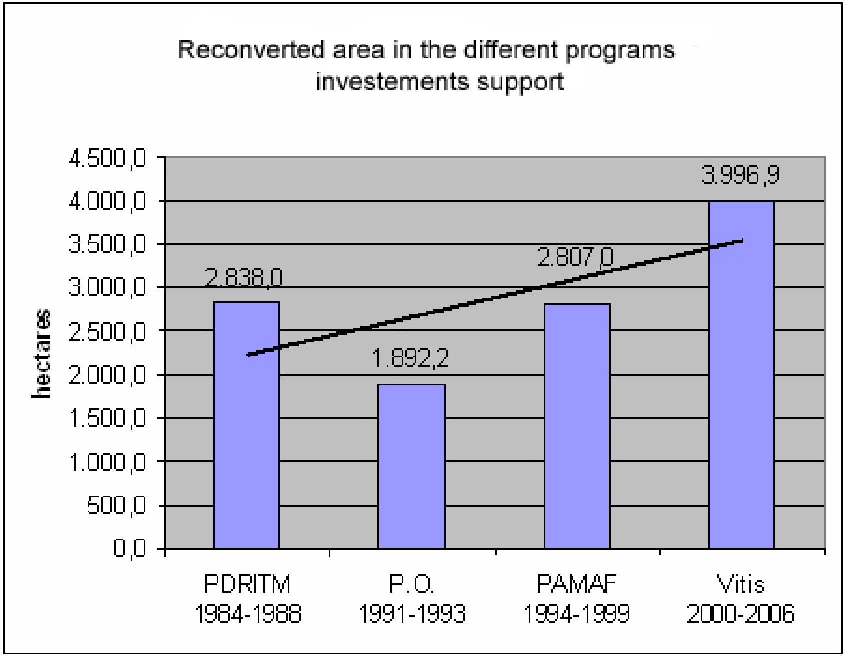
It is fundamental to find solutions that allow overcome this situation

Support programs

The vineyard restructuring reaches very high costs (~25.000 €/ha);

Majority of the restructured vineyards were implanted with resource to support programs to the investment;

It continues having demands of investment to support programs for the vineyard restructuring.



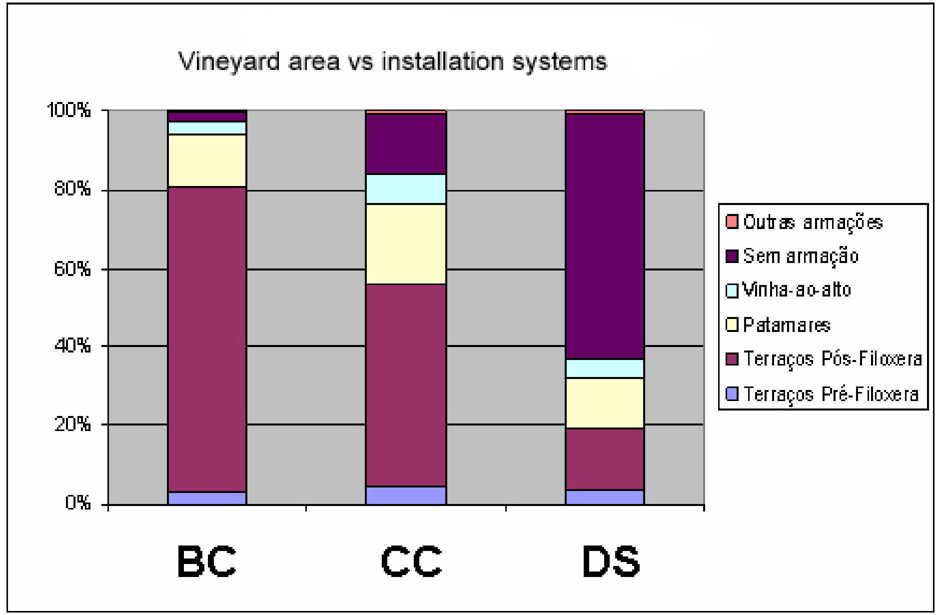
The VITIS program data are recent (not conclusive)

Actual situation

More than 50% of the vineyard area still maintain implanted in traditional systems (not restructured);

Only about 22% of the vineyard area is proper to the mechanization (terrasses and sloping vineyards)

It is necessary to continue the financial and technical support to the vineyards reconversion.

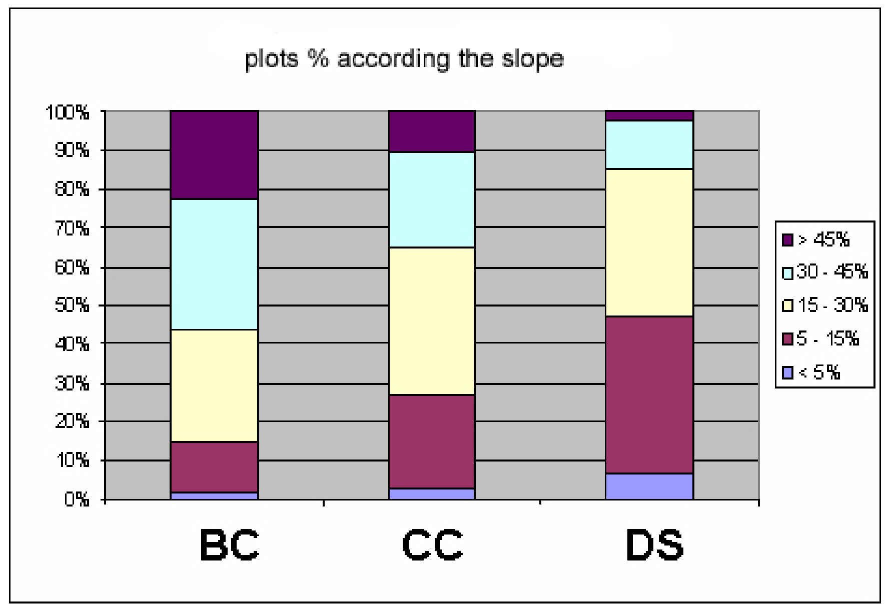


Source: IVV/DCV 2003

Actual situation (cont)

It is in the sub-regions of BAIXO-CORGO and CIMA-CORGO where exist the largest area of traditional vineyards and where the mechanization problems are more difficult to overcome (sloping hillsides) ;

It is also in this regions where the patches ground are far way, why the vineyard reconversion is more important, to decrease the mechanization costs.



Source: IVV/DCV 2003

Installation systems vs Mechanization solutions

The installation system more mechanized are the terrasses with 17% of total area, followed by sloping vineyards with 6%;

In all the subregions the general tendency is the same, being the terrasses system the preferred, as we can observe:

Baixo-Corgo -	terrasses: 13%
	sloping vineyards: 3,6%
Cima-Corgo -	terrasses: 20%
	sloping vineyards : 7,4%
Douro Superior -	terrasses: 13%
	sloping vineyards : 4,5%

Departamento de Fitotecnia e Engenharia Rural

General characterization of vineyard installation of Douro Region

UNIVERSIDADE DE TRÁS-OS-MONTES E ALTO DOURO

Different types of vineyards installations:

- Plain vineyards
- Hillside vineyards

Plain vineyards:

Lateral slope < 8 - 10 % (in this slopes the mobilization works gives origin to little terrasses, staying the plants in the slopes between its terrasses.

In this situation it is possible to use the same equipments than the other crops.

It is possible to use "enjambeurs" tractors.

Hillside vineyards:

- with big changes in the hillside:
  - terrasses
- with few changes in the hillside :
  - according the slope
  - according the level curves

Hillside vineyards:

- terrasses
  - narrow terrasses (< 2.5 m) - 1 row
  - wide terrasses (3.5- 4 m) - 2 rows

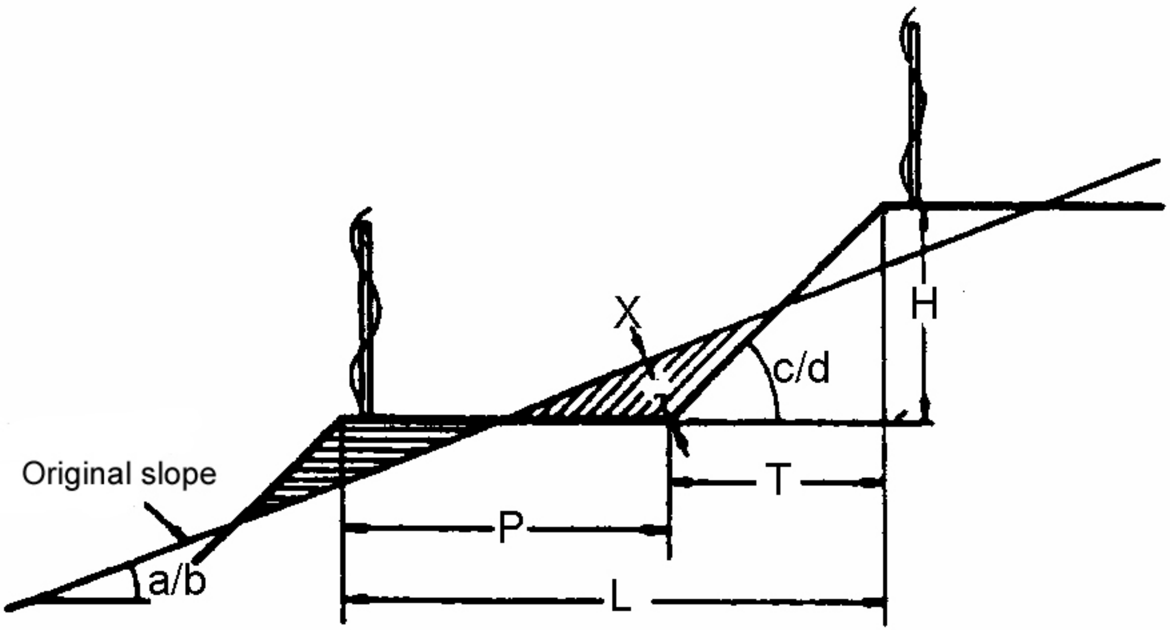
In the situations where the slope is bigger it is advisable to do narrow terrasses and in other situations we can have wide ones

- sloping vineyards

It is possible to use wheel tractors until ± 30 % of slope and for high slopes, until ± 45 %, lugs tractors.

- according the curves level
  - for slopes < 15 - 20 %, it is possible to use the same tractors than for the plain vineyards
  - for slopes > 20 % it is impossible to mechanize.

Lateral view of a terrasse.



T- width terrasse ramp (m)

H- hight terrasse ramp (m)

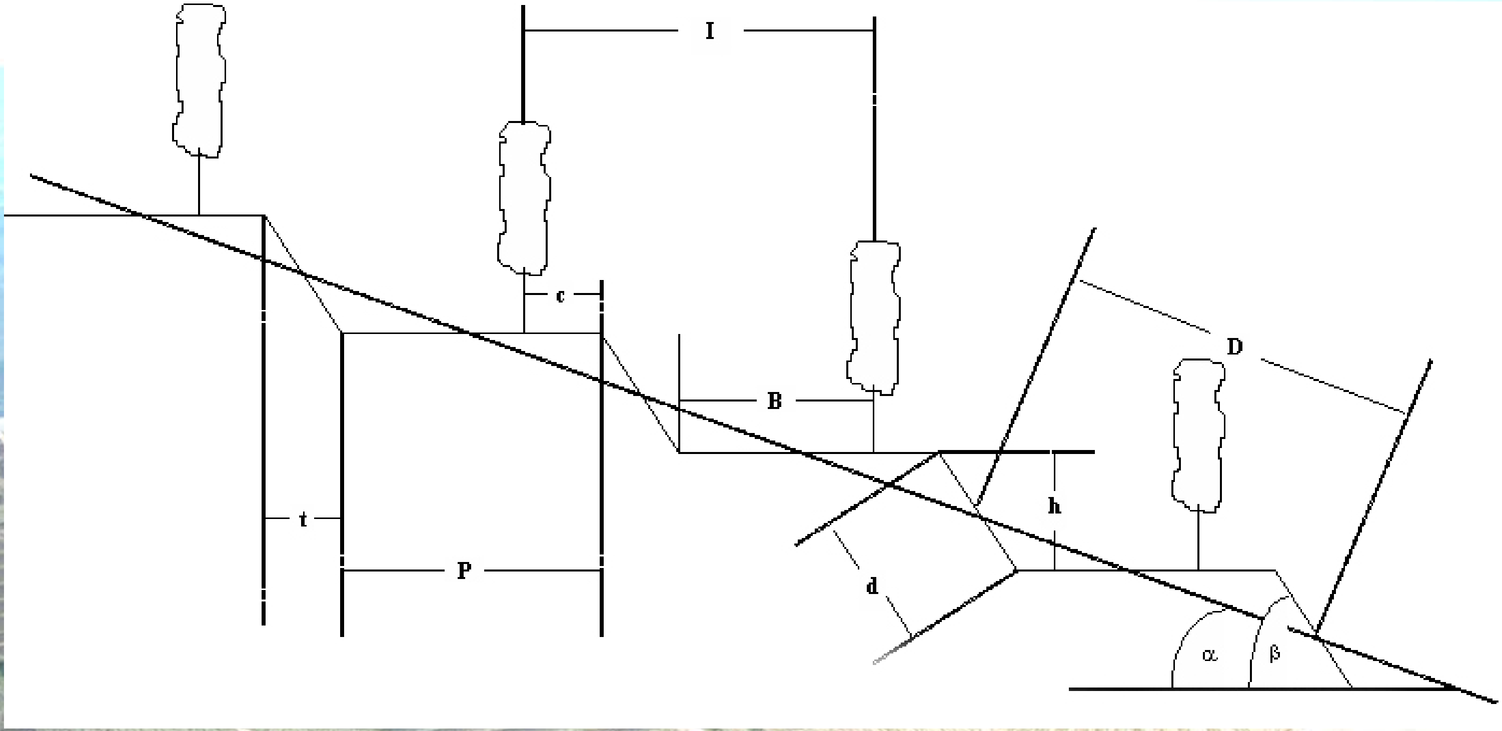
P- terrasse width (m)

a/b- slope hill side

c/d- decimal of slope hill side

X- digging dept (m)

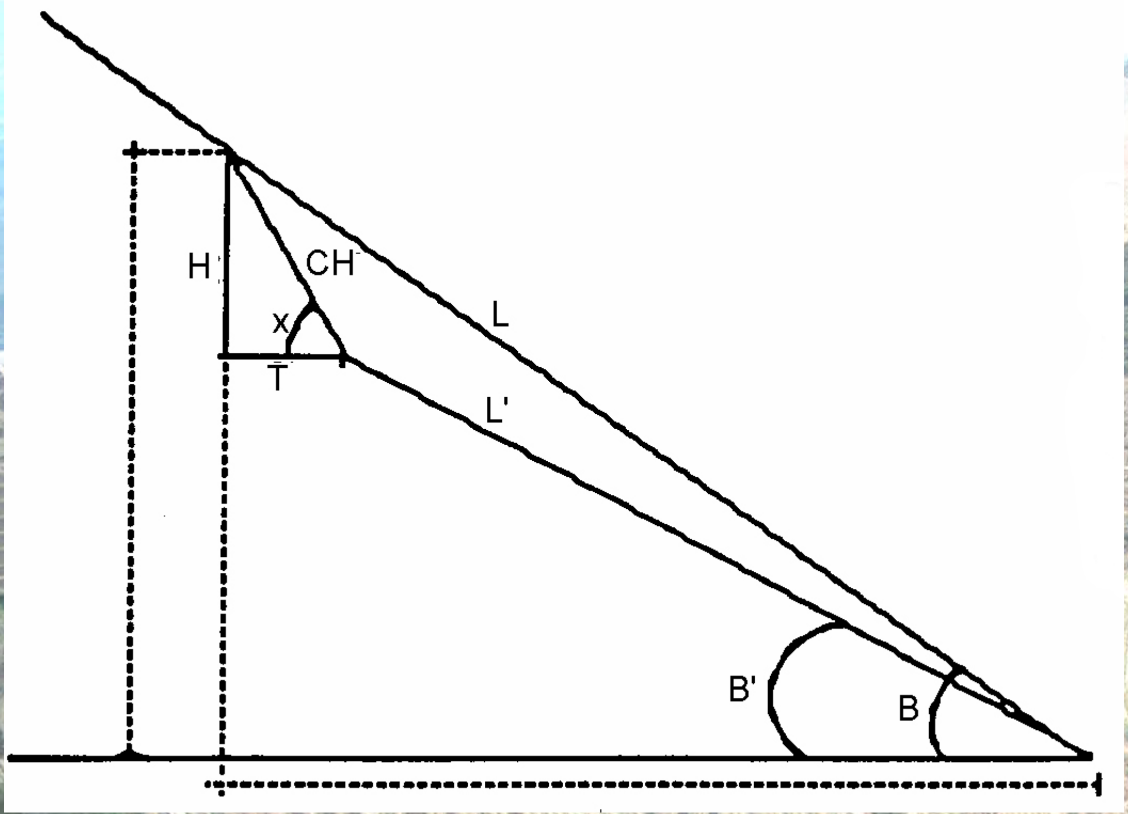
Graphical representation of a one row terrasse.



One row dimensions terrasses

- B- Distance from row to terrasse ramp
- D- Ramp length
- L- Row distances
- P- Width terrasse
- T- Base ramp width
- D- Length necessary to get a terrassse
- h- Ramp hight
- α- Hill side slope
- β- Ramp slope

Lateral view of a variation slope resulting from a rural way.



B- Primary hill side slope
B'- Slope after ramp
L- Primary hill side plot
L'- Final hill side plot
X- Ramp slope
H- Ramp hight
T- Ramp base
CH- Ramp lenght

Rural ways to access vineyards

Main purposes:

To allow the connections between patches ground.
To protect from water erosion

In terrasses.

Level roads (according level curves) and lateral roads (with slope).
These last ones must form angles of ± 120º with the level rows and a longitudinal slope < than 12 - 15 %.

In sloping vineyards

The roads are done according the level curves and the distance between them must be < than 60 - 80 m. The lateral slope, to the inside part, must be of de 4 - 5 %.

Standard agricultural equipments studied

Traditional traction used solutions

Wheel tractors

It is the solution more proper to the terrasses mechanization, unless for that situations where the stability, the maneuvers or traction draft are critical problems

Lug tractors

It is the best solution to the sloping vineyards because its traction draft and stability performances are greater than the wheel tractor.

The behavior of this kinds of traction units, in Douro region installation types, have been studied by UTAD e CEVD.

Traction units tested
Some technical data characterization

	Lug tractor	Wheel tractor	Multifuncional unit
Nominal power	41.7 kW @ 2300 rpm	31 kW @ 3000 rpm	26.4 kW @3000 rpm
Weight (ballast) (kg)	2339 - 2444 (1)	950	760
Weight (kg)	2463 - 2568 (1)	1144	-
Length (m)	2.6 - 2.9 (2)	2.9	2.07
Width (m)	1.15 - 1.17 (1)	1.215 - 1.555	0.8
Tires / Lugs	28 e 20 cm	8.25 - 16 * 10.0/75 - 15	20
Length to turn back (m)	2.6 - 2.9 (2)	3.0	2.07 – 3.0

(1) According the dimensional lugs characterization; (2) With and without front weights

Lug tractor

Analyzed situations:

Environmental factors:

- different vineyard installation systems;
- distance between rows;
- amount of soil stone;
- soil humidity;
- soil situations (plowed, compacted, etc.)

Characteristics tractors:

- different large lugs;
- different length lugs;
- with or without front ballast.

Lug tractor (cont)

Terrasses results:

- in mobilized soils the increase of stony surface leads to the traction reduction, being the lost of draft capacity minor with narrow lugs, specially with high slippage;

- in mobilized soils and with a coverage stone > 20%, the narrow lugs allow to develop bigger draft force than the large lugs;

- the narrow and short lugs have better performance in soils with few stone coverage, specially if they are mobilized;

- with a lower stone coverage and mobilized soils the increase length of the large lug increase the draft force;

- with length and large lugs the traction performance is lower, in spite of in high slippage its performance is quite similar to the other lug versions.

- in no mobilized and compacted soils, due to the lack of vertical deformation soil, even in that ones with few surface stone, we verified that the draft traction reduction decrease because the lack or irregular contact with the ground.

Lug tractor (cont)

Sloping vineyard results:

- the lug that has the best performance in lose stony soils is the length and large;

- in slopes < than 40% and a lot of stones under the soil surface the short and wide lug has a better performance than the length and wide;

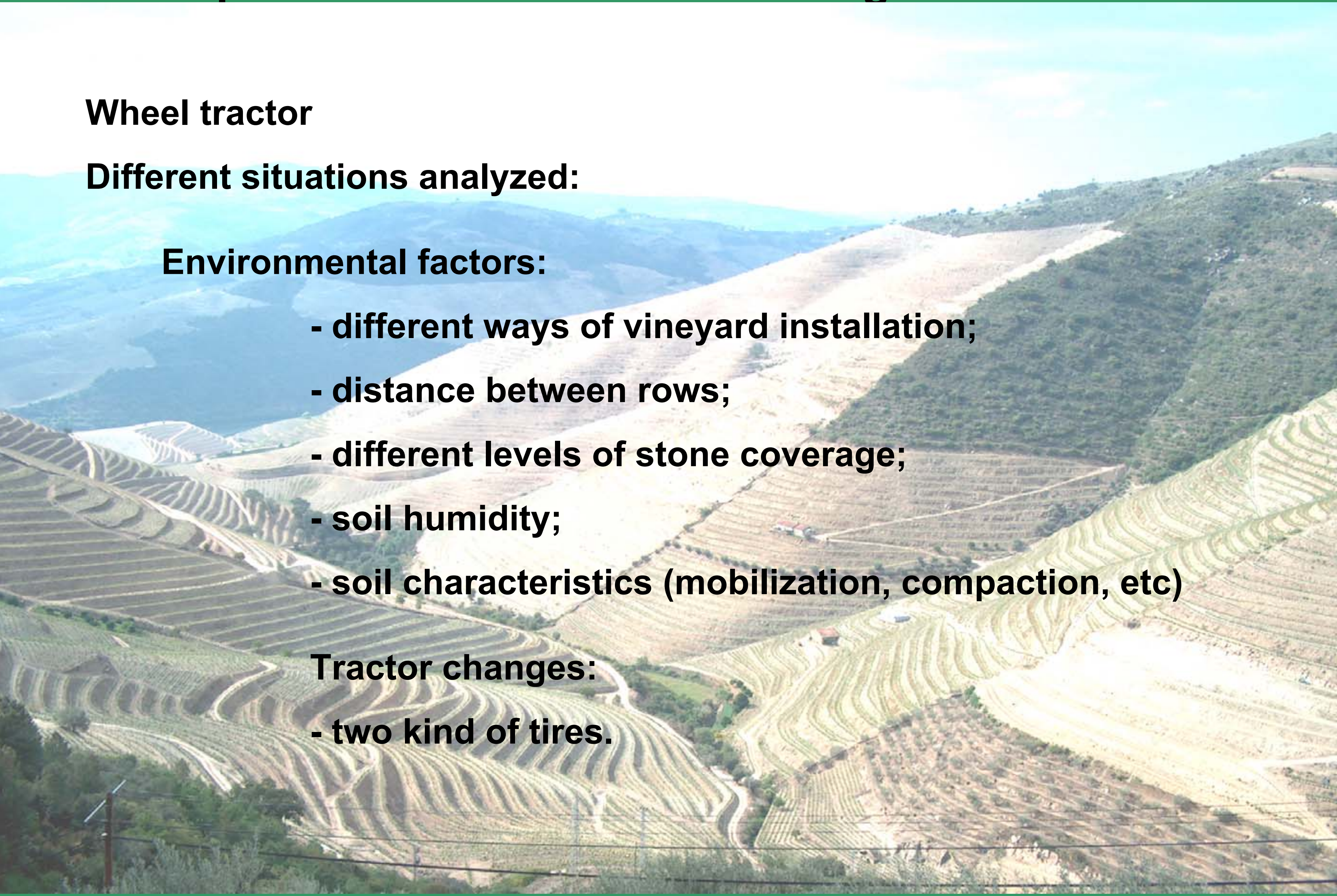
- in slopes < than 30-35% and soils with a lot stone at the surface the best performance is got with the lug narrow and length;

- for slopes > 50% the best choice is the wide and length lug having the short and narrow lug the poor performance.

Performance comparison in the two types of installation:

- in terrasses it is not necessary to introduce any changes in the lug tractor because its performance is sufficient;

- in sloping vineyards it is specially important to improve the locomotion system and find the best weight distribution, to increase the traction performance and tractor stability and so, reach high slopes.



Wheel tractor

Different situations analyzed:

Environmental factors:

- **different ways of vineyard installation;**
- **distance between rows;**
- **different levels of stone coverage;**
- **soil humidity;**
- **soil characteristics (mobilization, compaction, etc)**

Tractor changes:

- **two kind of tires.**

Wheel tractor (cont)

Terrasses results with narrow tires:

- the influence of soil surface stone coverage influence negatively the draft force;

- increasing the soil humidity there is a slight decrease of draft traction;

- decreasing the pressure tires the draft force increase;

- for a maximum slippage of 30 % the draft varies between 293 - 572 daN.

In general, we can say that the main factors that influence the draft force results are, basically, the surface stone coverage, the pressure tires and soil humidity.

Wheel tractor (cont)

Results from sloping vineyards:

- using narrow tires for a ± 30 % sloping vineyard, the main factor that influence the draft force is the pressure tire. Varying the pressure from 120 to 100 kPa, that force, with ± 30 % slippage, increase from 121 to 206 daN and, for ± 45 % slippage, from 205 a 233 daN;

- using wide tires the draft force increase 25 - 30 % and the slippage decrease. Without developing any draft force the slippage in hillsides with 28 % slope was ± 30 % with the narrow tires and ± 10 % with the large ones;

- In conclusion we can say that using wide tires there is a increase in draft force and a slippage reduction but a significant increase in the space necessary to turn back and decrease the distance between the tires and plants, why this is only advisable in vineyards with distance between rows bigger than 2.20 m.

Wheel tractor (cont)

Performance comparison in different installation systems:

- in terrasses vineyards generally there is no limitations to the use of wheel tractors;

- in sloping vineyards the biggest tractor performance it isn’t generally no sufficient for demanding draft force works; for soil mobilization it is necessary to use PTO equipments.

Performance comparison between the two tractors types:

In terrasses:

In terrasses without coverage surface stone and with 30% slippage the traction coefficients (CT) reached were 0.45 - 0.50 for wheel tractor and 0.50 - 0.60 for lug tractor.

Considering the total tractors weight, that is ± 1150 kg for the wheel tractor, it is possible to reach a maximum draft force of 520 - 575 daN, and for the lug one, whose weight is ± 2000 kg, the maximum draft force is 1000 - 1200 daN.

In sloping vineyards

In sloping vineyards, where the slope is the main factor for the performance determination, the wheel tractor can climb up until 30 - 35 % slope and the lug one to 45 - 50%, without developing any draft force. This values depend on the factors that interfere with the traction performance.

To chose a tractor type:

In terrasses:

In terrasses the chose must be done firstly for the wheel tractor. The lug tractor must be the option only when the draft force can not be reached for that one or where are lack of stability, space to turn back or problems of soil compaction.

Sloping vineyards

In sloping vineyards the lug tractor is, normally, the only possible solution, because the wheel tractors for slope greater than 18 - 20 %, can not develop enough draft force to work with the majority of equipments.

Other equipments

Vineyard plow

Trials done in terrasses, with humidity soil of ± 20%, stony coverage of ± 10% and weed coverage of 15 - 20%, we got, varying the work dept, the follow draft traction (kN).

	Dept work (cm)		
Reference	10	15	20
4 simple plows + cultivator shovel	8.17	14.23	22.39
4 simple plows + 1 double plow	6.14	14.53	22.95
simple plows	1.54	2.74	4.32
double plow	1.98	3.58	5.66
cultivator shovel	2.02	3.28	5.11

Souce: Bianchi (1987)

Vineyard tine cultivator

In trials done with a five tine cultivator with shovels, with a ± 6 - 7 cm wide, or a five tine cultivator with sweeps, of ± 25 cm wide, in similar plow conditions, we got, for different work dept, the following draft traction values (kN).

	Dept work (cm)			
Reference	5	10	15	20
5 cultivator shovels	2.93	4.73	7.32	10.70
5 cultivator sweeps	3.21	6.70	10.74	
1 cultivator shovel	0.59	0.95	1.46	2.14
1 cultivator sweep	0.64	1.34	2.15	
Cultivator shovel, for m wide	2.17	3.50	5.42	7.92
Cultivator sweep, for m wide	2.38	4.96	7.96	

Source: Bianchi (1987)

Tine cultivator (cont)

The wheel vineyard tractor in terrasses allows to work in all test situations but in slope vineyards with more than 18 - 20 % the work dept was < 10 cm using a cultivator shovel tine.

The stony surface is the main factor than interfere with the draft traction being the sweep tine more demanding than the shovel tine.

Mechanic hoe

The necessary power, in kW, by meter width, for dept between 10 - 20 cm and length of cut slice between 12 - 25 cm, were always < than 5 kW / m.

The power needed, without doing any work, was 0.77 kW.

In sloping vineyards the impulse resulting from the hoe rotational movement is very important for working in the ascending direction. The impulse value determined was ± 2.5 kN, working at 20 cm dept.

In the tests done with the wheel tractor we verify than the torque value depends mainly from the regime and the dept work. For a low regime (77 rpm) and 15-16 cm dept the torque varied from 100 - 120 Nm and, for the highest regime (116 rpm), at the same dept, it varied from 180 - 200 Nm.

In sloping vineyards the wheel tractor can move until slopes of ± 45 %.

Mechanic hoe (cont)

Trials done in sloping vineyards for power determination, in kW, necessary to move the equipments in different slopes (30, 40 e 50%) and work dept (10, 15 e 20 cm), gave the followed results:

		Speed, in km / h			
Slope	Dept (cm)	0.72	1.44	2.16	2.88
	10	2.5	5.0	7.5	10.0
30	15	2.0	4.1	6.1	8.1
	20	1.8	3.6	5.4	7.2
	10	3.1	6.3	9.4	12.6
40	15	2.7	5.3	8.0	10.6
	20	2.4	4.8	7.2	9.6
	10	4.6	9.3	13.9	18.5
50	15	3.5	7.0	10.5	14.0
	20	3.2	6.3	9.5	12.6

Source: Bianchi (1987).

Axial-flow fan sprayer

Trials done with a axial - flow fan sprayer of 200 L show that, for a work pressure < 5 bar, the necessary torque is lower than 100 Nm.

We achieve that, in the same way than the mechanic hoe, it is its weight the problem to work with them in sloping vineyards.

In sloping vineyards the weight transfer for the rear axle increase the draft capacity, why the use of support wheels in this equipment is inadvisable.

Comparison among the different no motorized equipments

According the trial tests done with the different equipments with the lug tractor, the highest traction coefficient reached with a maximum slippage of 20%, are the follow:

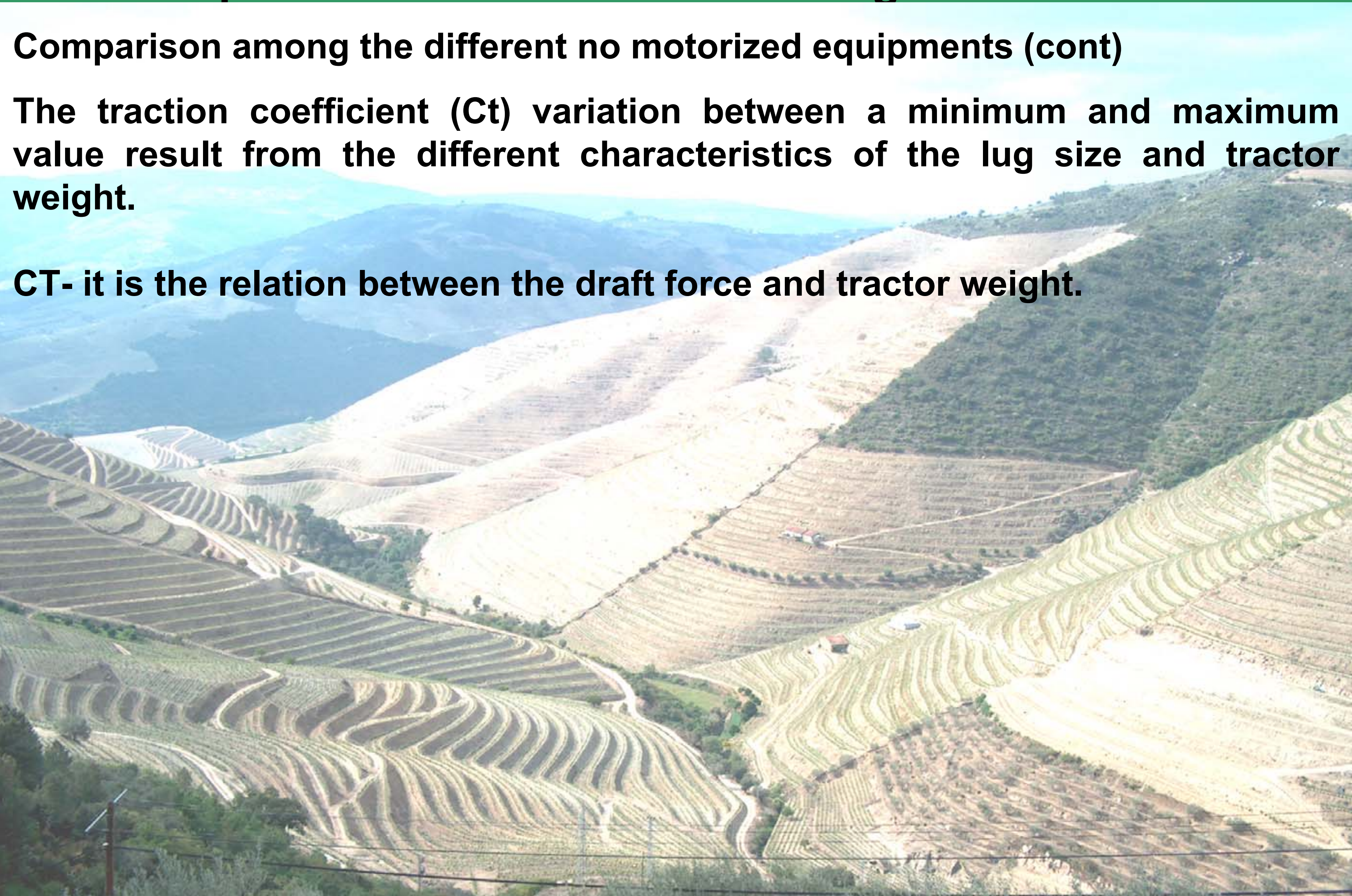
	Dept	Traction conditions	
	(cm)	Minimum Ct	Maximum Ct
Vineyard plow	10	25 - 30	35 - 40
Tine cultivator with shovels	5 10 15	35 - 40 30 - 35 20 - 25	40 - 45 35 - 40 25 - 30
Tine cultivator with sweeps	5 10	35 - 40 20 - 25	40 - 45 25 - 30
Mechanic hoe	10 15 20	40 - 45 45 - 50 > 50	45 - 50 > 50 > 50
Axial-flow fan sprayer	200 l 300 l	40 - 45 40 - 45	50 - 45 - 50

Source: Bianchi (1987)

Comparison among the different no motorized equipments (cont)

The traction coefficient (Ct) variation between a minimum and maximum value result from the different characteristics of the lug size and tractor weight.

CT- it is the relation between the draft force and tractor weight.



Conclusions

The traction unit choice for sloping vineyards must be done according its installation type and the equipments characteristics, in a way to have a good work rate and work safety.

Terrasses

The terrasses aren’ t a handicap for the traction units choice but, the patch ground access, namely ditches for water runoff, can worse the equipment safety.

Sloping vineyards

In sloping vineyards the slope is the main factor to consider in the traction unit choice. The maximum value that can be reached with the wheel tractor is 30 - 35 % and for lug tractors 45 - 50 %.

Multifunctional traction unit

Multifunctional traction unit

With the emergence of small units traction, it is being adopted a partial vineyard reconversion with one row terrasses that allow high plant densities and keep the support walls;

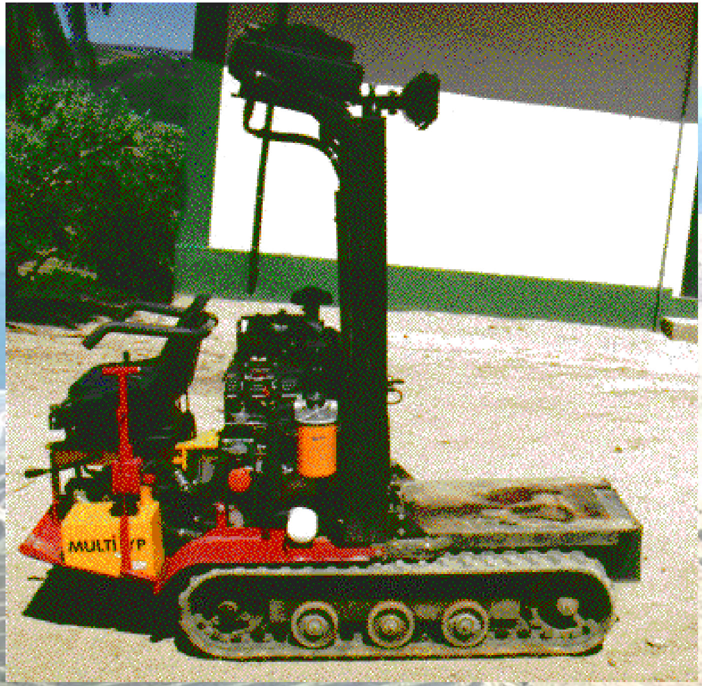
This solution, already used in a wide area, it is very interesting, specially for the small farmers, because it is possible to keep traditional vineyards characterization.

The purpose of this project was to study the performance of low size equipments for traditional vineyards mechanization.

The characteristics of this equipment, namely its weight, don' t allow to use it in demanding traction works why, for example, the mobilization equipment must be propelled by the traction unit hydraulic system.

There are, nowadays, some vineyard growers that has this kind of equipment

Traction unit:



Make: CHAPPOT
Model: MULTIJYP 2

ENGINE

- Lombardini - LDW 1503
- Cycle: Diesel
- Nº of cylinders: 3
- Cylinder capacity: 1551cc
- Power: 36cv 3000 rpm
- Refrigeration: water

- Transmission: hydrostatic
- Traction: gum lugs
- Drive: joystick
- Reversible drive position
- Equipments working hydraulic

DIMENSIONS (mm)

- Wide: 800- Distance from the ground: 63
- Length: 2070- Wide lug: 200
- Height: 1970- Maximum speed 6 km/h
- Drive height: 750- Tank fuel: 36 l
- Equipments height 410- Weight: 760 Kg

Mechanized hoe:

Make: CHAPPOT

TYPE OF WORK

- Soil mobilization.
- Weed control

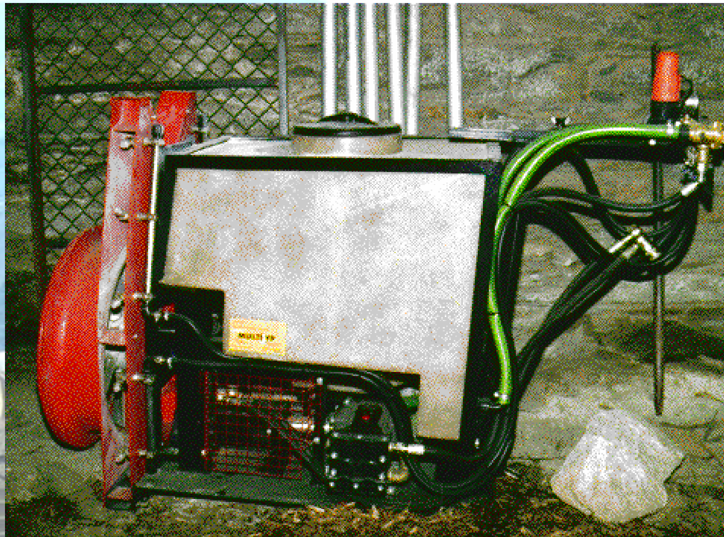
CONSTITUTION

- Nº of hoes: 6
- Adjustable rear protection.

DIMENSIONS (mm)

- Wide work: 950
- Length: 600
- Maximum work dept: 145
- Weight (kg):160

Sprayer with axial-flow fan :



Make: CHAPPOT

WORK TYPE

- Spraying using a axial-flow fan.

CONSTITUTION

- Tank 200 l,
- Pump piston, hydraulic moved, with a maximum output of 40 l / min. at 30 bar;

CONSTITUTION (cont.)

- 10 nozzles mounted in 4 independent sectors;
- Constant pressure device with electric valve close;
- Axial 500 mm fan, propelled by TDF with 8 guide blades.

Edge cutting equipment:

Make: PELLENC

WORK TYPE

- The cutting edge equipment is used to control the shots development to get a regular vineyard row.

CONSTITUTION

- 2 vertical alternative blades;
- 1 horizontal rotor with two blades;
- A support with 3 hydraulic piston to adjust the equipment height, verticality and lateral movement.

DIMENSIONS (mm)

- Length of vertical blades: 900*
- Cut diameter of horizontal blades: 600
- Lateral movement: 850
- Maximum height from the head cut to the ground: 1950

Transpor box:

Make: CHAPPOT

WORK TYPE

- Used to transport any solid material ; it has hydraulic movement to empty the box .

CONSTITUTION

- Steel box
- 2 hydraulic pistons;
- removable box lateral parts to empty the container.

DIMENSIONS (mm)**

- Length: 980
- Wide: 660
- Height: 580
- Weight (kg): 70
- Capacity, (liters): 375

Pre - pruning equipment:

Make: PELLENC
Model: TC 10

WORK TYPE

- Equipment used to cut the wood branches to make easier the manual pruning.

CONSTITUTION

- Cut head with a 4 cut disks inside rotor and a external one with 4 fixation disks;

CONSTITUTION (cont)

- The support has 3 hydraulic pistons that allow the height, the verticality and lateral movement equipment adjust;
- Hydraulic system to move away the rotors.

Crushing branches:

Make: CHAPPOT

WORK TYPE

- Equipment used to crush the plant material from pruning making easier its soil incorporation.

CONSTITUTION

- A horizontal rotor with 6 hammers
- Compaction steel cylinder mounted in the rear part of rotor.
- Protection steel cylinder mounted ahead the hammer rotor.

DIMENSIONS (mm)

- Work wide: 900
- Hammer distance: 150
- Cylinder compaction diameter: 120
- Cylinder protection diameter: 300

Results:
Traction unit:

UNIDADE DE TRACÇÃO																
NºEns.	pat	C.L	Cb.(p)		Solo		Tp(20m)	Tp(100m)	Vel.	Vel.	LT	CtC	Tpn/Ef	EfC(%)	CeC	CeC
		(m)	(m)	M/nM	Pedr.	Inc%	(s)	(s)	(m/s)	(km/h)	(m)	(ha/h)	(s)	(100m)	(ha/h)	(h/ha)
Méd	P4	130.8	2.2	nM	24	16	15.2	76.0	1.3	4.8	1.8	0.9	16.8	82	0.71	1.4
Méd	P5	132.0	3.0	nM	32	12	14.8	74.2	1.3	4.9	1.8	0.9	13.8	84	0.75	1.3
Méd	P7	98.4	3.0	nM	23	10	14.5	72.5	1.4	5.0	1.8	0.9	10.8	87	0.79	1.3
Méd	P8	52.8	2.8	nM	24	10	14.5	72.5	1.4	5.0	1.8	0.9	10.5	87	0.79	1.3
Méd	P9	220.8	2.2	nM	24	6	15.6	78.0	1.3	4.8	1.8	0.9	14.2	85	0.72	1.4

Crushing branches equipment:

Dt/Mod.	Tp	Tp(rep)	TpMéd	Vel.	Vel.	LT	CtC	Tpn/Ef	EfC(%)	CeC
99-00	(s)	(s)	(s)	(m/s)	(km/h)	(m)	(ha/h)	(s)	(100m)	(h/ha)
Med.A-B	24.67	21.39	23.03	0.46	1.65	2.00	0.33	58.00	79.49	3.37
Med.C-D	26.25	22.13	24.19	0.45	1.60	2.00	0.32	58.00	80.23	3.53
Med.C	28.00	20.50	24.25	0.43	1.56	2.00	0.31	58.00	80.07	3.53

Results:
Pre - pruning equipment

TEMPO DE MÃO DE OBRA / CEPA (s)									
		Mod.A-B			**Mod. C-D**			**Mod. E**	
	BE	**BI**	**(Be+BI)/2**	**BE**	**BI**	**(Be+BI)/2**	**BE**	**BI**	**(Be+BI)/2**
1998	36	41	**39**	37	38	**38**	49	43	**46**
1999	34	30	**32**	59	63	**61**	75	64	**70**
2000	34	29	**32**	35	42	**39**	56	52	**54**
Média	35	33	**34**	44	48	**46**	60	53	**57**
TEMPO DE EQUIPAMENTO / CEPA (s)									
		Mod.A-B			**Mod. C-D**			**Mod. E**	
	BE	**BI**	**(Be+BI)/2**	**BE**	**BI**	**(Be+BI)/2**	**BE**	**BI**	**(Be+BI)/2**
1998	9	9	**9**	3	4	**4**	0	0	**0**
1999	19	17	**18**	3	3	**3**	0	0	**0**
2000	17	18	**18**	4	4	**4**	0	0	**0**
Média	15	15	**15**	3	4	**4**	0	0	**0**
TEMPO DE MÃO DE OBRA + EQUIPAMENTO / CEPA (s)									
		Mod.A-B			**Mod. C-D**			**Mod. E**	
	BE	**BI**	**(Be+BI)/2**	**BE**	**BI**	**(Be+BI)/2**	**BE**	**BI**	**(Be+BI)/2**
1998	45	50	**48**	40	42	**41**	49	43	**46**
1999	53	47	**50**	62	66	**64**	75	64	**70**
2000	51	47	**49**	39	46	**42.5**	56	52	**54**
Média	50	48	**49**	47	51	**49**	60	53	**57**

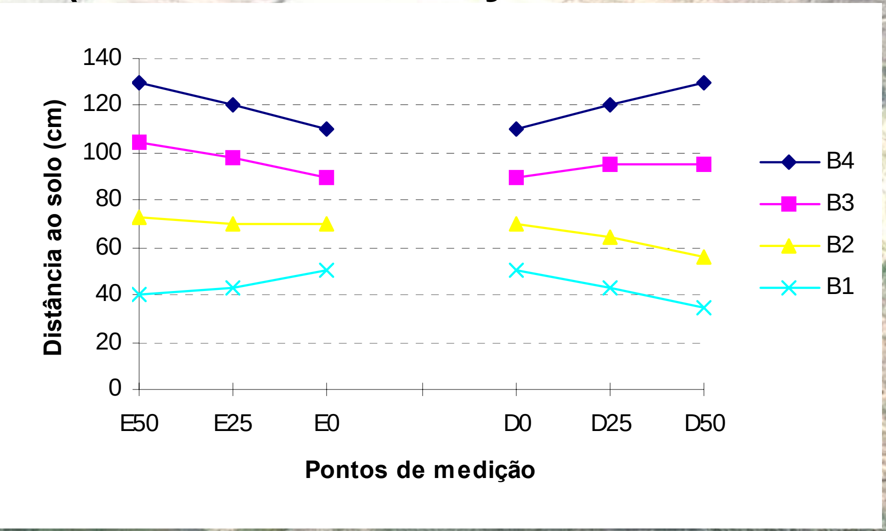
Results:
Mechanical hoe equipment:

ENXADA MECÂNICA													
C.L	Cb.(p)		Solo		Tp(20m)	Tp(100m)	Vel.	Vel.	LT	CtC	TpCb	EfC(%)	CeC
(m)	(m)	M/nM	Pedr.	Inc%	(s)	(s)	(m/s)	(km/h)	(m)	(ha/h)	(s)	(100m)	(h/ha)
130.8	2.2	nM	24	10	37.0	185.0	0.54	1.95	1.80	0.35	29.75	86	3.31
98.4	3.0	nM	23	10	37.0	185.0	0.54	1.95	1.80	0.35	20.75	90	3.18
104.4	3.2	nM	24	14	37.0	185.0	0.54	1.95	1.80	0.35	60.00	76	3.78
44.4	3.2	nM	24	14	35.6	177.9	0.56	2.02	1.80	0.36	60.00	75	3.67
98.4	3.0	nM	23	10	38.0	190.0	0.53	1.89	1.80	0.34	22.00	90	3.27
25.2	3.0	nM	23	10	37.0	185.0	0.54	1.95	1.80	0.35	52.50	78	3.67
220.8	3.0	nM	6	<10	38.0	190.0	0.53	1.89	1.80	0.34	30.00	86	3.40
63.6	2.3	nM	8.0	18	41.0	205.0	0.49	1.76	1.80	0.32	27.67	88	3.59
80.4	3.0	nM	9.0	6	38.0	190.0	0.53	1.89	1.80	0.34	25.00	88	3.32
75.6	3.0	nM	9.0	10	33.0	165.0	0.61	2.18	1.80	0.39	30.00	85	3.01
84.0	3.5	nM	3.0	15	32.3	161.3	0.62	2.23	1.80	0.40	29.50	85	2.94
51.6	2.8	nM	3.0	9	31.0	155.0	0.65	2.32	1.80	0.42	22.00	88	2.73
126.0	3.8	nM	6.3	9	34.0	170.0	0.59	2.12	1.80	0.38	26.00	87	3.02
33.6	4.0	nM	6.0	14	33.0	165.0	0.61	2.18	1.80	0.39	17.00	91	2.81

Results:
Sprayer with axial-flow fan (air system):

Distância ao solo (cm) do fio, a várias distâncias dos bicos (pás do ventilador no mínimo)						
	E50	E25	E0	D0	D25	D50
B4	130	120	110	110	120	130
B3	105	98	90	90	95	95
B2	73	70	70	70	64	56
B1	40	43	50	50	43	35

Distance from ground to the nozzles and in two points of the stream air (25 and 50 cm away from the nozzles)

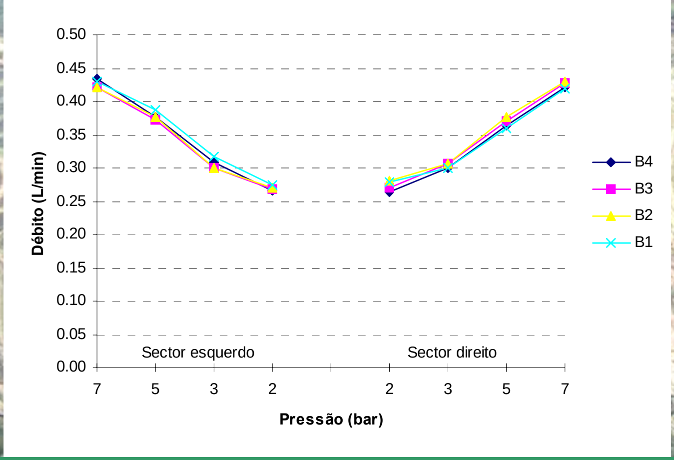


Results:

Sprayer with axial-flow fan (liquid system):

	Sector esquerdo				Sector direito			
	7	5	3	2	2	3	5	7
B4	0.43	0.38	0.31	0.27	0.26	0.30	0.36	0.42
B3	0.42	0.37	0.30	0.27	0.27	0.31	0.37	0.43
B2	0.42	0.38	0.30	0.27	0.28	0.31	0.38	0.43
B1	0.43	0.39	0.32	0.27	0.28	0.30	0.36	0.42
Média	0.43	0.38	0.31	0.27	0.27	0.30	0.37	0.42
Total	1.71	1.51	1.23	1.08	1.09	1.21	1.47	1.70

Output, in L/min, from several nozzles of each sector at different pressures



Results:
Edge cut equipment:

DESPONTADORA														
Bardo	Tp	Vel	Vel	Bardo	Tp	Vel	Vel	TpMéd	V.Méd.	LT	CtC	Tpn/EF	EfC(%)	CeC
BE	(s)	(m/s)	(km/h)	BI	(s)	(m/s)	(km/h)	(s)	(km/h)	(m)	(ha/h)	(s)	(100m)	(h/ha)
BE	38.7	0.5	1.9	BI	33.2	0.6	2.2	35.9	2.0	0.9	0.2	39.5	90.0	6.0
BE	31.5	0.6	2.3	BI	28.3	0.7	2.5	29.9	2.5	0.9	0.2	29.7	90.8	4.7
BE	18.8	0.6	2.1	BI	15.0	0.7	2.5	16.9	2.3	1.0	0.2	60.0	73.1	5.7
BE	20.4	0.5	1.8	BI	18.7	0.5	1.9	19.5	1.9	1.0	0.2	60.0	76.2	6.8
BE	16.9	0.6	2.2	BI	15.8	0.6	2.3	16.4	2.3	1.0	0.2	70.8	69.6	6.3
BE	15.7	0.6	2.3	BI	19.1	0.5	1.9	17.4	2.1	1.0	0.2	53.7	76.3	6.9
BE	15.7	0.7	2.5	BI	18.8	0.5	1.9	17.3	2.1	1.0	0.2	53.7	76.0	6.9

Conclusions:
The main conclusions from this trial tests are:

Traction unit:
The traction unit, with a hydraulic transmission, reversible drive seat and a joysteak drive it is easier to maneuver with all equipments.

Its light weight don’ t allow to do demanding traction draft operations.

Its use with the several equipments lower its operation cost but its purchase price it to height for the small farms.

Cutting edges equipment
The cutting edge equipment has a low work rate but do a good work; increasing the speed the shots are not cut properly and can be pulled out from the plant.

Mechanic hoe

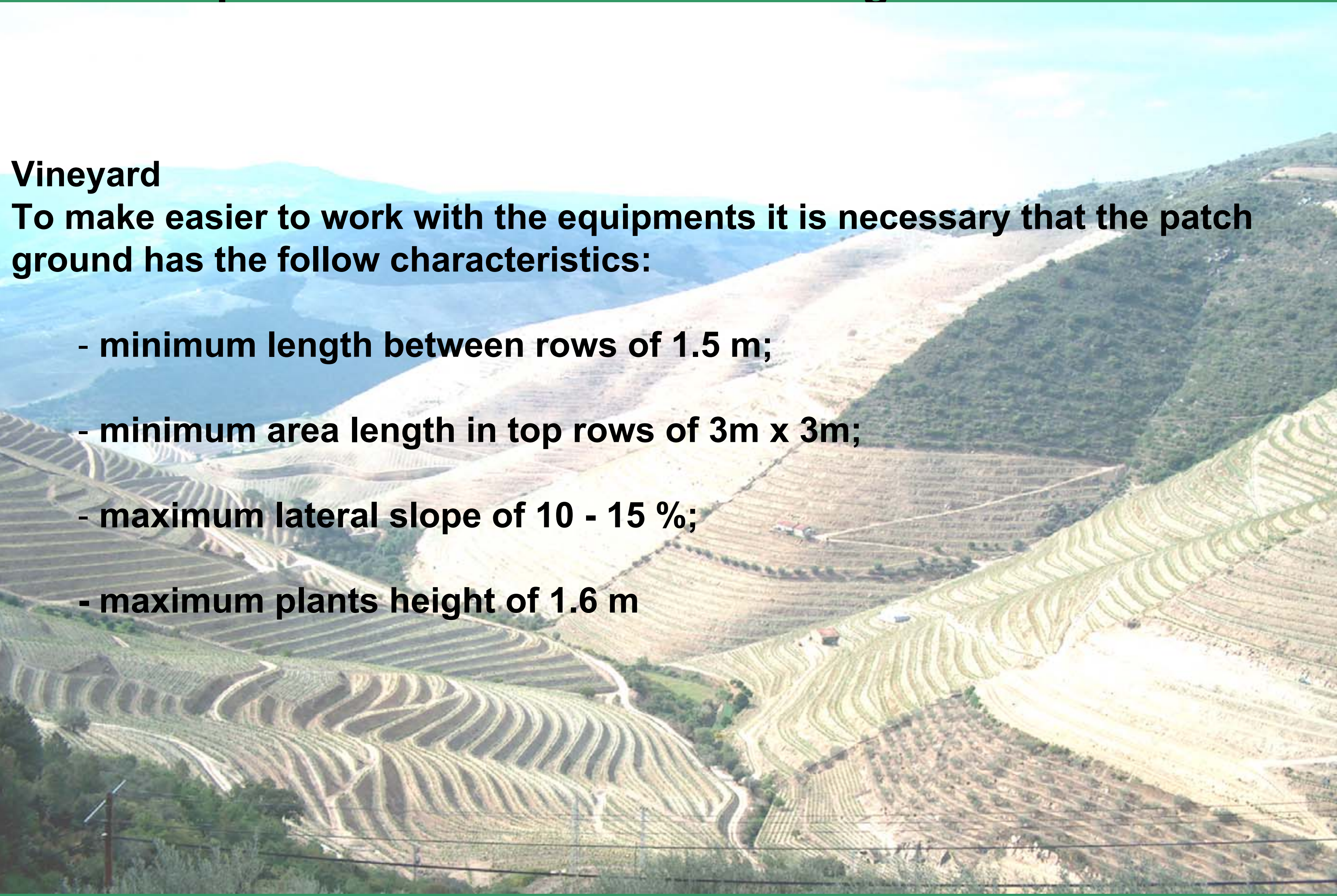
The mechanic hoe has a low work rate, because this speed, to have a good soil mobilization, must be lower than 1.94 - 2.08 km/h.

The mobilization work with just a passage, when there are a lot of weeds is not good enough what force a second passage.

Sprayer with axial-flow fan

The Sprayer with axial-flow fan, after some changes in air and liquid systems allow, with ± 200 l / ha, a good distribution uniformity.

A electric system to interrupt the liquid circuit allow in the beginning and end of spray application do not waste liquid.



Vineyard

To make easier to work with the equipments it is necessary that the patch ground has the follow characteristics:

- **minimum length between rows of 1.5 m;**
- **minimum area length in top rows of 3m x 3m;**
- **maximum lateral slope of 10 - 15 %;**
- **maximum plants height of 1.6 m**

Departamento de Fitotecnia e Engenharia Rural

Tractors performance tests

UNIVERSIDADE DE TRÁS-OS-MONTES E ALTO DOURO

Trials to evaluate the tractors performance

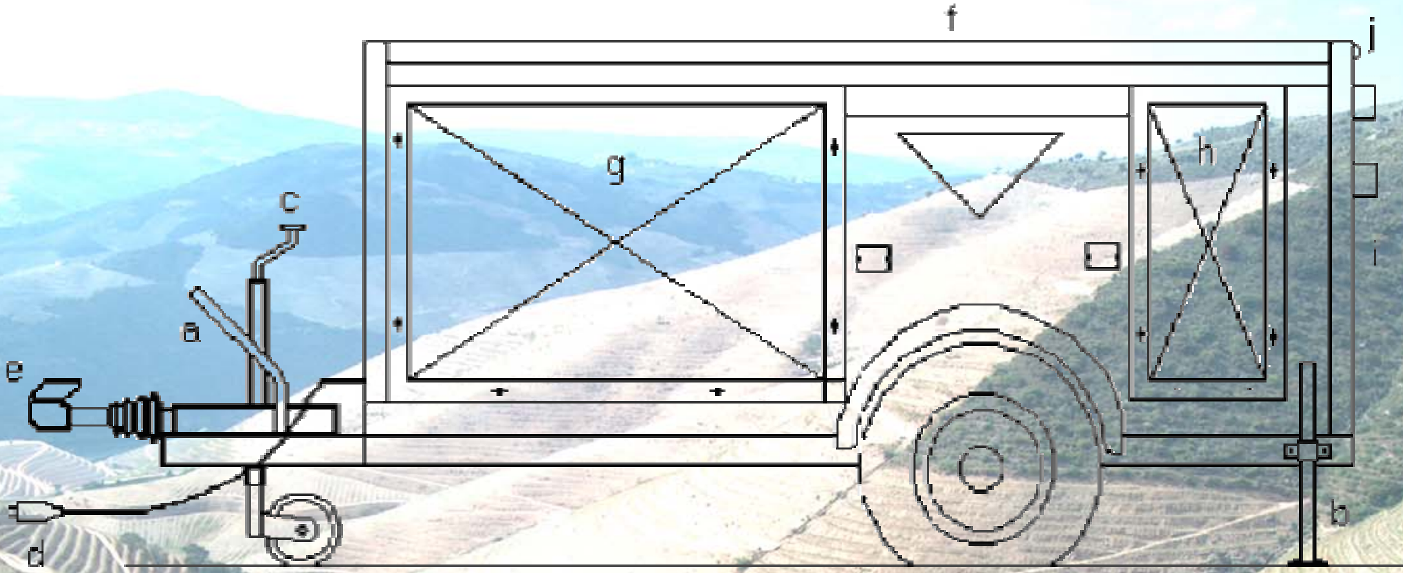
Used equipment

- electric dynamometer, Make Froment, model XT - 200, with a acquisition electronic system data;

- a portable computer with a specific software to save data;

- tractors to test.

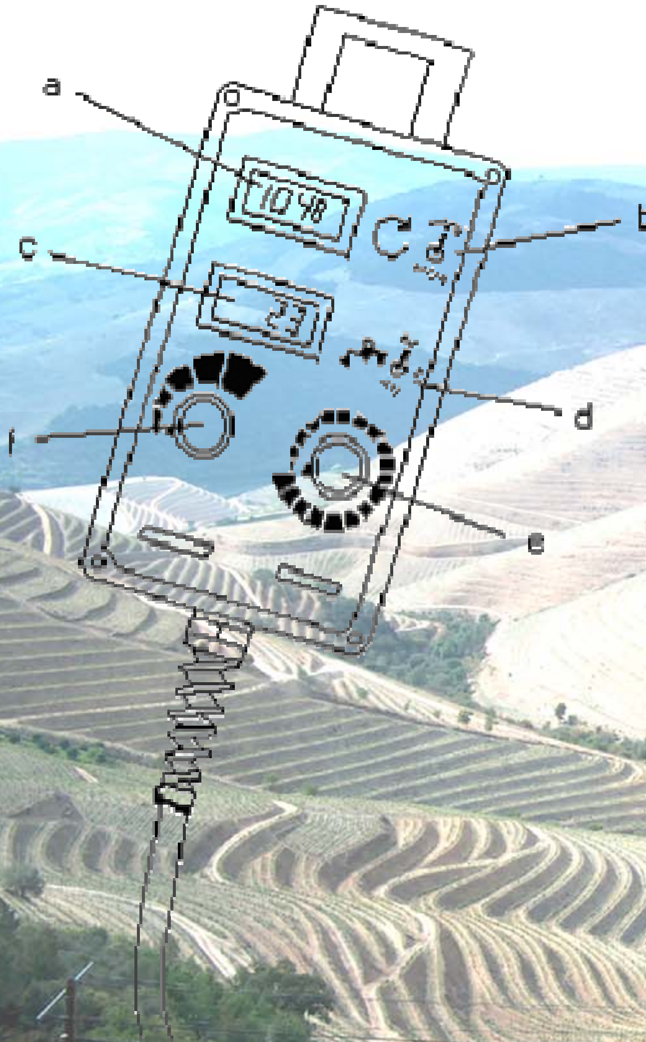
Besides this material it is fundamental to have the support of vehicle to tow the electric dynamometer, transport the other material and to be a source of electric energy because the tests duration take all day.



Electric dynamometer used in tractors tests

a- parking brake; b- prop stands or corner steadies; c- jockey wheel level adjuster; d- seven pine trailer plug for highway lighting; e- coupling to suit 50 mm ball; f- canopy; g- slide curtains small h- slide curtains small; i- end curtain; j- speedlite lamp

Source: Operating instructions "Froment Tractor Test Center". (1991)



Hand held control unit

a- digital read out speed b- digital speed out selector switch 540 or 1000 rpm c- digital read out power; d- digital read out power selector switch hp, CV or kW e- fine load control; f- coarse load control.

Source: Froment Tractor Test Center. (1991).

Methodology

- connect dynamometer to the tractor;
- turn on the engine to the maximum regime;
- gradually increase the power charge, saving data resulting from this;
- file save.

The file include:

- data from power, torque and regime;
- a “display” with tractor details, variables of dynamometer setup and a summary test;
- a graphic display from power and torque curves, according the regime.

Data are saved using the software Dyntest, being later exported as a file with a “dat” extension to be imported by a worksheet.

The display are later saved as a picture to be used by other software.

Dynamometer tractor test

Results

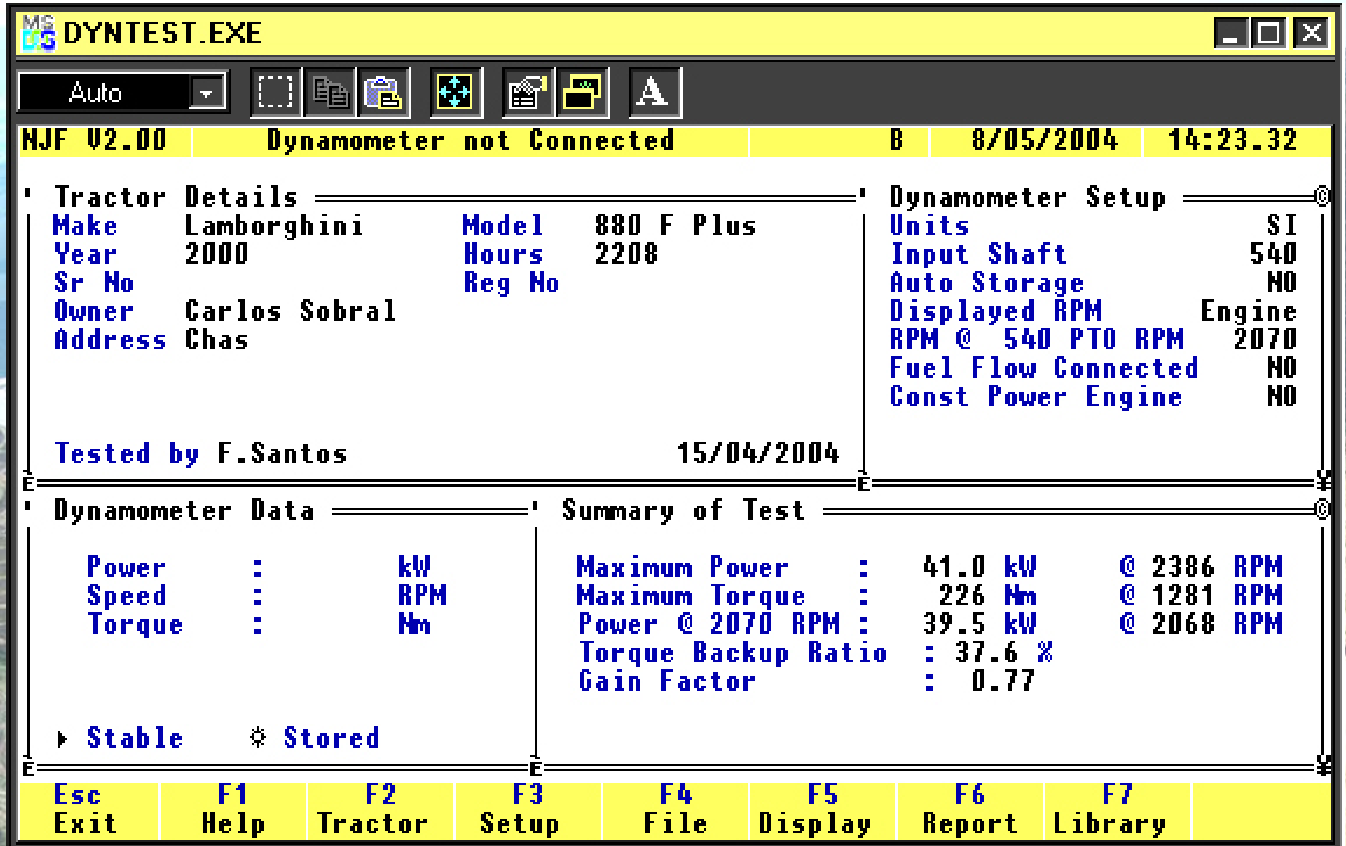
The trial data presented in the computer are:

- **nominal power and its regime;**
- **maximum torque and its regime;**
- **engine power at the normalized TDF regime;**
- **torque backup ratio;**
- **gain factor.**

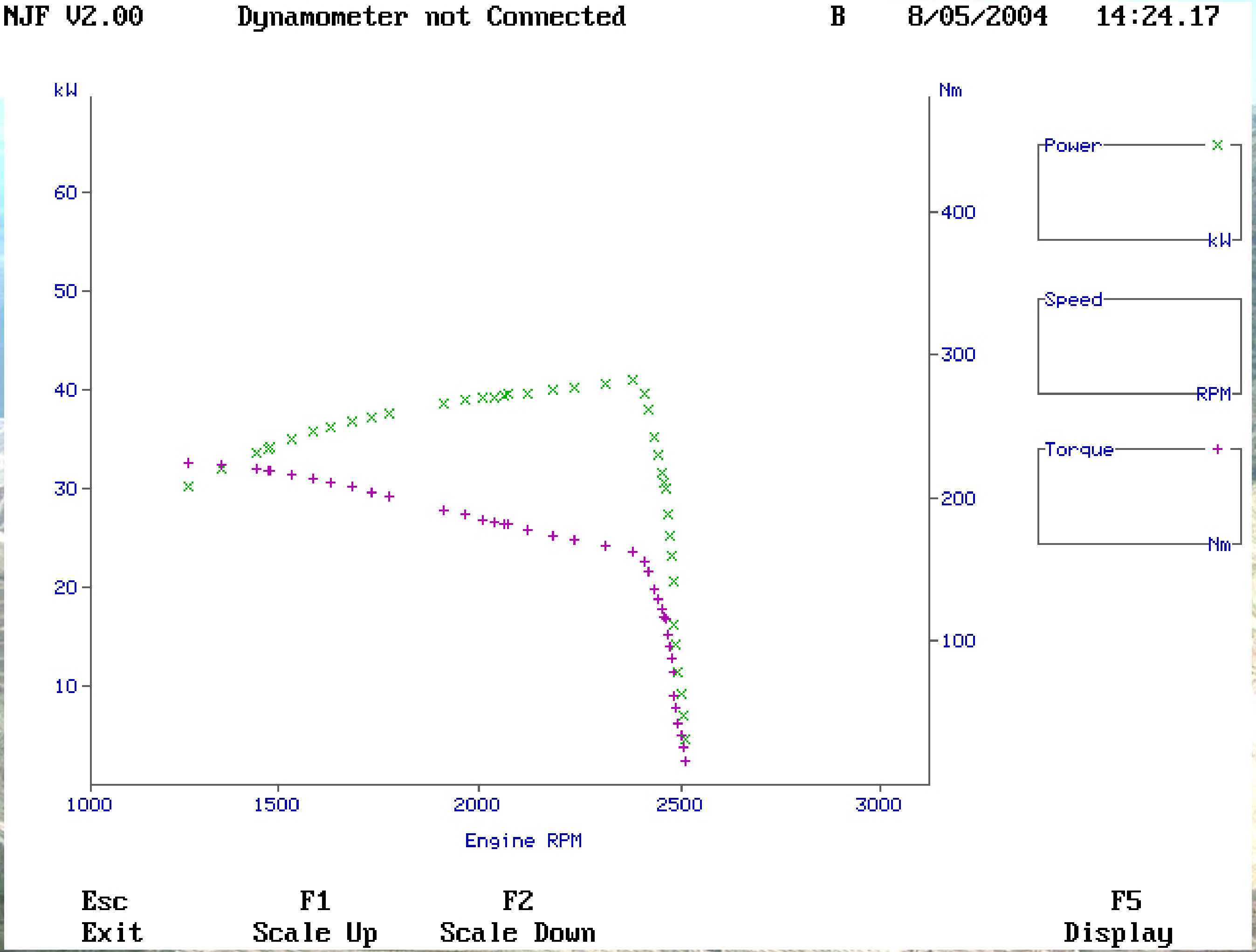
Torque backup ratio is the relationship between the difference of maximum torque to the nominal torque relatively to this last one.

Gain factor indicate the ready of the tractor answer to charge variations; bigger is its value lower is the regime variation to reach the maximum torque.

Departamento de Fitotecnia e Engenharia Rural



UNIVERSIDADE DE TRÁS-OS-MONTES E ALTO DOURO


NJF V2.00
Dynamometer not Connected
B
8/05/2004
14:24.17
kW
Nm
60
50
40
30
20
10
400
300
200
100
1000
1500
2000
2500
3000
Engine RPM
Power
kW
Speed
RPM
Torque
Nm
Esc
Exit
F1
Scale Up
F2
Scale Down
F5
Display

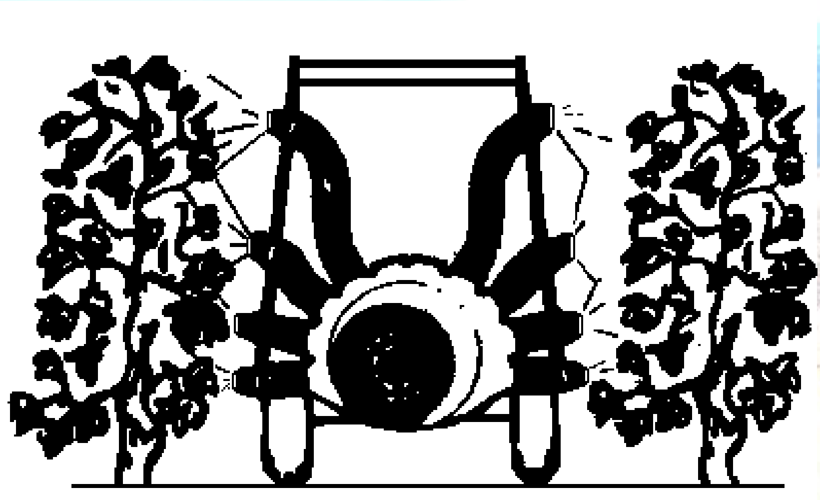
Departamento de Fitotecnia e Engenharia Rural

Marca	Modelo		rgM	Ano	Horas	Mt (novo)			Mt (reg.max.)			Mt (reg.nom.)			Mt (TDF-540)			Mt (bin.max.)			R.B.	SDR	GF	GIR
		SL	(540)			(rpm)	(kw)	(cv)	(rpm)	(kW)	(daNm)	(rpm)	(kW)	(daNm)	(rpm)	(kW)	(daNm)	(rpm)	(kW)	(daNm)	(%)	(%)		(%)
António Carraro	Tigrone 5500	4RM	2200	1987	1500	2356	28.7	39.0	2761	5.1	1.76	2119	19.8	8.93	2191	19.2	8.37	1439	1.6	10.40	16.5	47.9	0.34	23.3
Case	2120	4RM	2100	1996	1687	2115	40.4	55.0	2507	4.5	1.71	2351	26.1	10.61	2088	25.5	11.67	1331	2.1	14.80	39.5	46.9	0.84	6.2
David Brow n	885	2RM	1100	1973	12000	2200	32.1	43.7	1429	5.6	3.74	1276	27.9	20.89	1078	24.6	21.80	878	2.1	23.30	11.5	38.6	0.30	10.7
Ebro	155 E	2RM	2050	1978	6990				2122	3.0	1.35	1608	29.6	17.59	2044	6.1	2.85	1244	2.5	19.10	8.6	41.4	0.21	24.2
Ferrari	System50AR	4RM	1520	2002	1253	???	??	???	1979	5.1	2.46	1570	23.2	14.12	1537	23.1	14.36	1118	2.0	17.10	21.1	43.5	0.49	20.7
Fiat	45-66	2RM	2150	1992	2771	2199	33.1	45.0	2200	2.9	1.26	1935	23.3	11.50	2150	7.7	3.42	1348	1.9	13.70	19.1	38.7	0.49	12.0
Fiat	55-65	RT	2160	1987	5008?	2199	37.5	51.0	2743	5.3	1.85	2477	27.4	10.57	2201	26.6	11.55	1281	2.0	15.20	43.8	53.3	0.82	9.7
Fiat	55-76	4RM	2150	1991	2806?	2199	37.5	51.0	2434	4.0	1.57	2232	27.6	11.81	2232	27.6	11.81	1430	2.4	15.80	33.7	41.2	0.82	8.3
Fiat	55-85	RT	1960	1998	3900	2199	37.5	51.0	2434	5.0	1.96	2235	33.0	14.11	1942	30.8	15.15	1250	2.2	17.00	20.5	48.6	0.42	8.2
Fiat	55-86	4RM	1900	1994	3571	2199	37.5	51.0	2324	4.4	1.81	1955	34.7	16.96	1955	34.7	16.96	1159	2.4	19.60	15.6	50.1	0.31	15.9
Fiat	FD 72-85	RT	2150	1995	3047	2199	50.7	69.0	2538	4.3	1.62	2323	47.1	19.37	2208	46.2	19.99	1367	3.3	23.30	20.3	46.1	0.44	8.5
Ford	1720	4RM	2300	1992	966				2704	4.5	1.59	2166	13.0	5.73	2291	12.7	5.30	1617	1.0	6.10	6.4	40.2	0.16	19.9
Ford	3930	4RM	1760	1990	???		40.4	55.0	2161	4.9	2.17	2036	34.0	15.95	1790	32.2	17.19	1038	1.9	17.80	11.6	52.0	0.22	5.8
Ford	4610	4RM	1800		5383	2300	36.8	50.0	2324	5.6	2.30	2103	42.0	19.08	1804	37.8	20.02	1175	2.6	21.50	12.7	49.4	0.26	9.5
Ford	1910	2RM	2450	1986	1070				2713	3.6	1.27	2573	17.6	6.54	2435	17.5	6.87	1691	1.5	8.30	27.0	37.7	0.72	5.2
Goldoni	Compac 604 D	4RM	2100	1997	1828				2231	3.2	1.37	1887	31.4	15.90	2100	11.2	5.10	1354	2.4	16.70	5.0	39.3	0.13	15.4
Goldoni	Gitma 3.45 L	RT	2000	1994	1567				2126	10.4	4.67	1930	26.3	13.02	2008	19.6	9.33	1206	1.9	15.00	15.2	43.3	0.35	9.2
Goldoni	U 238	4RM	1800	1986	>10000	2806	23.6	32.0	1444	14.8	9.79	1444	14.8	9.79				1444	1.5	9.80	0.1	0.0		0.0
Goldoni	U 238	4RM	1800	1984	4400?	2806	23.6	32.0	1843	2.5	1.30	1627	17.5	10.28				1313	1.5	10.90	6.1	28.8	0.21	11.7
Goldoni	U 238	4RM	1800	1985	5400	2806	23.6	32.0	1880	2.6	1.32	1561	16.8	10.28				1275	1.5	11.00	7.0	32.2	0.22	17.0
Hurlimann	Prince 435	4RM	2600	2002	216	2646	25.7	35.0	3119	4.6	1.41	2827	17.0	5.75	2647	16.7	6.03	1883	1.4	6.90	20.1	39.6	0.51	9.4
JD	1140	2RM	2100	1982	8900		44	60	2690	5.4	1.92	2528	34.0	12.85	2115	31.7	14.32	1380	2.3	16.10	25.3	48.7	0.5	6.0
JD	1550	2RM	2120	1988	5858				2460	4.1	1.59	2241	36.3	15.48	2163	35.7	15.77	1210	2.2	17.70	14.4	50.8	0.28	8.9
JD	1030 VU	2RM	2100	1977	2878	2500	30.6	41.6	2389	3.9	1.56	2233	24.5	10.48	2138	24.1	10.77	1413	1.8	12.40	18.3	40.9	0.45	6.5
JD	1445 FA	4RM	2150	1990	2899				2424	3.8	1.50	2213	27.1	11.70	2213	27.1	11.70	1197	1.9	14.80	26.5	50.6	0.52	8.7
JD	1745 F	4RM	2150	1989	7000	2160	32.4	44.0	2454	3.9	1.52	1982	31.3	15.09	2131	30.7	13.76	1395	2.6	18.10	20.0	43.2	0.46	19.2
JD	1846 F	4RM	2200	1999	1916	2160	37.5	51.0	2392	20.9	8.35	2247	35.9	15.26	2247	35.9	15.26	1366	2.4	16.80	10.1	42.9	0.23	6.1
JD	5400 S	4RM		2000	842	2400	44.6	60.7	2441	4.2	1.64	1803	39.8	21.09	2102	37.9	17.23	1563	3.9	23.80	12.8	36.0	0.36	26.1
JD	5500 N	4RM	2100	2001	1585				2443	4.1	1.60	2250	56.8	24.12	2119	55.8	25.16	1538	4.6	28.40	17.8	37.0	0.48	7.9
Kubota	L4200	4RM	2500	1998	1304		33.1	45.0	2824	3.8	1.29	2628	24.7	8.98	2533	24.7	9.32	1688	2.1	11.80	31.4	40.2	0.78	6.9
Lamborghini	555ST	RT	2020	1998	1541		40.4	55.0	2440	9.2	3.60	2367	34.7	14.01	2063	32.4	15.01	1420	2.5	16.90	20.7	41.8	0.49	3.0
Lamborghini	613DTV	4RM	1980	1985	4931	2000	41.2	56.1	2232	3.8	1.63	2030	34.4	16.19	1942	33.5	16.48	1460	2.7	17.70	9.3	34.6	0.27	9.1
Lamborghini	660 F plus	4RM	2050	1999	3656	2273	44.1	60.0	2373	4.1	1.65	2196	35.4	15.40	2040	34.2	16.02	1207	2.3	18.50	20.1	49.1	0.41	7.5
Lamborghini	C533	RT	1500	1985	5000?	1969	39.7	54.1	1754	3.7	2.02	1520	26.3	16.53	1520	26.3	16.53	1085	2.1	18.10	9.5	38.1	0.25	13.3
Lamborghini	C554	RT	1500	1990	>10000	1969	39.7	54.1	1563	3.1	1.89	1389	33.1	22.77	1502	16.2	10.30	1315	3.1	22.80	0.1	15.9	0.01	11.1
Lamborghini	C554	RT	1960	1985	>10000	1969	39.7	54.1	2210	3.8	1.64	2027	29.9	14.09	1958	29.6	14.44	1298	2.1	15.50	10.0	41.3	0.24	8.3
Lamborghini	C583S	RT	1960	1990	>10000	1968	39.7	54.1	2316	4.4	1.82	1996	23.4	11.20	1996	23.4	11.20	1160	1.8	14.60	30.3	49.9	0.61	13.8
Lamborghini	Grimper 555 ST	RT	2050	2000	362	2350	40.4	55.0	2494	4.7	1.80	2354	33.5	13.60	2034	32.3	15.17	1254	2.3	17.90	31.7	49.7	0.64	5.6
Lamborghini	Grimper 555 ST	RT	2050	2001	247	2350	40.4	55.0	2515	4.9	1.86	2375	32.0	12.87	2050	31.1	14.49	1252	2.3	17.30	34.4	50.2	0.68	5.6
Lamborghini	Grimper 555 ST	RT	2050	2000	524	2350	40.4	55.0	2490	4.7	1.80	2324	32.5	13.36	2065	31.5	14.57	1298	2.4	17.40	30.2	47.9	0.63	6.7
Lamborghini	Grimper 555 ST	RT	2050	2002	492	2350	40.4	55.0	2320	5.9	2.43	2271	36.3	15.27	2120	35.3	15.91	1337	2.5	17.90	17.2	42.4	0.41	2.1

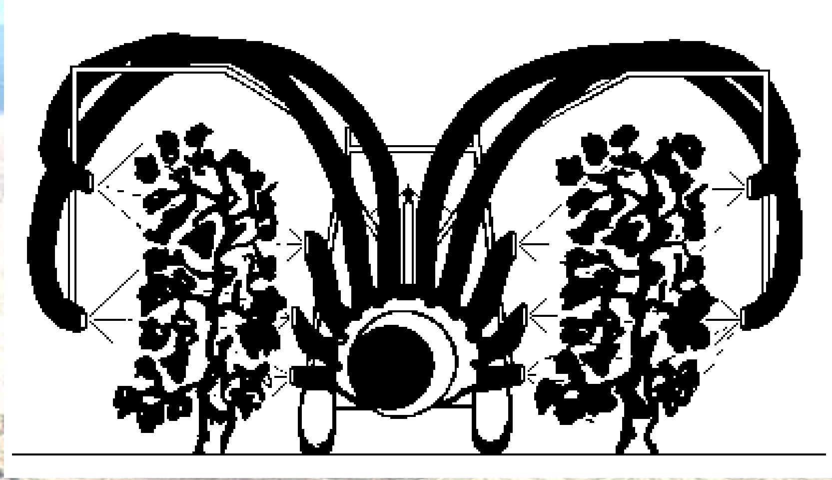
Departamento de Fitotecnia e Engenharia Rural

Study and adaptation of a radial - flow fan sprayer to vineyard terrasses of Douro Region

UNIVERSIDADE DE TRÁS-OS-MONTES E ALTO DOURO



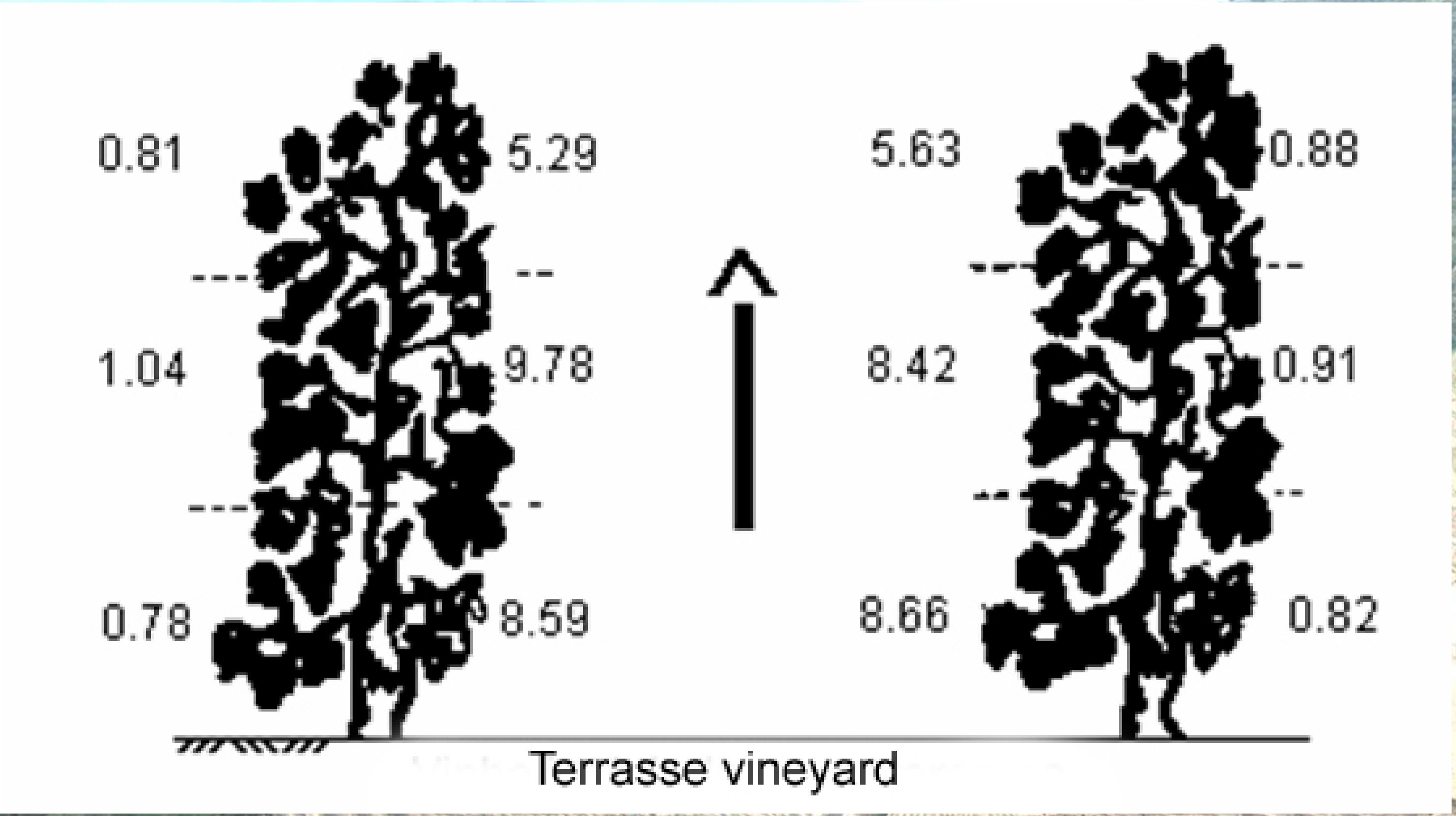
A- original sprayer



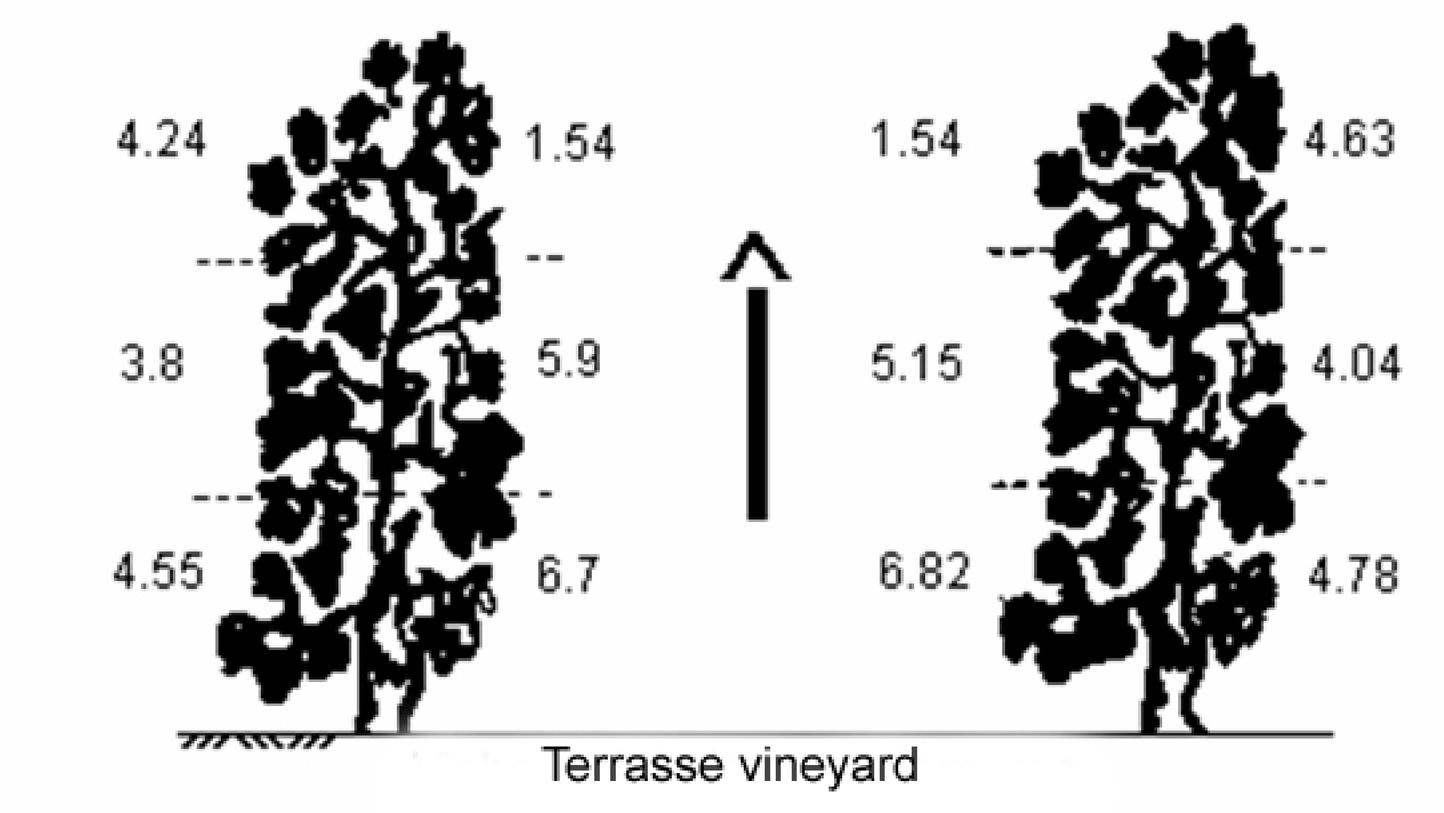
B- changed sprayer

Adaptation of a sprayer with radial-flow fan to terrasses with two rows

Cupper deposit in different parts of the plants using the original sprayer



Cupper deposit in different parts of the plants using the changed sprayer



Departamento de Fitotecnia e Engenharia Rural

Performance comparison of a sprayer with axial-flow fan with and without a liquid sprayer control system

UNIVERSIDADE DE TRÁS-OS-MONTES E ALTO DOURO

Departamento de Fitotecnia e Engenharia Rural

UNIVERSIDADE DE TRÁS-OS-MONTES E ALTO DOURO

CCS - Liquid Sprayer Control System Table

Set Up No.	SPRAYER CONSTANTS
10	p or Pn
20	Application Rate
30	Application Rate +/-
40	Nozzle Spacing
50	Nozzle Capacity Pressure
60	Nozzle Flow Capacity
70	Flush Pressure
80	Conversion Factor
90	Zero Pressure Cal.
100	System Response
110	Nozzle Mon. Set
120	Ground Speed Cal.
130	Pressure Limits Set

CMS - Custom Monitoring System Table

Set Up No.	SPRAYER CONSTANTS
CO	P
C1	Conversion Factor
C2	Sum of Nozzle Capacities
C4	Nozzle Capacity Pressure
C5	Pressure Sensor Offset
C6	Tank Level -Full (÷10)
C7	Tank Alarm Level (÷10)
U2	Volume Units Constant
U6	Ground Speed Calibration
E0	Boom Switch Sense
E1	Boom Section 1
E2	Boom Section 2
E3	Boom Section 3
E4	Boom Section 4
E5	Boom Section 5
E6	Boom Section 6

Trial results comparing the performance of a radial – flow fan sprayer with a liquid sprayer control system

Output spray (l/ha) at 3 bar

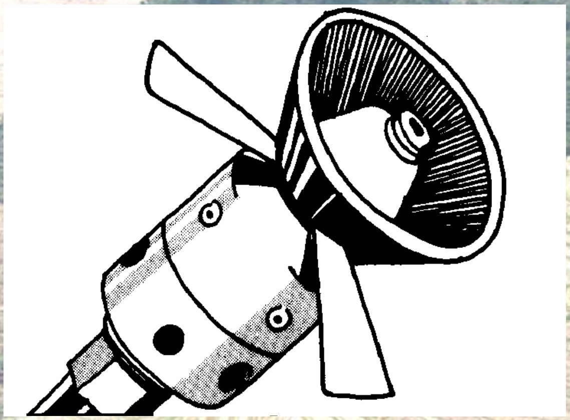
se / ce nmb/mb	-18%		-8%		0%		8%		18%	
	1,0	1,2	1,0	1,2	1,0	1,2	1,0	1,2	1,0	1,2
se-nmb	418,00	517,33	406,76	536,00	442,50	550,67	436,78	577,33	490,00	594,67
se-mb	405,33	550,40	424,50	537,33	466,00	558,66	446,50	568,00	472,67	593,33
ce-nmb	498,67	493,33	493,33	494,67	504,00	500,00	502,67	508,00	504,00	509,33
ce-mb	496,00	494,67	497,33	494,67	502,67	501,33	509,33	504,00	508,00	505,33

Output spray (l/ha) at 5 bar

se / ce nmb/mb	-18%		-8%		0%		8%		18%	
	1,0	1,2	1,0	1,2	1,0	1,2	1,0	1,2	1,0	1,2
se-nmb	512,67	-	523,93	701,33	569,50	724,00	567,14	762,67	564,00	732,67
se-mb	552,67	717,33	554,00	708,00	589,50	728,00	595,00	752,00	606,00	793,07
ce-nmb	497,33	498,67	501,33	497,33	500,00	501,33	504,00	506,67	506,67	504,00
ce-mb	500,00	494,67	497,33	497,33	505,33	502,67	509,33	509,33	504,00	510,67

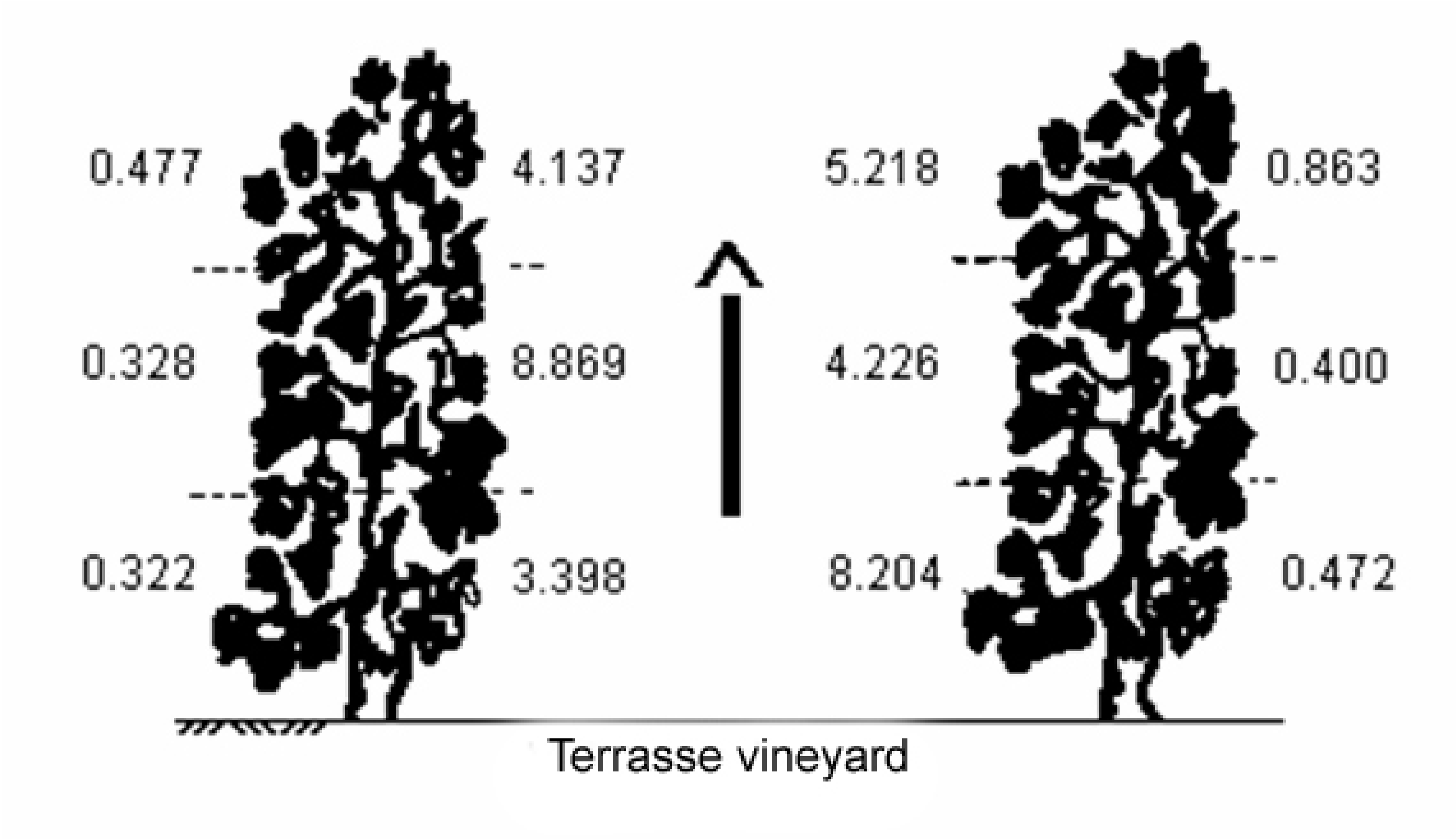
Pesticides application with centrifugal sprayers in Douro Region (1995)

Centrifugal sprayer

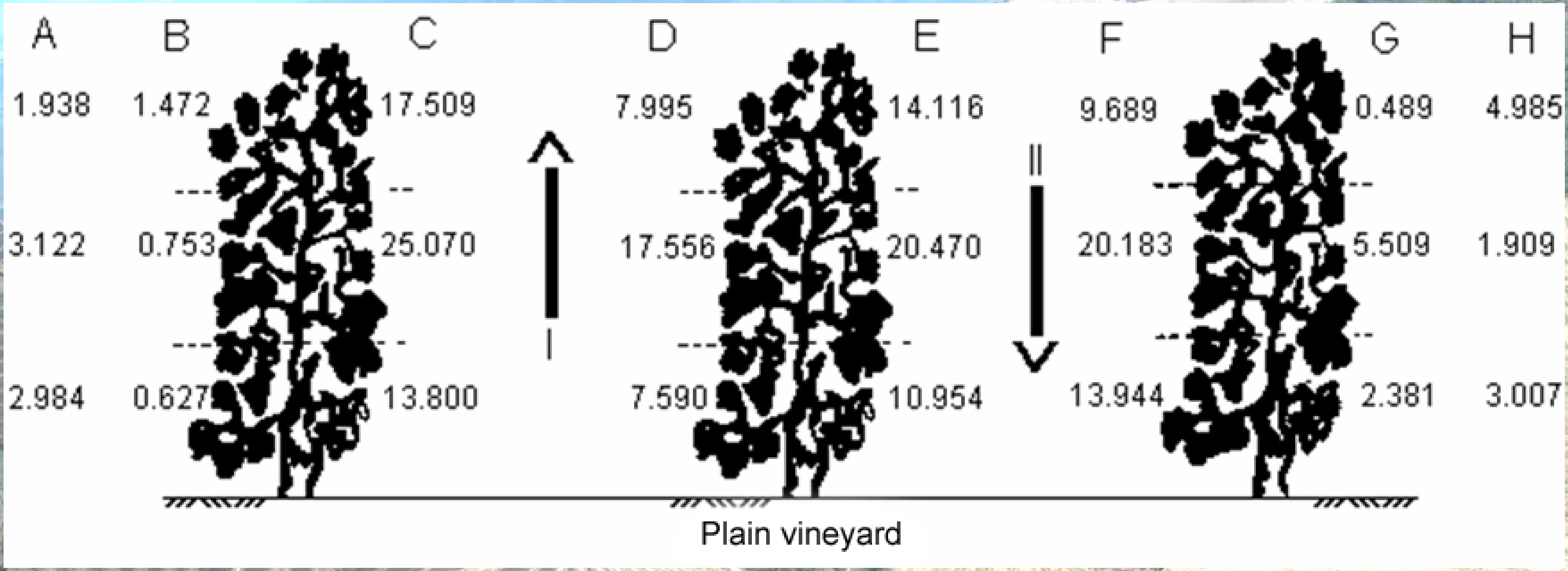


Centrifugal sprayer nozzle

Cupper quantity deposit in different part plants of a terrasse vineyard



Cupper quantity deposit in different part plants of plain continuous vineyard



Departamento de Fitotecnia e Engenharia Rural

Fungicides application with aerial sprayers in Douro Region

UNIVERSIDADE DE TRÁS-OS-MONTES E ALTO DOURO

Sprayer output:

Trial 1:

- sprayer output: 94 l / min; (pressure 53 psi = 3.7 bar)
- output: 35 l / ha;
- helicopter speed: 40 miles (64 km/h).

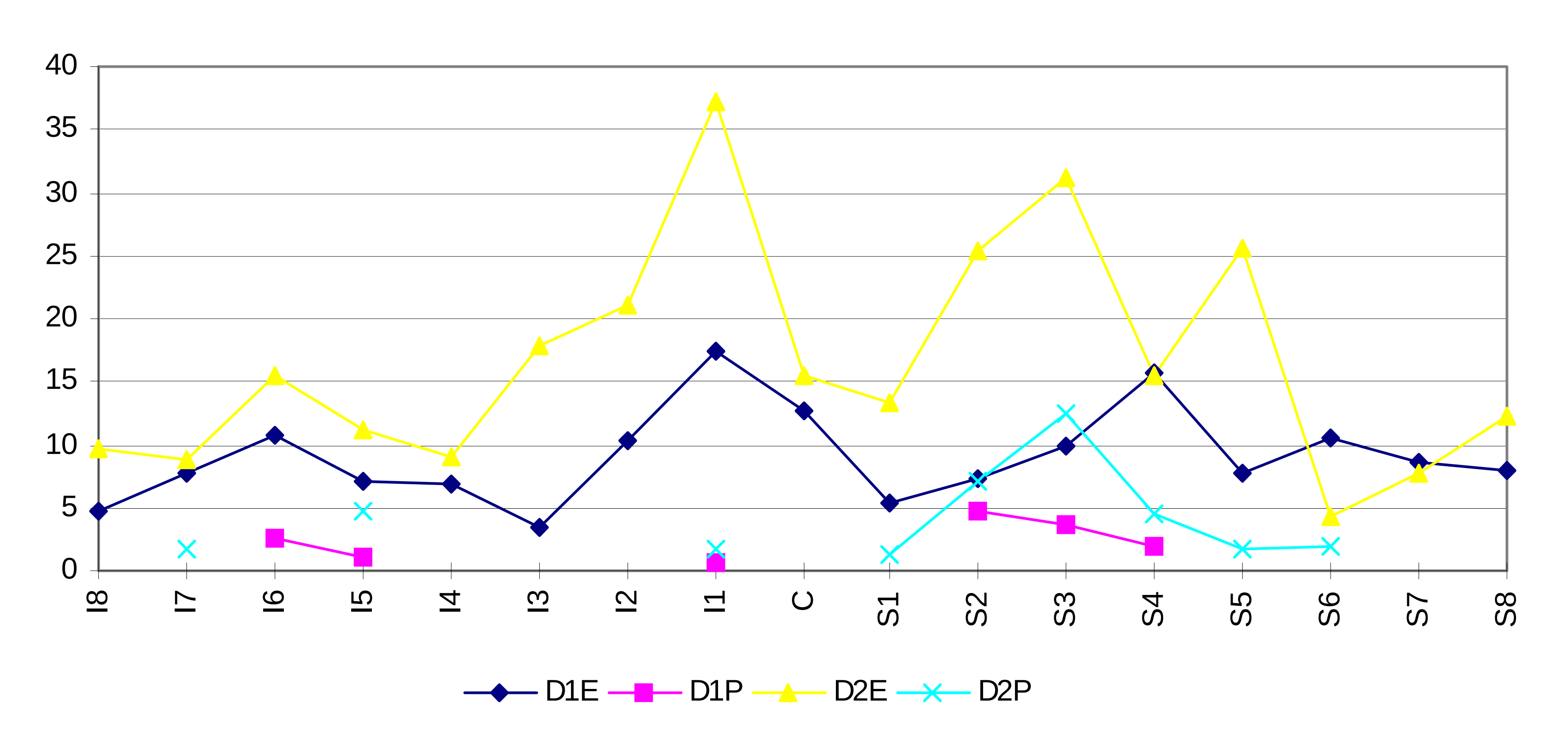
Trial 2:

- sprayer output: 75 l/min (pressure 40 psi = 2.8 bar);
- output: 25 l / ha;
- helicopter speed: 64 km /h.

Blower air speed near the grapes:

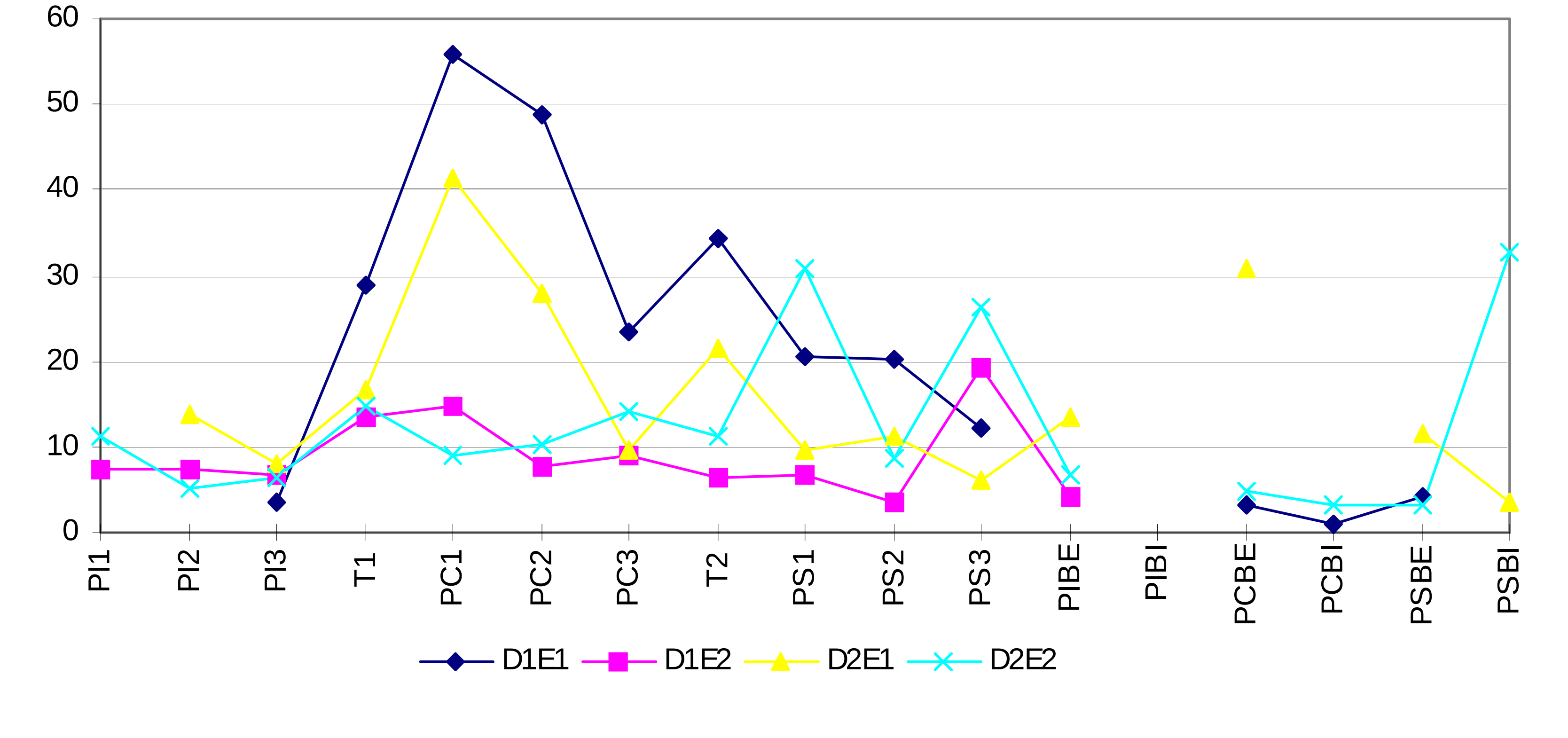
Trial 1 - 0 m/s; Trial 2 - 0.6 m/s

Droplets number in soil and plants in a traditional installed vineyard using 25 l / ha spray output per hectare.



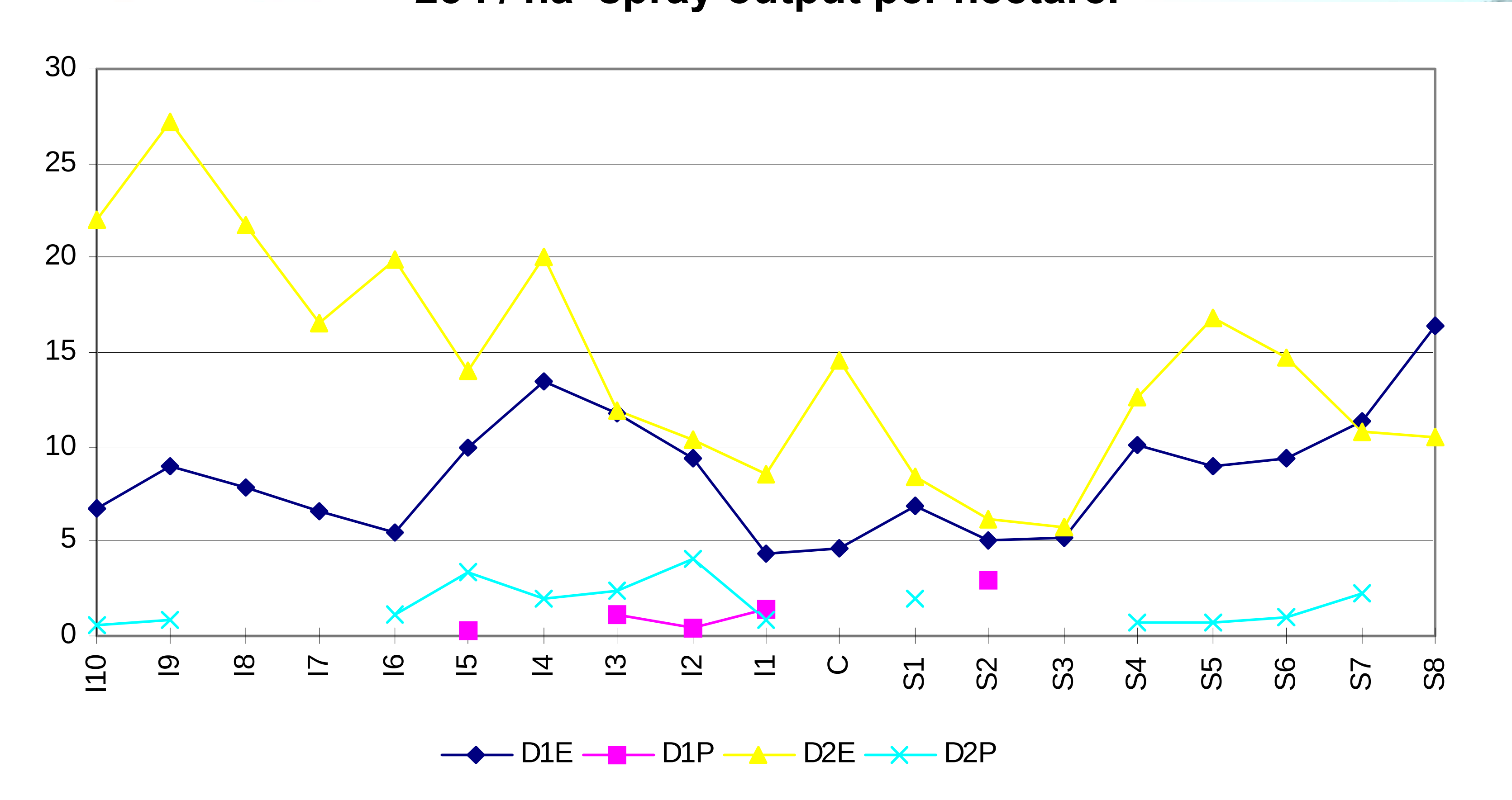
D- output; P- plants, E- ground

Droplets number in soil and plants in a terrasse vineyard using 25 l / ha spray output per hectare.



D- output; P- plants, E- ground

Droplets number in soil and plants in a sloping vineyard using 25 l / ha spray output per hectare.



D- output; P- plants, E- ground

Motorcycle - sprayer for traditional vineyard

Departamento de Fitotecnia e Engenharia Rural

UNIVERSIDADE DE TRÁS-OS-MONTES E ALTO DOURO