MANAGEMENT OF *LOLIUM PERENNE* RESISTANT TO GLYPHOSATE

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INTRODUCTION

Glyphosate is the most important herbicide used worldwide and since 2000 the problem of glyphosate resistance is exponentially increased. Glyphosate resistance in Mediterranean area was reported for *Conyza bonariensis, C. canadensis, C. sumatrensis* and *Lolium rigidum* particularly in perennial cops. Recently a survey was carried out in Portugal, to respond to growers complains of poor control of *Lolium* spp. in vineyards (Douro, North Portugal). In 2012 glyphosate resistance was confirmed in two vineyards with *Lolium perenne* populations (Portugal *et al*., 2013). To study the extent of glyphosate resistance and looking for IWM strategies to control the problem two extended surveys were conducted in 2012 and 2013 together with field experiments with herbicide in IWM programs.

MATERIAL AND METHODS

FIELD TRIALS

An IWM programme with herbicide and mowing was carried out in two trials in Douro vineyards to assess *Lolium perenne* control with ACCase – and ALS-inhibiting herbicides (cycloxidym, cletodym, quizalofop-butyl, flazasulfuron), applied either in mixture or sequence with glyphosate – Table 1.

Table 1 – Field trial treatments

Nº	EARLY POSTEMERGENCE-EARLY TILLERING OF *LOLIUM* (3-8 LEAVES)	TILLERING STAGE OF *LOLIUM* (FEBRUARY – EARLY MARCH)	*LOLIUM* AT FULL HEADING STAGE BEFORE FLOWERING (APRIL-MAY)
1	untreated		mechanical mowing
2	glyphosate 720 g/ha		mechanical mowing
3	glyphosate 720 g/ha (MON79991)		mechanical mowing
4	glyphosate 1800 g/ha		
5	glyphosate 1800 g/ha		mechanical mowing
6	glyphosate 1800 g/ha (MON79991)		mechanical mowing
7	glyphosate 1800 g/ha	cletodim 100 g/ha	
8		cletodim 100 g/ha + glyphosate 1800 g/ha	
9	glyphosate 1800 g/ha	cycloxidim 250 g/ha	
10		cycloxidim 250 g/ha + glyphosate 1800 g/ha	
11	glyphosate 1800 g/ha	flazasulfuron 50 g/ha	
12		flazasulfuron 50 g/ha + glyphosate 1800 g/ha	
13	glyphosate 1800 g/ha	quizalofop-ethyl 125 g/ha	
14		quizalofop-ethyl 125 g/ha + glyphosate 1800 g/ha	
15	glyphosate 1800 g/ha	fluazifop-p-buthyl 250 g/ha	
16		fluazifop-p-buthyl 250 g/ha + glyphosate 1800 g/ha	
17	glyphosate 1800 g/ha	diquat 800 g/ha	

SOIL SEED BANK

Sampling – 5 soil core samples per replicate on treatments (1),(4) and (5) , along vine row(Régua) and interrow (Pinhão) with a 5 cm diameter steel probe at a depth of 10 cm.
Bioassay - Clean samples were spread over vermiculite layer with 2 cm soil layer thickness, on plastic trays placed in the greenhouse (25 ºC/ 16 º c).
Resistance confirmation - Seedlings of *L. perenne* (BBCH 12-13) were identified, counted and transplanted to individual containers and submitted to glyphosate application (N= 360 e.a.ha-1) . Mortality rate was assessed at 21 DAA. Statistical analysis (ANOVA) was performed with the software package STATISTICA.

RESULTS AND DISCUSSION

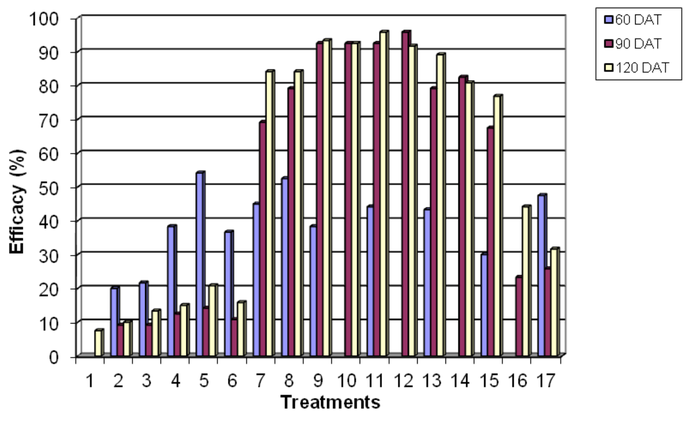

Fig 1 - Efficacy assessment 60, 90 and 120 (DAT) of 17 treatments on *Lolium perenne* populations R to glyphosate in RÉGUA vineyard (Trial 1).

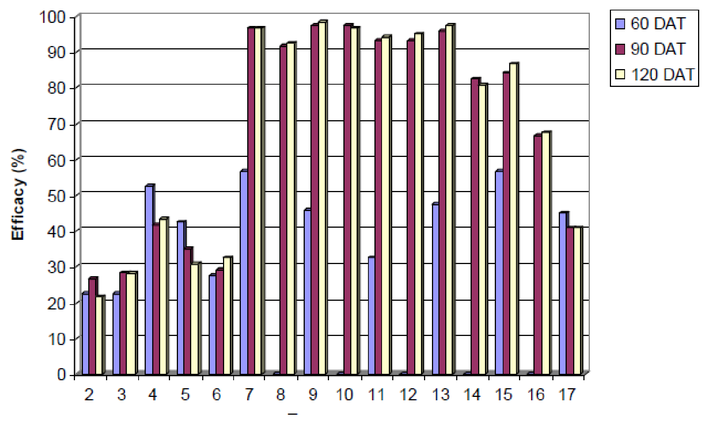

Figure 2 - Efficacy assessment 60, 90 and 120 (DAT) of 17 treatments on *Lolium perenne* populations R to glyphosate in PINHÃO vineyard (Trial 2).

FIELD TRIALS

In RÉGUA (trial 1) weed control strategy had different efficacy according to herbicides.
For cletodym (7 and 8), quizalofop-P-ethyl (13 and14) and fluazifop-P-buthyl (15 and 16) the efficacy of sequence application was significantly higher than the mixture with glyphosate. For cicloxydim (9 and 10) and flazasulfuron (11 and 12) the efficacy was high either for mixed or sequence applications, 97.5 % and 93.3 % (90 DAT) and 96.7 % and 95.0 % (120 DAT) respectively. Confirming the results of last year trial in the same location (Calha *et al.,* 2012).
The sequence application of diquat following glyphosate gave no effective control of *Lolium perenne* populations (45 % to 40.8 %) .

In Pinhão (trial 2) the herbicides showed lower efficacy than in Régua (trial 1) except for cycloxidym (7 and 8) and flazasulfuron (11 and 12) where both strategies were effective and efficacy values comparable between sites.
In the last observation, 120 days after first application, there was an increase in efficacy for all treatments, although it was not significant except for sequence application of quizalofop-P-ethyl (13) that increased to 89.17 % .

SOIL SEED BANK

In RÉGUA, glyphosate alone had higher seed bank than the integrated treatment but the differences were not significant among treatments (F= 1,03, p > 0,05).

	Pinhão		Régua	
	pl m^{-2}	(SE)	pl m^{-2}	(SE
Mowing	509,6	(222,39)	509,6	(289,96)
glyphosate	1970,3	(546,7)	305,7	(108,95)
glyphosate + mowing	577,5	(198,08)	135,9	(78,10)

In PINHÃO, *Lolium* seed bank in integrated treatment were significantly lower than in glyphosate treatment and similar to mowing alone . Confirming the effect of mowing in reducing the *Lolium* seed bank (F= 5,26, p < 0,01). Long term application of glyphosate on Douro vineyards had already selected for resistance on seed bank. In fact, 80 to 90 % the total of *Lolium* seedlings emerged were resistant to glyphosate.

CONCLUSIONS

Sequence application of herbicides was either more or as effective in controlling *L. perenne* populations than mixtures of the same herbicides. Mowing with glyphosate application could be an effective integrated weed management (IWM) to limit the dissemination of resistant biotypes as it prevents seed set and reduces soil seed bank.

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