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Effectiveness of different mitigation measures to reduce runoff in sloping vineyards

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Abstract

Water flow regulation is particularly complex in hilly environments: the erosive and runoff flows that originate from cultivated areas may represent a potential risk for water resources, since runoff water may be responsible for transferring organic materials, nutrients and pesticides to superficial water bodies.

Over the last twenty years, many mitigation measures to reduce runoff were proposed and tested: in particular, buffer strips can effectively contribute to surface water protection. In orchards and vineyards, permanent grass cover between rows may also contribute. Both measures allow for runoff flow containment, hindering water movement and facilitating the infiltration processes and adsorption phenomena.

In order to test the effectiveness of these measures in a sloping environment, a 5 m grassed buffer strip placed at the bottom of the rows and grass cover between rows were compared to the traditional system of total weeding over three growing seasons in a sloping vineyard (gradient greater than 30%) in Aosta Valley. In the third year, the effect of soil compaction due to tractor traffic was also evaluated. Runoff flow volumes in the vineyard were measured.

During the first two years of experimentation, no significant differences between the three treatments were found in terms of runoff volumes. In the third year, significant mitigation due to buffer strips and grass cover between rows was observed, but only when there was no tractor traffic, indicating that soil compaction may nullify the mitigation effects of buffer strips and grass cover.

Keyword

Runoff; mitigation measures; sloping vineyards

Introduction

Water flow regulation is particularly complex in hilly environments: the erosive and runoff flows that originate from cultivated areas may represent a potential risk for water resources, since runoff water may be responsible for transferring organic materials, nutrients and pesticides to superficial water bodies.

Over the last twenty years, many mitigation measures to reduce runoff have been proposed and tested: in particular, buffer strips can effectively contribute to surface water protection. The first studies related to the buffer strips date back to the late 1970s (Asmussen et al., 1977) and their effectiveness is widely documented by the international scientific literature, which mainly refers to experiments conducted in Europe and in the USA (Arora, 2010; CORPEN, 2007).

In orchards and vineyards, permanent grass cover between rows may also contribute. Both measures allow for runoff flow containment, hindering water movement and facilitating the infiltration processes and adsorption phenomena (USDA, 2000).

Material and methods

Study area

The study was carried out in the experimental vineyard of the Institut Agricole Régional (IAR), located in Moncenis (Aosta) (45° 74'88.98 " N, 7° 31'40.93 " E) in 3 cultural seasons (2012-2014). The vineyard rows are oriented in the maximum slope direction with average 30% slope (Figure 1).

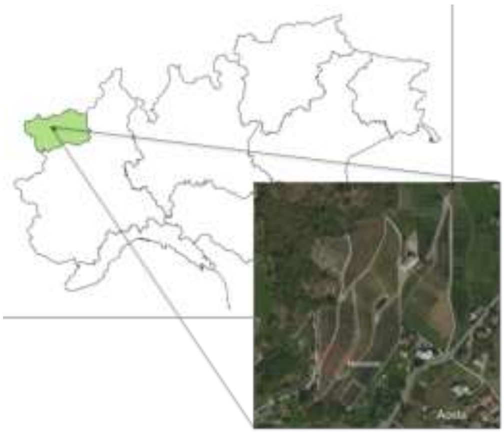


Figure 1. Moncenis experimental vineyard.

To test the effectiveness of different mitigation measures in a sloping environment, a 5 m grassed buffer strip (BF) placed at the bottom of the rows and grass cover between rows (GC) and the traditional system of total weeding (TW) were compared. The study was carried out on 9 plots (3 treatments; 3 replications; 2 vineyard rows per replication), each 3.4x29.5 m. Nine tanks for collecting runoff (CT) were installed (Figure 2; left).

During the 2014 growing season, the experimental design was modified to separate the effect of tractor traffic to soil compaction and the consequent reduction of runoff water infiltration; 18 adjoining plots each 1.6x29.5 m were arranged (3 replications for each treatment; with and without tractor tracks) (Figure 2; right).

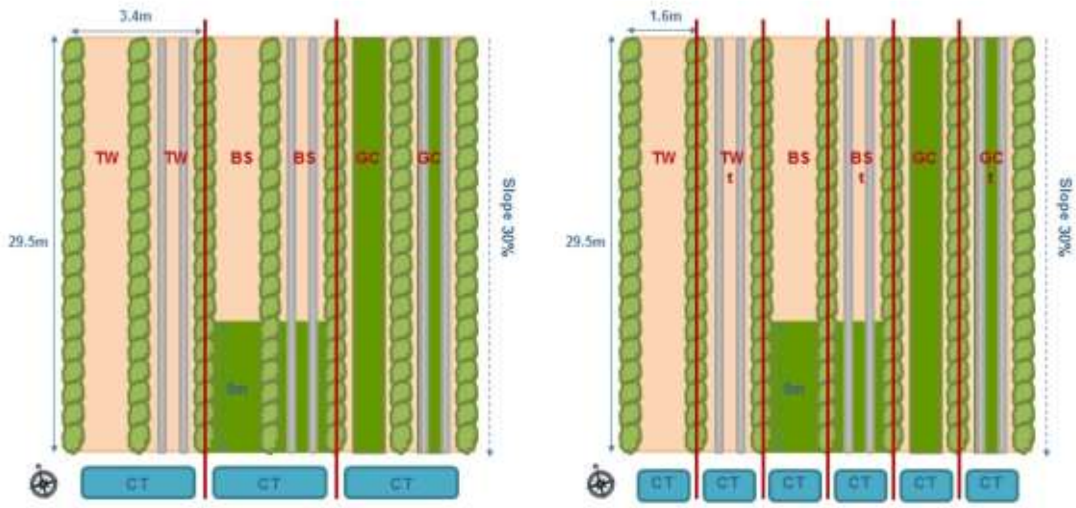


Figure 2. Experimental design in 2012-2013 growing seasons (left; only one replication is represented) and 2014 (right; only one replication is represented).

During the experimentation, treatments were carried out in the absence of wind with a crawler tractor equipped with an axial atomizer. In order to replicate the vineyard weed management usually adopted in the region, weeding treatments were performed using a shoulder sprayer.

Runoff flow volumes in the vineyard were measured starting from the beginning of May and for the whole growing season.

SPSS was used for the statistical analysis; a Ryan-Eynot-Gabriel-Welsch-F test (*P <0.05) was employed to determine the statistical significant differences between treatments in term of runoff volumes.

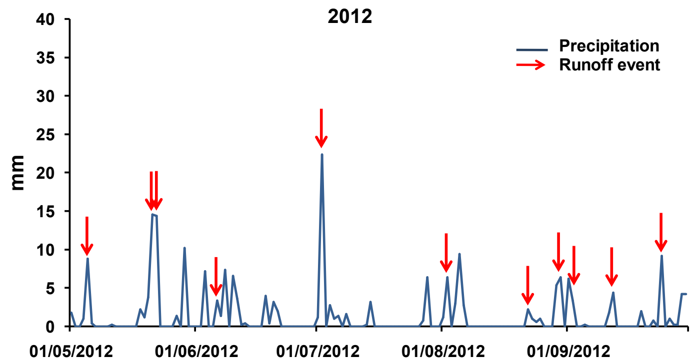
Results

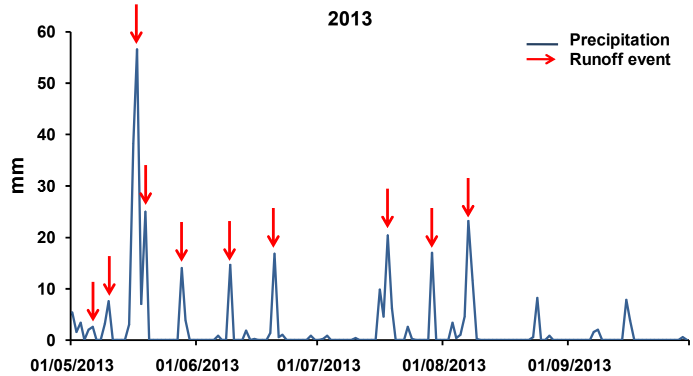
In the 3-years experimentation, all the main climatic variables (rainfall, wind, temperature) were monitored: meteorological data, in particular precipitation, were processed in order to compare them with those recorded in previous years and obtain information about the meteorological trend of the year. Table 1 shows rainfall monthly averages during the 3 year.

Table 1. Seasonal precipitation.

	May	June	July	August	September	Total
			Precipitation (mm)			
2012	60	40	41	39	38	218
2013	173	38	62	54	16	343
2014	25	17	111	54	38	246

During the 2012 growing season, from the first treatment until October, 12 runoff events occurred; 10 (5 in May)and 8runoff events were observed in 2013 and 2014 respectively (Figure 3).





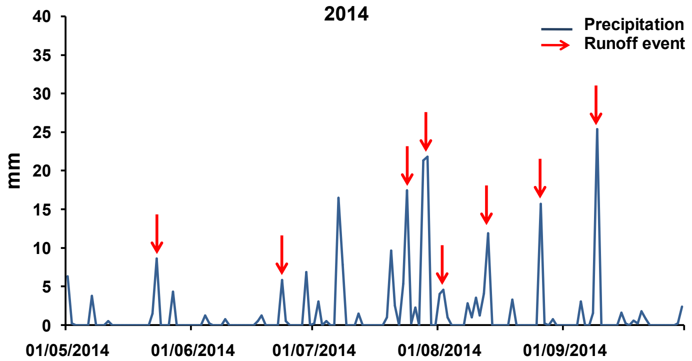


Figure 3. Precipitations and Runoff events.

During the 2012 growing season, in first months of experimentation, no statistically significative differences between the different managements were found, probably because the vegetation cover was not well established and homogeneous (Table 2). However, in the last events, BC and GC treatments had lower (but not statistically significant) runoff volumes, compared to TW, with a reduction of 58% and 64% respectively.

During the 2013 growing season, starting from the first runoff events, an evident effect of the tested mitigating measures was observed, GC has always shown a reduction in the volume of runoff water, ranging from 10% to 70%, depending on the events.

During the first two years, no significant differences between the three treatments were found, in terms of runoff volumes.

In the third year, in particular in case of high rainfall events, significant mitigation due to buffer strips and grass cover between rows was observed, but only when there was no tractor traffic, indicating that soil compaction may nullify the mitigation effects of buffer strips and grass cover (Table 3). As observed in similar studies (Soane and van Ouwerkerk, 1995), the infiltration rate in grassed soil was higher in areas not subjected to tractor traffic compaction.

Table 2. Runoff volumes (litres/ha) in 2012-2013 experimentation. No significant differences were found (REGWF test (*P <0.05)).

	2012											
Treat.	5 May	21 May	22 May	6 Jun	2 Jul	2 Aug	22 Aug	30 Aug	2 Sept	12 Sept	24 Sept	9 Oct
TW	465,3	1638,4	1379,2	498,5	2459,3	565,0	299,1	365,6	1113,3	309,1	7261,5	6463,9
BS	548,4	2426,1	1744,8	448,7	2941,2	398,8	166,2	292,5	1395,8	299,1	3207,0	2741,8
GC	515,1	2618,8	2010,6	375,5	2259,9	498,5	315,7	465,3	1744,8	309,1	2475,9	2343,0

Treat.	6 May	10 May	17 May	19 May	28 May	9 Jun	20 Jun	18 Jul	29 Jul	8 Aug
	2013									
TW	465,3	1030,2	13825,2	4669,3	2392,8	781,0	1013,6	4752,4	1595,2	4187,4
BS	182,8	764,4	11731,5	3340,0	1994,0	847,5	1179,8	4835,5	2127,0	4453,3
GC	265,9	581,6	12329,7	3772,0	1827,8	216,0	614,8	2791,6	1296,1	3722,2

Table 3. Runoff volumes (litres/ha) in 2014 experimentation. Values sharing the same letter are not significantly different (REGWF test (*P <0.05)).

Treat.	23 May	23 Jun	24 Jul	29 Jul	3 Aug	13 Aug	26 Aug	9 Sep
	2014							
TW	847.5a	346.0a	1619.9ab	4601.4a	600.3a	1320.6a	600.3a	21186.4ab
TWt	741.5a	374.3a	12747.5c	22663.1b	706.2a	1363.0a	1165.3a	31779.7b
BS	494.4a	374.3a	641.0a	2278.1a	141.2a	953.4a	423.7a	4307.9a
BSt	1285.3a	706.2a	8301.5bc	7771.2a	600.3a	2097.5a	1235.9a	31779.7b
GC	430.8a	395.5a	726.2a	1872.2a	127.1a	600.3a	600.3a	8933.6a
aGCt	536.7a	444.9a	6790.7abc	3510.3a	550.8a	791.0a	953.4a	31779.7b

Conclusions

The study confirms the effectiveness of different mitigation measures to reduce runoff in sloping vineyards. However, their efficacy is also highly influenced by tractor traffic compaction. In fact, soil compaction has been the key factor in reducing runoff water infiltration.

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