Effect of Cover Crops, and the Management Thereof, on the Weed Spectrum in a Drip-irrigated Vineyard: 1. Weeds Growing During Winter and From Grapevine Bud Break to Grapevine Berry Set

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Submitted for publication: January 2017
Accepted for publication: April 2017

Key words: Mechanical weed control, chemical weed control, grapevines, soil surface management

A five-year trial (2009 to 2013) was executed in a drip-irrigated full-bearing seven-year-old Shiraz/101-14 Mgt vineyard established on a sandy to sandy clay loam soil at Blaauwklippen Farm (33°58'S, 18°50'E) near Stellenbosch, South Africa. Fourteen treatments, consisting of two management practices applied to five cover crop species, as well as winter-growing weeds (no cover crop) and winter-growing weeds (no cover crop) with nematicide applied in the vine row, were applied. The effect of the five cover crop species, either controlled chemically (CC) or mechanically (MC) during grapevine bud break, on the weed spectrum was determined at the end of winter and during grapevine berry set. Total suppression of *Lolium* species (ryegrass) was achieved with *Avena sativa* cv. Pallinup (oats) (CC) and *Eruca sativa* cv. Nemat (Nemat) (CC) after three years. A grass-specific herbicide applied at the end of May 2012 terminated the dominance of ryegrass and facilitated the dominance of *Erodium moschatum* (musk heron's bill). Sowing the cover crops as late as 2013-05-23 prevented ryegrass from regaining its dominance. After five winters, ryegrass was totally eradicated from oats (CC), oats (MC), *Sinapus alba* cv. Braco (white mustard) (CC) and Nemat (CC). Musk heron's bill was totally suppressed in all treatments during berry set within two seasons and ryegrass in all the CC treatments by 2011. This probably facilitated the dominance of *Digitaria sanguinalis* (crab fingergrass).

INTRODUCTION

Effective weed control can be achieved by using grain and broadleaf annuals as cover crops for the biological control of weeds in the vineyards and orchards of South Africa (Fourie, 2005; Fourie *et al*., 2005; 2006; Fourie, 2010; Fourie *et al*., 2015). Facelli and Pickett (1991), as well as Shrestha *et al*. (2002), observed that the type of plant residue cover affected the weed species composition. Consequently, there is a need for future studies to document the response of the weed flora to different cover crops and their mulches (Dastgheib & Frampton, 2000).

It has been reported that soil cultivation practices cause changes in the weed population (Teasdale *et al*., 1991; Buhler *et al*., 1997; De la Fuente *et al*., 1999; Swanton *et al*., 1999; Shrestha *et al*., 2002; Westra *et al*., 2008). In contrast to this, however, Wrucke and Arnold (1985) indicated that the distribution of broad-leaved weeds did not differ between conventional tillage and conservation tillage, while Pollard and Cussans (1981), as well as Pollard *et al*. (1982), indicated an inconsistency in the weed response to tillage. Certain species are adapted to survive intermittent habitat disturbances (Smith, 1970) and will quickly fill the vacated niches created by a specific practice (Putnam, 1990). Légère and Samson (1999) observed that species dominance was brought about by interactions between crop rotation, weed management intensity and tillage. Consequently, situations where the weed population is dominated by a small number of species are indicative of a weed management system that creates conditions under which these species can flourish (Cousens & Mortimer, 1995).

It is important to determine the effect of cover crops, and the management thereof, on the weed spectrum. In doing so, our understanding of long-term weed population dynamics under different soil cultivation practices can be improved, and the domination of the weed spectrum by problem weeds may be avoided.

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Acknowledgements: The authors thank the ARC, Winetech, Dried Fruit Technical Services and the National Research Foundation of South Africa (NRF-THRIP TP2009072100026), for financial support; K. Freitag, D. Mashamba, V.R. Nyamande, C.H. Ochse and I. van Huyssteen, for technical support; and Blaauwklippen Wine Estate, for supplying the trial site. Any opinions, findings and conclusions or recommendations expressed in any publication generated through THRIP-supported research are those of the authors and therefore the NRF/THRIP will not accept any liability in that regard

The aim of this study therefore was to determine the effect of cover crops, selected for their bio-fumigation properties, on the weed spectrum at the end of winter and during grapevine berry set, when controlled chemically or incorporated mechanically into the topsoil during grapevine bud break in a drip-irrigated vineyard.

MATERIALS AND METHODS

Experiment vineyard and layout

The trial was conducted over five years (2009 to 2013) in a full-bearing seven-year-old Shiraz/101-14 Mgt vineyard established on a sandy (0 to 300 mm soil layer) to sandy clay loam soil (300 to 600 mm soil layer) at Blaauwklippen Farm (33°58'S, 18°50'E) near Stellenbosch in the Western Cape, South Africa (Fourie *et al*., 2015). Fourteen treatments were applied (Table 1), consisting of two management practices applied to five cover crop species, as well as to two treatments in which no cover crop was sown, one in which a nematicide was applied in the vine row. Each replicate (experimental unit) covered an area of 81 m^2. A work row and two vine rows functioned as a buffer zone between treatments in different work rows. A buffer, consisting of five vines, was left between the experimental vines of treatment plots situated in the same vine row.

The cover crops were established as described by Fourie *et al*. (2015) at the seeding densities indicated in Table 1. During the 2009/2010 to 2012/2013 seasons, the cover crops were sown annually during early May (seeding dates varying between 4 and 10 May) after the onset of the first good winter rain. The late onset of winter rain in 2013 resulted in the cover crops being established on 23 May. Fertilisers were applied as described by Fourie *et al.* (2015).

The cover crops were controlled between late bloom and early seed/pod formation, which coincided with grapevine bud break. Two management practices were applied. One practice consisted of full-surface post-emergence chemical weed control (CC), while the other consisted of slashing the above-ground growth and incorporating the macerated fibre mechanically into the top 200 mm soil layer (MC), as described by Fourie *et al*. (2015). In the last-mentioned practice, chemical weed control was applied to the vine row (one metre-wide strip). Full-surface chemical control applied during grapevine berry set was part of both management practices. The herbicide used just before bud break (first week of September) and during berry set (first week of December) was glyphosate at a dosage of 1 800 g/L per hectare. Fluazyfopbutyl, at a dosage of 625 g/L per hectare, was applied full surface in all the treatments at the end of May 2012, except in the two oats treatments. This was done to prevent the *Lolium* species (ryegrass) from impacting negatively on the dry matter production (DMP) of the four broadleaf cover crops.

Grapevine cultivation practices conducted on this site were in keeping with the standard practices applied in the vineyards of South Africa. Supplementary drip irrigation was applied from December to March. The standard pest and disease management programme used by the farm was applied.

Measurements

Weed DMP was determined just before grapevine bud break (end of August) and during grapevine berry set (end of November) to determine weed dominance. In each plot (replication), one of the three grapevine inter-rows was randomly chosen and five 0.5 m^2 quadrants were placed diagonally across the grapevine inter-row, spaced 0.7 m apart. The weed species were harvested separately by removing the above-ground growth and placing it in a paper bag. After the samples had been gathered in the field, the DMP was determined as described by Fourie *et al*. (2001).

TABLE 1
Treatments applied

Cover crops	Management practice	Seeding density (kg/ha)
Avena sativa L. cv. Pallinup (oats)	CC[1]	100
Oats	MC[2]	100
Sinapis alba cv. Braco (white mustard)	CC	8
White mustard	MC	8
Brassica napus cv. AVJade (canola)	CC	8
Canola	MC	8
Brassica juncea cv. Caliente 199 (Caliente)	CC	10
Caliente	MC	10
Eruca sativa cv. Nemat (Nemat)	CC	5
Nemat	MC	5
No cover crop (weeds)	CC	NA[3]
Weeds	MC	NA
Weeds + nematicide (Rugby 10ME @15 mL/m²) (weedsnem)	CC	NA
Weedsnem	MC	NA

[1] Full-surface chemical control from just before bud break to grapevine harvest. [2] Chemical control in the vine row and mechanical incorporation of the weeds/cover crops in the work row just before bud break, CC from berry set. [3] Not applicable

 DOI: http://dx.doi.org/10.21548/38-2-1353

Statistical procedures

The experiment was a complete randomised block design with 14 treatments (two management practices applied to five cover crop species, as well as to two treatments in which no cover crop was sown, one in which a nematicide was applied in the vine row) replicated three times. The experiment was repeated for five consecutive years. DMP was measured randomly within each experiment plot at the end of August and at the end of November. The data were tested for normality (Shapiro & Wilk, 1965), found to be acceptably normally distributed, and subjected to analysis of variance. Analyses of variance were performed according to the treatment design for each season separately, using the General Linear Models Procedure (PROC GLM) of SAS software (Version 9.2; SAS Institute Inc, Cary, USA). Fisher's least significant difference was calculated at the 5% level to compare treatment means (Ott & Longnecker, 2001).

RESULTS AND DISCUSSION

Effect of treatments on the composition of the winter weed population just before grapevine bud break

2009

At the end of the first winter in which the cover crops were established in the grapevine inter-row (work row), the ryegrass was either the dominant or next to dominant species in all the treatments, with the exception of *Avena sativa* cv. Pallinup (oats) (CC), *Sinapis alba* cv. Braco (white mustard) (MC) and *Brassica juncea* cv. Caliente 199 (Caliente) (MC) (Table 2). The stand of ryegrass in the two oats treatments and white mustard (MC) was lower than that of the treatment in which no cover crop was sown (weeds) and the weeds treatment in which a nematicide was applied during bud break (weedsnem), indicating effective suppression of the species at this time. *Raphanus raphanistrum* (wild radish) was the most dominant species in the two oats treatments, while *Oxalis pes-caprae* (yellow sorrel) dominated the CC treatments of white mustard, *Brassica napu*s cv. AVJade (canola), Caliente and the two *Eruca sativa* cv. Nemat (Nemat) treatments. In common practice, wild radish and yellow sorrel are easy to control chemically, while ryegrass has the tendency to become resistant to glyphosate and paraquat, as well as to other grass-specific herbicides. The *Vicia* species dominated Caliente (MC) and white mustard (MC), with the stand in Caliente (MC) being significantly more than that observed for all the weeds in all the treatments, with the exception of ryegrass in weeds (MC). The *Vicia* species, however, are N-fixers and are also used as cover crops on sandy soils (Fourie *et al*., 2001; 2005).

2010

Ryegrass dominated all the treatments in which MC was applied, with the exception of oats (MC) (Table 3). For each cover crop species the ryegrass stand was higher in the MC treatment than in the CC treatment, with the exception of oats. Although not significant, the same trend was observed for oats. The ryegrass stand in weeds (MC) and weedsnem (MC) was also higher than that of weeds (CC) and weedsnem (CC). This is an indication that the weed control method applied during grapevine bud break influenced the ryegrass stand during the following winter. The ryegrass stand in the treatments where the cover crops were combined with CC, as well as with oats (MC), was lower than that of all the treatments in which no cover crop was sown. This is an indication that oats *per se* suppressed the ryegrass effectively, whereas the other species had to be combined with chemical control during bud break to achieve effective suppression. Similar to the 2009 season, wild radish was the dominant species in the two oats treatments. This weed became more prevalent in the canola, Nemat and weedsnem treatments, while dominating weeds (CC). During this season, the stand of yellow sorrel decreased in all the treatments, with the exception of canola (CC). In white mustard (CC) it was reduced from being dominant to full eradication. *Erodium moschatum* (musk heron's bill) remained the next to dominant species in oats (MC), whilst becoming next to dominant in white mustard CC, white mustard (MC) and weeds (CC). This species also became the dominant species in weedsnem (CC) and Caliente (CC). *Euphorbia peplus* (stinging milkweed) was observed in all the treatments for the first time and was the dominant species in Nemat (CC) and the next to dominant species in oats (CC).

2011

Ryegrass remained dominant in the MC treatments of Caliente, Nemat and weeds (Table 4). As in 2010, the ryegrass stand for each cover crop species was higher in the MC treatment than in the CC treatment (Table 4). This supports the observation that CC plays a major role in the suppression of ryegrass during winter. During this season, the absence of ryegrass in oats (CC) and Nemat (CC) indicated total control. Similar to the previous two seasons, wild radish was the dominant species in oats (CC) and oats (MC) (Tables 2 to 4). Wild radish became the dominant species in canola (MC), canola (CC) and Nemat (CC) (Table 4). Musk heron's bill remained dominant in weedsnem (CC) and the next to dominant species in oats (MC) and white mustard (CC). This weed became dominant in weeds (CC), and the next to dominant species in oats (CC), canola (CC) and Nemat (CC). It therefore seemed as if a trend was developing in which musk heron's bill was starting to manifest its dominance in the CC treatments, with the exception of Caliente. Although yellow sorrel occurred in all the treatments, it did not dominate in any of the treatments (Table 4), which is in contrast to the previous two seasons (Tables 2 and 3). Although stinging milkweed was once again present in all the treatments (Table 4), the species lost its dominance in Nemat (CC) and became dominant in white mustard (MC). However, as in the previous season, no definite trends could be detected.

2012

Musk heron's bill became the dominant species in all the treatments with the exception of canola (MC), in which it was the third most prevalent species, as well as Nemat (MC) and weedsnem (MC), in which it was the next to dominant species (Table 5). In the case of the two oats treatments, it replaced wild radish, which had dominated during the previous three seasons (Tables 2 to 4). The application of a grass-specific herbicide in all the treatments, except the two oats treatments, approximately two weeks after sowing

TABLE 2

Effect of soil cultivation practices on the spectrum of dominant winter-growing weeds (species presenting 10% or more of the total spectrum of weeds present in any year of the study were selected) in a seven-year-old drip-irrigated Shiraz/101-14 Mgt vineyard established on a sandy to sandy clay loam soil, at the end of August 2009.

	Weed stand in g/0.5 m^2									
Treatment	*Raphanus raphanistrum*	*Oxalis pes-caprae*	*Erodium moschatum*	*Vicia species*	*Avena fatua*	*Rapistrum rigosum*	*Euphorbia peplus*	*Lolium species*	*Galinsoga parviflora*	Other
1. *Avena sativa* cv. Pallinup (oats), CC[1]	2.05	0.88	0	0.07	0	0	0	0.09	0	0.27
2. Oats, MC[2]	2.68	1.34	1.39	0.07	0	0	0	1.47	0	0.18
3. *Sinapis alba* cv. Braco (white mustard), CC	0	4.79	0.22	0.13	0.33	0.01	0	2.46	0	0.26
4. White mustard, MC	3.67	3.24	1.18	6.03	0	0.05	0	2.04	0	0.30
5. *Brassica napus* cv. AVJade (canola), CC	2.59	7.23	0	0.14	0.02	0	0.13	2.71	0	0.27
6. Canola, MC	0.02	7.81	0.18	0	0	0	0	10.72	0	0.19
7. *Brassica juncea* cv. Caliente 199 (Caliente), CC	0	5.31	0.07	0.01	0.22	0	0	2.91	0	0.12
8. Caliente, MC	0.19	6.33	0	20.75	0	0.34	0.20	3.65	0	0.21
9. *Eruca sativa* cv. Nemat (Nemat), CC	0	6.23	0	1.02	0	0	0	3.16	0	0.34
10. Nemat, MC	1.35	12.37	0.29	0	0	0	0	5.01	0	0.17
11. No cover crop (weeds), CC	3.59	9.18	1.03	0	3.55	0	0	11.86	0	1.51
12. Weeds, MC	6.07	4.82	0	1.79	0	0	0	21.91	0	1.35
13. Weeds + nematicide (weedsnem), CC	0.05	3.51	3.07	0.46	0	0	0.07	8.29	0	1.88
14. Weedsnem, MC	0.66	1.69	1.65	0	5.28	0	0.03	7.39	0	1.53
LSD (p = 0.05)					4.98					

[1] Full-surface chemical control from grapevine bud break. [2] Chemical control vine row, mechanical incorporation in work row during grapevine bud break, full-surface chemical control from grapevine berry set.

DOI: http://dx.doi.org/10.21548/38-2-1353

TABLE 3

Effect of soil cultivation practices on the spectrum of dominant winter-growing weeds (species presenting 10% or more of the total spectrum of weeds present in any year of the study were selected) in a seven-year-old drip-irrigated Shiraz/101-14 Mgt vineyard established on a sandy to sandy clay loam soil, at the end of August 2010.

	Weed stand in g/0.5 m^2									
Treatment	*Raphanus raphanistrum*	*Oxalis pes-caprae*	*Erodium moschatum*	*Vicia species*	*Avena fatua*	*Rapistrum rigosum*	*Euphorbia peplus*	*Lolium species*	*Galinsoga parviflora*	Other
1. *Avena sativa* cv. Pallinup (oats), CC[1]	7.64	0.05	0.02	0.15	0	0	3.37	0.32	0	0.07
2. Oats, MC[2]	9.78	0.15	1.83	0.21	0	0	0.51	1.65	0	0.14
3. *Sinapis alba* cv. Braco (white mustard), CC	0.49	0	1.38	0.06	0	0	1.10	3.11	0	0.08
4. White mustard, MC	2.06	0.29	7.95	1.98	0	0	0.11	15.70	0	0.07
5. *Brassica napus* cv. AVJade (canola), CC	5.26	8.29	4.03	0	0	0	3.78	0.71	0	0.19
6. Canola, MC	6.09	3.87	0.15	0	0	0	1.53	24.24	0	0.06
7. *Brassica juncea* cv. Caliente 199 (Caliente), CC	0.37	0.29	1.89	0.21	0	0	0.75	1.32	0	0.06
8. Caliente, MC	0.90	1.30	0.01	0.01	0	0	0.47	9.51	0	0.08
9. *Eruca sativa* cv. Nemat (Nemat), CC	1.20	0.15	0	0.13	0	0	1.28	0.03	0	0.04
10. Nemat, MC	1.71	1.13	0.62	0	0	0	0.38	18.63	0	0.04
11. No cover crop (weeds), CC	22.55	1.13	16.74	1.65	1.24	0	5.33	7.64	0	0.39
12. Weeds, MC	10.82	3.15	4.23	0.11	18.28	0	1.82	43.73	0	0.37
13. Weeds + nematicide (weedsnem), CC	19.31	2.26	26.71	4.46	1.69	0	9.59	9.23	0	0.48
14. Weedsnem, MC	16.57	1.79	4.87	0	15.08	0	0.87	30.24	0	0.20
LSD (p = 0.05)	4.20									

[1] Full-surface chemical control from grapevine bud break. [2] Chemical control vine row, mechanical incorporation in work row during grapevine bud break, full-surface chemical control from berry set.

DOI: http://dx.doi.org/10.21548/38-2-1353

TABLE 4

Effect of soil cultivation practices on the spectrum of dominant winter-growing weeds (species presenting 10% or more of the total spectrum of weeds present in any year of the study were selected) in a seven-year-old drip-irrigated Shiraz/101-14 Mgt vineyard established on a sandy to sandy clay loam soil, at the end of August 2011.

	Weed stand in g/0.5 m^2									
Treatment	*Raphanus raphanistrum*	*Oxalis pes-caprae*	*Erodium moschatum*	*Vicia species*	*Avena fatua*	*Rapistrum rigosum*	*Euphorbia peplus*	*Lolium species*	*Galinsoga parviflora*	Other
1. *Avena sativa* cv. Pallinup (oats), CC[1]	4.26	0.42	3.08	0	0.39	0	0.73	0	0	0.11
2. Oats, MC[2]	12.80	0.26	6.62	0	0	0	3.37	0.61	0	0.02
3. *Sinapis alba* cv. Braco (white mustard), CC	4.36	1.03	4.60	0	0	0	1.38	9.64	0	0.11
4. White mustard, MC	0.36	1.03	2.21	0.11	0.35	0	5.61	2.25	0	0.03
5. *Brassica napus* cv. AVJade (canola), CC	10.07	1.25	2.74	0	0	0.81	1.87	0.04	0	0.17
6. Canola, MC	40.64	1.22	2.72	0	0.94	0	3.35	31.93	0	0.06
7. *Brassica juncea* cv. Caliente 199 (Caliente), CC	3.53	0.51	0.96	0	0.02	0.02	2.86	4.33	0	0.09
8. Caliente, MC	3.38	3.12	2.51	1.09	0	1.47	5.36	24.92	0.15	0.13
9. *Eruca sativa* cv. Nemat (Nemat), CC	8.20	1.94	4.52	0.04	0	0	1.03	0	1.09	0.27
10. Nemat, MC	19.88	4.30	0	0	1.34	0	7.76	48.69	0	0.14
11. No cover crop (weeds), CC	28.52	1.58	80.71	6.52	1.43	0	23.60	3.01	1.88	0.34
12. Weeds, MC	17.94	6.08	7.51	1.05	16.49	0.20	26.00	41.04	0	1.09
13. Weeds + nematicide (weedsnem), CC	12.00	3.66	70.11	1.38	0	0	9.49	8.64	0	0.56
14. Weedsnem, MC	32.14	4.02	16.48	0	54.92	0.10	13.56	35.25	0	0.63
LSD (p = 0.05)	7.89									

[1] Full-surface chemical control from grapevine bud break. [2] Chemical control vine row, mechanical incorporation in work row during grapevine bud break, full-surface chemical control from berry set.

DOI: http://dx.doi.org/10.21548/38-2-1353

TABLE 5

Effect of soil cultivation practices on the spectrum of dominant winter-growing weeds (species presenting 10% or more of the total spectrum of weeds present in any year of the study were selected) in a seven-year-old drip-irrigated Shiraz/101-14 Mgt vineyard established on a sandy to sandy clay loam soil, at the end of August 2012.

	Weed stand in g/0.5 m²									
Treatment	*Raphanus raphanistrum*	*Oxalis pes-caprae*	*Erodium moschatum*	*Vicia species*	*Avena fatua*	*Rapistrum rigosum*	*Euphorbia peplus*	*Lolium species*	*Galinsoga parviflora*	Other
1. *Avena sativa* cv. Pallinup (oats), CC[1]	0.27	0.23	2.73	0	0	0	0	0.02	0.21	0.08
2. Oats, MC[2]	12.77	0.03	13.28	0	0.05	0.02	0	0.01	0	0.27
3. *Sinapis alba* cv. Braco (white mustard), CC	3.70	1.04	5.26	0	0	2.07	0	0.13	0	0.12
4. White mustard, MC	0	6.89	14.13	0	1.05	0.01	0	0.03	0.03	0.19
5. *Brassica napus* cv. AVJade (canola), CC	1.29	5.31	6.79	0	0	0.04	0	0	0	0.21
6. Canola, MC	0	10.21	8.00	0	0.21	11.50	0	5.32	0.18	0.13
7. *Brassica juncea* cv. Caliente 199 (Caliente), CC	0.13	2.99	24.57	0	0	0	0	1.63	0	0.13
8. Caliente, MC	1.44	8.46	25.66	0	0	0	0	5.10	0	0.15
9. *Eruca sativa* cv. Nemat (Nemat), CC	0.43	2.65	8.71	0	0	0.08	0	0.05	1.54	0.13
10. Nemat, MC	1.68	6.64	10.34	0	26.86	0	7.28	3.77	0.13	0.23
11. No cover crop (weeds), CC	12.04	7.71	122.52	0	0	7.34	6.00	0.88	1.22	0.36
12. Weeds, MC	9.51	4.36	53.95	0	28.75	4.91	2.84	19.96	0	0.30
13. Weeds + nematicide (weedsnem), CC	1.56	14.57	92.83	0	4.56	6.00	2.43	1.70	0.18	0.53
14. Weedsnem, MC	15.49	9.57	19.28	0	66.87	2.85	1.51	10.67	0	0.29
LSD (p = 0.05)	7.11									

[1] Full-surface chemical control from grapevine bud break. [2] Chemical control vine row, mechanical incorporation in work row during grapevine bud break, full-surface chemical control from berry set.

DOI: http://dx.doi.org/10.21548/38-2-1353

the cover crops (end of May) terminated the dominance of ryegrass in most of these treatments (Table 5). The chemical control of ryegrass during autumn therefore most probably facilitated the dominance of musk heron's bill in all the treatments, with the exception of the two oats treatments. This supports the results of Teasdale *et al*. (1991), Buhler *et al*. (1997), De la Fuente *et al*. (1999), Swanton *et al*., (1999), Shrestha *et al*. (2002) and Westra *et al*. (2008). Stinging milkweed disappeared from all the cover crop treatments, with the exception of Nemat (MC). From 2010 onwards, the stand of *Avena fatua* (wild oats) in weeds (MC) and weedsnem (MC) was always higher than that in the other treatments, with the exception of Nemat (MC) (Tables 3 to 5). Wild oats dominated the weed spectrum in weedsnem from 2011 (Tables 4 and 5) and in Nemat (MC) during 2012 (Table 5). It was also the next to dominant species in weeds (MC) during 2010 and 2012 (Tables 3 and 5). *Rapistrum rigosum* (wild mustard) dominated the weed spectrum in canola (MC), after being absent from this treatment during the previous three seasons (Tables 2 to 5).

2013

Musk heron's bill remained the dominant or next to dominant species in all the treatments (Table 6). It seems that because the cover crops were established as late as 23 May during this season prevented the ryegrass from regaining its dominance in any treatment. Ryegrass was totally eradicated from oats (CC), oats (MC), white mustard (CC) and Nemat (CC). Wild radish dominated oats (MC), canola (MC) and Nemat (MC), while wild oats remained dominant in weedsnem (MC) (Table 6), as in the previous two seasons (Tables 4 and 5). *Galinsoga parviflora* (gallant soldier) appeared in both Nemat (CC) and weeds (CC) for the first time during the 2011 season and remained in these treatments during 2012 and 2013 (Tables 2 to 6). This species was the third most prevalent species in Nemat (CC) during 2012 and became dominant in 2013 (Tables 4 to 6). In the case of weeds (CC), the species became the next to dominant during 2013 (Table 6).

Effect of treatments on the composition of the summer weed population at grapevine berry set

2009

During this first season of application, either musk heron's bill or ryegrass dominated the weed spectrum in all the treatments at the end of November (Table 7). Wild radish was the only other species present in all the treatments. It was the next to dominant weed in oats (MC), white mustard (MC), weeds (MC), weedsnem (MC) and weedsnem (CC). The stand of wild radish exceeded the non-classified weeds (other) only in weedsnem (MC).

2010

The stand of musk heron's bill was reduced from being either the dominant or next to dominant species in 2009 (Table 7) to total suppression in the two oats and two Caliente treatments, as well as in white mustard (MC), canola (MC) Nemat (MC) and weedsnem (CC) in the 2010/2011 season (Table 8). This species, however, remained dominant in canola (CC) and was still the next to dominant species in weeds (CC) (Table 8), despite the drastic reduction in the stand of this weed in these two treatments from 2009 to 2010 (Tables 7 and 8).

Ryegrass remained the dominant species in canola (MC) and Caliente (MC) (Tables 7 and 8) and became the dominant species in white mustard (MC), Nemat (MC) and weedsnem (MC) (Table 8). It was also the next to dominant species in weeds (MC). A trend was establishing, in which the stand of ryegrass in the MC treatment of a species always exceeded that of the CC treatment of the same species. With the exception of oats, this difference was significant. Ryegrass was suppressed totally from grapevine bud break to grapevine berry set by all the CC treatments, with the exception of white mustard (CC) and weedsnem (CC). This management practice therefore can play an important role in the control of this problem weed. Wild radish remained the next to dominant weed in white mustard (MC) and weedsnem (MC) (Tables 7 and 8). This species also filled the niche left by musk heron's bill and, to a lesser extent, by ryegrass, by dominating the weed spectrum in both the oats treatments and both the weeds treatments, as well as white mustard (CC), Nemat (CC) and weedsnem (CC) (Table 7). Although *Tribulus terrestris* (common dubbeltjie) and *Digitaria sanguinalis* (crab fingergrass) infested most of the treatments during 2010, common dubbeltjie was the most aggressive, dominating Caliente (CC) within a season (Tables 7 and 8). Common dubbeltjie also became the next to dominant species in oats (MC), white mustard (CC), Nemat (CC) and Caliente (MC) (Table 8).

2011

With the exception of oats (MC), musk heron's bill was suppressed totally in all the treatments during 2011 (Table 9). Ryegrass was totally suppressed from grapevine bud break to grapevine berry set by all the CC treatments. The stand of this species was also reduced in all the MC treatments compared to the stand observed in the previous season (Tables 8 and 9). However, ryegrass remained dominant in white mustard (MC) and Nemat (MC) (Table 9). This species was also the next to dominant species in canola (MC), weeds (MC) and weedsnem (MC). The trend observed during 2010, in which the stand of ryegrass in the MC treatment of a species always exceeded that of the CC treatment of the same species, was once again observed, even though it was only significant for Nemat (Tables 8 and 9). This confirmed that CC can play an important role in the control of ryegrass. Wild radish remained dominant in oats (MC), weeds (MC) and white mustard (MC) (Tables 8 and 9). Wild radish also became dominant in canola (MC), Caliente (MC) and weedsnem (MC) (Table 9). However, this species was totally suppressed in white mustard (CC), for the second consecutive season, and in Nemat (CC), with crab fingergrass becoming dominant in these treatments (Tables 8 and 9). In contrast to the previous season, crab fingergrass also dominated the weed spectrum in canola (CC), Caliente (CC) and weeds (CC) (Tables 8 and 9). It seems that the application of CC during grapevine bud break facilitated the dominance of crab fingergrass during grapevine berry set. No definite trend was observed for common dubbeltjie. This

 DOI: http://dx.doi.org/10.21548/38-2-1353

TABLE 6

Effect of soil cultivation practices on the spectrum of dominant winter growing weeds (species presenting 10% or more of the total spectrum of weeds present in any year of the study were selected) in a seven-year-old drip-irrigated Shiraz/101-14 Mgt vineyard established on a sandy to sandy clay loam soil, at the end of August 2013.

Treatment	Weed stand in g/0.5 m^2									
	Raphanus raphanistrum	*Oxalis pes-caprae*	*Erodium moschatum*	*Vicia species*	*Avena fatua*	*Rapistrum rigosum*	*Euphorbia peplus*	*Lolium species*	*Galinsoga parviflora*	Other
1. *Avena sativa* cv. Pallinup (oats), CC[1]	3.78	0	14.57	0	0	0	0	0	0	0.14
2. Oats, MC[2]	18.44	0.05	13.57	0	0	0.31	0	0	0	0.08
3. *Sinapis alba* cv. Braco (white mustard), CC	2.97	0.53	5.88	0	0	0	0.28	0	0.33	0.12
4. White mustard, MC	0.66	2.31	16.48	0	0	0.19	0.26	0.96	0.59	0.16
5. *Brassica napus* cv. AVJade (canola), CC	0.92	1.20	11.76	0	0.94	0	0	0.04	0.12	0.24
6. Canola, MC	28.83	2.58	3.23	0	0	0	0	1.96	3.12	0.21
7. *Brassica juncea* cv. Caliente 199 (Caliente), CC	0.30	0.98	13.14	0	0.33	0	0	1.49	0	0.11
8. Caliente, MC	3.50	3.76	8.93	0	0	0.36	0.22	2.94	0	0.27
9. *Eruca sativa* cv. Nemat (Nemat), CC	5.38	0.29	7.46	0	0	0.81	0	0	16.25	0.17
10. Nemat, MC	16.10	1.89	7.70	0	0.28	0.20	0	2.19	5.74	0.15
11. No cover crop (weeds), CC	0.12	7.26	76.93	0	20.58	0	0	1.33	21.55	0.42
12. Weeds, MC	1.28	6.17	34.95	0	25.79	0	0	4.95	0	0.54
13. Weeds + nematicide (weedsnem), CC	0.67	7.56	81.31	0	5.24	0	0	3.90	0.63	0.41
14. Weedsnem, MC	0.54	6.45	18.61	0	60.69	0	0	3.86	0	0.26
LSD (p = 0.05)	6.04									

[1] Full-surface chemical control from grapevine bud break. [2] Chemical control vine row, mechanical incorporation in work row during grapevine bud break, full-surface chemical control from berry set.

DOI: http://dx.doi.org/10.21548/38-2-1353

TABLE 7

Effect of soil cultivation practices on the spectrum of dominant weeds growing from grapevine bud break to berry set (species presenting 15% or more of the total spectrum of weeds present in any year of the study were selected) in a seven-year-old drip-irrigated Shiraz/101-14 Mgt vineyard established on a sandy to sandy clay loam soil, at the end of November 2009.

	Weed stand in g/0.5 m^2						
Treatment	*Tribulus terrestris*	*Amaranthus thunbergii*	*Digitaria sanguinalis*	*Raphanus raphanistrum*	*Erodium moschatum*	*Lolium species*	Other
1. *Avena sativa* cv. Pallinup (oats), CC[1]	0	0	0	2.53	8.67	0.87	3.49
2. Oats, MC[2]	0	0	0.53	4.33	40.13	1.93	2.62
3. *Sinapis alba* cv. Braco (white mustard), CC	2.23	14.53	4.43	11.17	16.40	5.60	3.68
4. White mustard, MC	0.20	0	0	5.07	15.63	0.23	2.58
5. *Brassica napus* cv. AVJade (canola), CC	0	0	0	1.67	23.53	35.57	2.53
6. Canola, MC	0	0	0.60	0.63	36.70	49.93	2.05
7. *Brassica juncea* cv. Caliente 199 (Caliente), CC	0	1.53	0	1.80	10.37	9.47	2.39
8. Caliente, MC	0.23	0	2.43	3.97	9.87	12.30	3.15
9. *Eruca sativa* cv. Nemat (Nemat), CC	0	0	0.20	2.07	5.70	11.33	2.95
10. Nemat, MC	0.23	0	0	2.07	10.03	3.27	2.24
11. No cover crop (weeds), CC	0	0	0	0.37	40.43	15.90	2.10
12. Weeds, MC	0.13	0	2.17	11.70	102.63	2.63	3.11
13. Weeds + nematicide (weedsnem), CC	2.17	0	0	6.37	33.20	5.70	1.79
14. Weedsnem, MC	0	0	0	27.07	157.87	16.27	1.62
LSD (p = 0.05)	15.30						

[1] Full-surface chemical control from grapevine bud break. [2] Chemical control vine row, mechanical incorporation in work row during grapevine bud break, full-surface chemical control from berry set.

DOI: http://dx.doi.org/10.21548/38-2-1353

TABLE 8

Effect of soil cultivation practices on the spectrum of dominant weeds growing from grapevine bud break to berry set (species presenting 15% or more of the total spectrum of weeds present in any year of the study were selected) in a seven-year-old drip-irrigated Shiraz/101-14 Mgt vineyard established on a sandy to sandy clay loam soil, at the end of November 2010.

	Weed stand in g/0.5 m^2						
Treatment	*Tribulus terrestris*	*Amaranthus thunbergii*	*Digitaria sanguinalis*	*Raphanus raphanistrum*	*Erodium moschatum*	*Lolium species*	Other
1. *Avena sativa* cv. Pallinup (oats), CC[1]	0.60	3.67	0.43	4.90	0	0	0.25
2. Oats, MC[2]	1.37	0	0.93	66.10	0	0.83	0.66
3. *Sinapis alba* cv. Braco (white mustard), CC	0.50	0.37	0.30	0.90	0.20	0.13	0.23
4. White mustard, MC	2.40	2.07	0.07	2.83	0	21.43	0.50
5. *Brassica napus* cv. AVJade (canola), CC	0.17	0.10	0.57	0	1.57	0	0.27
6. Canola, MC	0.93	0	0.50	10.13	0	60.53	1.73
7. *Brassica juncea* cv. Caliente 199 (Caliente), CC	20.17	0	0.10	0	0	0	0.35
8. Caliente, MC	13.30	0	1.80	2.67	0	19.30	1.05
9. *Eruca sativa* cv. Nemat (Nemat), CC	1.33	0	0.47	3.00	0.27	0	0.33
10. Nemat, MC	1.63	0.13	0.47	8.37	0	42.67	0.62
11. No cover crop (weeds), CC	1.07	0.63	0.40	7.90	1.73	0	0.83
12. Weeds, MC	0.27	0	0	13.53	0.10	10.27	1.66
13. Weeds + nematicide (weedsnem), CC	0	0	0.30	5.17	0	0.17	0.87
14. Weedsnem, MC	0.07	0	0	9.00	0.63	23.93	1.18
LSD (p = 0.05)	6.94						

[1] Full-surface chemical control from grapevine bud break. [2] Chemical control vine row, mechanical incorporation in work row during grapevine bud break, full-surface chemical control from berry set.

DOI: http://dx.doi.org/10.21548/38-2-1353

TABLE 9

Effect of soil cultivation practices on the spectrum of dominant weeds growing from grapevine bud break to berry set (species presenting 15% or more of the total spectrum of weeds present in any year of the study were selected) in a seven-year-old drip-irrigated Shiraz/101-14 Mgt vineyard established on a sandy to sandy clay loam soil, at the end of November 2011.

	Weed stand in g/0.5 m^2						
Treatment	*Tribulus terrestris*	*Amaranthus thunbergii*	*Digitaria sanguinalis*	*Raphanus raphanistrum*	*Erodium moschatum*	*Lolium species*	Other
1. *Avena sativa* cv. Pallinup (oats), CC[1]	1.49	0	0	0.42	0	0	0.04
2. Oats, MC[2]	1.30	0	0.15	52.55	0.43	0	0.26
3. *Sinapis alba* cv. Braco (white mustard), CC	0.48	0	7.01	0	0	0	0.17
4. White mustard, MC	0.19	0	0	0.49	0	2.77	0.05
5. *Brassica napus* cv. AVJade (canola), CC	0.20	0	1.91	0	0	0	0.02
6. Canola, MC	0	0	0.13	7.82	0	4.01	0.41
7. *Brassica juncea* cv. Caliente 199 (Caliente), CC	0.69	0	2.57	0.26	0	0	0.03
8. Caliente, MC	2.70	0	0	6.35	0	2.27	0.38
9. *Eruca sativa* cv. Nemat (Nemat), CC	0.10	0	15.04	0	0	0	0.18
10. Nemat, MC	0	0	1.57	3.81	0	5.75	0.30
11. No cover crop (weeds), CC	0.07	0	0.49	0.05	0	0	0.06
12. Weeds, MC	0	0	0	44.28	0	3.59	1.10
13. Weeds + nematicide (weedsnem), CC	0	0	0	0.29	0	0	0.28
14. Weedsnem, MC	0	0	0	16.66	0	3.67	1.41
LSD (p = 0.05)	5.26						

[1] Full-surface chemical control from grapevine bud break. [2] Chemical control vine row, mechanical incorporation in work row during grapevine bud break, full-surface chemical control from berry set.

DOI: http://dx.doi.org/10.21548/38-2-1353

TABLE 10

Effect of soil cultivation practices on the spectrum of dominant weeds growing from grapevine bud break to berry set (species presenting 15% or more of the total spectrum of weeds present in any year of the study were selected) in a seven-year-old drip-irrigated Shiraz/101-14 Mgt vineyard established on a sandy to sandy clay loam soil, at the end of November 2012.

	Weed stand in g/0.5 m^2						
Treatment	*Tribulus terrestris*	*Amaranthus thunbergii*	*Digitaria sanguinalis*	*Raphanus raphanistrum*	*Erodium moschatum*	*Lolium species*	Other
1. *Avena sativa* cv. Pallinup (oats), CC[1]	0	2.43	0	0	0	0	0.05
2. Oats, MC[2]	0	0.02	11.39	0.38	0.03	0	0.08
3. *Sinapis alba* cv. Braco (white mustard), CC	0.29	0	31.53	0	0	0.89	0.19
4. White mustard, MC	0	1.49	9.44	0	1.08	10.26	0.36
5. *Brassica napus* cv. AVJade (canola), CC	0	0.39	2.15	0	0	0.61	0.08
6. Canola, MC	10.55	0	7.88	4.67	0	43.59	0.54
7. *Brassica juncea* cv. Caliente 199 (Caliente), CC	0	0.81	7.63	0	0.86	0	0.11
8. Caliente, MC	3.48	0	28.04	6.14	0.79	10.36	0.60
9. *Eruca sativa* cv. Nemat (Nemat), CC	0.45	0	39.16	0	0	0	0.12
10. Nemat, MC	0	0	8.25	11.41	0	65.83	0.29
11. No cover crop (weeds), CC	0	0	1.53	0	0	1.59	0.13
12. Weeds, MC	0	0	3.15	20.30	2.31	2.52	0.76
13. Weeds + nematicide (weedsnem), CC	0	0	0	0	5.38	0	0.29
14. Weedsnem, MC	0	0	3.52	26.05	2.50	0	0.35
LSD (p = 0.05)	4.97						

[1] Full-surface chemical control from grapevine bud break. [2] Chemical control vine row, mechanical incorporation in work row during grapevine bud break, full-surface chemical control from berry set.

DOI: http://dx.doi.org/10.21548/38-2-1353

weed, however, became dominant in oats (CC) and was the next to dominant species in oats (MC), canola (CC), the two Caliente treatments and weeds (CC) (Table 9).

2012

Musk heron's bill regained dominance in weedsnem (CC) (Table 10). Ryegrass was suppressed totally for the third consecutive season in oats (CC), Caliente (CC) and Nemat (CC), as well as for the second consecutive season in oats (MC) and weedsnem (CC) (Tables 8 to 10). Although total control could not be achieved with white mustard (CC) and canola (CC), the ryegrass stand was significantly lower than that of the corresponding MC treatment (Table 10). The trend that occurred during 2010 and 2011 was once again observed for the third consecutive season (Tables 8 to 10). It therefore can be accepted that CC plays an important role in the control of ryegrass. Wild radish remained dominant in weeds (MC) and weedsnem (MC) (Tables 9 and 10). This species also remained next to dominant in oats (MC) and Nemat (MC). Wild radish, however, was totally suppressed in all the CC treatments (Table 10), this being the third consecutive season in canola (CC) and the second consecutive season in white mustard (CC) and Nemat (CC) (Tables 8 to 10). Total suppression of this species was also achieved with white mustard (MC) (Table 10). The dominance of crab fingergrass, which was first observed in the CC treatments of white mustard, canola, Caliente and Nemat at the end of November 2011 (grapevine berry set), was also observed at the end of November 2012 (Tables 9 and 10). This species also dominated oats (MC) and Caliente (MC) for the first time and was next to dominant in white mustard (MC), weeds (MC), weeds (CC) and weedsnem (MC).

CONCLUSIONS

Within one winter, ryegrass can be effectively suppressed by oats and white mustard. During the following two seasons, it was observed that post-emergence chemical control just before grapevine bud break played a major role in lowering the stand of ryegrass during the following season. Total suppression of ryegrass was achieved in the CC treatments of oats and Nemat in the third year of application. The dominance of ryegrass was terminated in 2012 (fourth season) by the application of a grass-specific herbicide approximately a fortnight after sowing the broadleaf cover crops (end of May). The chemical control of ryegrass most probably facilitated the dominance of musk heron's bill. The cover crops, which were established as late as 23 May during 2013, prevented the ryegrass from regaining its dominance in any treatment. After five winters, ryegrass was totally eradicated from oats (CC), oats (MC), white mustard (CC) and Nemat (CC).

During the first season of implementation, either musk heron's bill or ryegrass dominated the weed spectrum during grapevine berry set (early summer). Musk heron's bill was totally suppressed in all the treatments during berry set within two seasons. Ryegrass was suppressed totally during berry set in all the CC treatments by 2011. This trend persisted in the CC treatments of oats, Caliente and Nemat during 2012. It therefore can be accepted that CC plays an important role in the control of this problem weed from bud break to berry set. It seems that the application of CC facilitated the eventual dominance of crab fingergrass during grapevine berry set.

The elimination or suppression of one species led to the dominance of another. This supports previous studies indicating that soil cultivation practices cause changes in the weed population, as well as the view that certain species are adapted to survive intermittent habitat disturbances and will quickly fill the vacated niches.

The above-mentioned illustrates the importance of studies in which not only the weed stand in general is evaluated, but where the weed spectrum is also analysed to provide information on weed dominance and population shifts that is crucial to decision making concerning weed control in the medium to long term.

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