Effect of Cover Crops, and the Management Thereof, on the Weed Spectrum in a Drip-irrigated Vineyard: 2. Weeds Growing From Grapevine Berry Set to Post-harvest

J.C. Fourie[1*], E.C. Kunjeku[2], M. Booyse[3], T.G. Kutama[2], K. Freitag[1], C.H. Ochse[1]

(1) ARC Infruitec-Nietvoorbij, Private Bag X5026, Stellenbosch, 7599, South Africa
(2) Department of Plant Production, School of Agriculture, University of Venda, Private Bag X5050, Thohoyandou, 0950, South Africa
(3) ARC Biometry, Private Bag X5026, Stellenbosch, 7599, South Africa

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 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 weeds and cover crop species were either controlled chemically (CC) or mechanically (MC) during grapevine bud break, followed by full-surface chemical control during berry set (for both CC and MC treatments). *Rhynchelytrum repens* (Natal red-top) dominated the post-harvest pre-treatment weed spectrum in all the treatments except *Eruca sativa* cv. Nemat (Nemat) (MC). This species lost its post-harvest dominance from 2010 onwards. It seems that the relatively low summer rainfall during the 2010/2011 season allowed *Anagallis arvensis* to appear in April 2011 and dominate some of the treatments, which coincided with the disappearance of *Cynodon dactylon* (common couch) and *Polygonum aviculare* (prostrate knotweed). *Digitaria sanguinalis*, common couch and prostrate knotweed seemed to establish better during late summer where MC was applied. The pre-treatment average post-harvest weed stand of 5.53 t/ha was reduced to 0.53 t/ha within one season, illustrating the benefit of full-surface chemical weed control applied during grapevine berry set.

INTRODUCTION

Weed management systems create conditions under which certain species can flourish (Cousens & Mortimer, 1995). Shrestha *et al*. (2002) and Westra *et al*. (2008) found that soil cultivation practices cause changes in the weed population. Fourie *et al.* (2017) show that both the weed control mechanism applied during grapevine bud break, and the winter cover crop used, affect the weed spectrum of the winter-growing weeds and weed dominance from grapevine bud break to grapevine berry set. This supports the observations of Légère and Samson (1999), namely that species dominance is brought about by interactions between crop rotation, weed management intensity and tillage.

The aim of this study was to determine the effect of cover crops on the grapevine post-harvest weed spectrum and weed dominance when controlled chemically or incorporated mechanically into the topsoil during grapevine bud break, both followed by full-surface chemical weed control during grapevine berry set in a drip-irrigated vineyard.

MATERIALS AND METHODS

Experiment vineyard and layout

The trial was conducted for five consecutive years (2009 to 2013) in a full-bearing seven-year-old Shiraz/101-14 Mgt drip-irrigated vineyard established on a sandy (0 to 300 mm soil layer) to sandy clay loam (300 to 600 mm soil layer) soil at Blaauwklippen Farm (33°58'S, 18°50'E) near Stellenbosch in the Western Cape, South Africa (Fourie *et al*., 2015). Fourteen treatments (Table 1) consisting of two management practices applied to five cover crop species, as well as winter-growing weeds (no cover crop) and no cover crop with nematicide applied in the vine row, were applied. These treatments were replicated three times. Each replicate

**Corresponding author: E-mail address: fouriej@arc.agric.za*
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; D. Mashamba, V.R. Nyamande, L.W Sassman 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

TABLE 1
Treatments applied

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

[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.

(experimental unit) covered an area of 81 m². A work row and two vine rows functioned as a buffer zone between treatments in different work rows, and a buffer consisting of five vines was left between the experimental vines of treatment plots in the same vine row.

The cover crops were established as described by Fourie *et al*. (2015) and Fourie *et al*. (2017). Fertilisers were applied as described by Fourie *et al.* (2015). The cover crops were controlled just before grapevine bud break (first week of September). Two management practices were applied. One practice consisted of full-surface post-emergence 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) (Table 1). 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 herbicides used from bud break to berry set are discussed in Fourie *et al*. (2017). 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 having a negative impact 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 after harvest (beginning of April) just before seedbed preparation for the cover crops to evaluate weed dominance. The weeds were harvested (Fourie *et al*., 2017) and the DMP was determined (Fourie *et al*., 2001).

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 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 seasons (years). Dry matter production was measured randomly within each experiment plot at the beginning of April. The data were tested for normality (Shapiro & Wilk, 1965), found to be acceptably normally distributed, and were 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
2009
Replications were blocked to accommodate soil differences, and treatments were assigned randomly to plots within a block. During this pre-treatment measurement at the end of summer (post-harvest), *Rhynchelytrum repens* (Natal red-top), a perennial grass, was the dominant species in all the plots except those assigned to *Eruca sativa* cv. Nemat (Nemat) (MC), in which it was absent (Table 2). The *Conyza* species, problem broadleaf annuals, were present in all the plots and were next to dominant in the plots assigned to *Sinapis alba* cv. Braco (white mustard) (CC), *Brassica napus* cv. AVJade (canola) (CC), canola (MC), *Brassica juncea* cv.

 DOI: http://dx.doi.org/10.21548/38-2-1354

TABLE 2
The pre-treatment weed spectrum (species presenting 22% 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, as measured early April 2009.

	Weed stand in g/0.5 m²								
Treatment	*Conyza bonariensis*	*Tribulus terrestris*	*Digitaria sanguinalis*	*Rhynchelytrum repens*	*Cynodon dactylon*	*Polygonum aviculare*	*Boerhavia erecta*	*Anagallis arvensis*	Other
1. *Avena sativa* cv. Pallinup (oats), CC[1]	5.60	16.93	7.07	85.63	0.10	0.93	0	0	155.94
2. Oats, MC[2]	2.80	2.97	15.43	37.50	21.03	3.20	1.67	0	260.30
3. *Sinapis alba* cv. Braco (white mustard), CC	15.20	4.27	13.90	17.07	9.23	4.97	0.03	0	203.90
4. White mustard, MC	7.00	0.30	7.63	50.54	12.77	1.73	1.60	0	295.60
5. *Brassica napus* cv. AVJade (canola), CC	16.20	0	14.47	96.03	1.77	0.03	0	0	161.57
6. Canola, MC	47.43	5.27	0	66.23	5.33	2.27	1.07	0	200.10
7. *Brassica juncea* cv. Caliente 199 (Caliente), CC	14.60	50.10	9.97	96.97	5.90	0	0.03	0	106.80
8. Caliente, MC	18.97	0.83	6.57	66.17	12.20	2.37	0	0	105.03
9. *Eruca sativa* cv. Nemat (Nemat), CC	2.60	8.40	28.00	102.60	0	2.33	0	0	64.03
10. Nemat, MC	4.80	21.70	2.73	0	0	2.67	0.93	0	122.73
11. No cover crop (weeds), CC	13.93	7.87	3.07	109.43	7.40	2.07	0	0	127.80
12. Weeds, MC	0.73	4.20	0	194.57	4.47	0	5.97	0	83.13
13. Weeds + nematicide (weedsnem), CC	0.43	1.90	0	147.33	5.33	0	2.50	0	143.97
14. Weedsnem, MC	13.10	0.10	0	103.27	0.30	6.70	1.47	0	187.67
LSD ($p = 0.05$)	79.48								

[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/10.21548/38-2-1354

Caliente 199 (Caliente) (MC), Nemat (MC), no cover crop (weeds) (CC) and the weed treatment in which a nematicide (Rugby 10ME) was to be applied at 15 mL/m² to the vine row (weedsnem) (MC). With the exception of the plots allocated to canola (CC), *Tribulus terrestris* (common dubbeltjie) was found in all the plots and observed to be dominant in the plots assigned to Nemat (MC), and next to dominant in the plots assigned to *Avena sativa* cv. Pallinup (oats) (CC) and Caliente (CC). *Cynodon dactylon* (common couch), a perennial grass generally observed to be one of the problem weeds in the vineyards of South Africa, was present in all the plots, except those allocated to the two Nemat treatments. Common couch was found to be the next to dominant species in the plots allocated to oats (MC), white mustard (MC) and weedsnem (CC). *Digitaria sanguinalis* (crab fingergrass) was the next to dominant species in the plots allocated to oats (MC) and Nemat (CC), but absent in the plots allocated to canola (MC), weeds (MC), weedsnem (MC) and weedsnem (CC). Although *Polygonum aviculare* (prostrate knotweed) did not dominate any treatment, it was present in all the plots, with the exception of those allocated to Caliente (CC), weeds (MC) and weedsnem (CC). *Boerhavia erecta* (erect Boerhavia) was found in the plots allocated to nine of the 14 treatments and was next to dominant in the plots allocated to weeds (MC).

The high values of the 'other' species is an indication that a lot of species were found in these treatments that did not exceed the criteria of 22% or more of the total weed stand in any of the treatments during the study. The average total DMP of the weed stand at the end of summer in this drip-irrigated vineyard before the trial started was 5.53 t/ha pre-treatment. This is relatively high compared to the summer weed stands reported by Fourie (2005), Fourie *et al*. (2005; 2006) and Fourie (2010) in vineyards irrigated with micro-sprinklers.

2010

At the end of the first season during which the different treatments were applied, Natal red-top lost its dominance in all the treatments, except in weedsnem (CC) (Tables 2 and 3). It appeared in Nemat (MC) for the first time and was totally controlled in white mustard (MC) (Table 3). The Conyza species dominated the CC treatments of oats, white mustard, canola and Nemat, whilst becoming the next to dominant species in oats (MC), white mustard (MC) and Caliente (CC). It also remained the next to dominant species in Caliente (MC) and Nemat (MC). Common dubbeltjie was absent in canola (CC) for the second consecutive season and disappeared from Nemat (MC), after dominating this treatment (Tables 2 and 3). However, this species became dominant in weeds (CC) and weedsnem (MC) (Table 3). Common couch became the dominant species in white mustard (MC) and the two Caliente treatments, while becoming the next to dominant species in the two canola treatments. The species disappeared from white mustard (CC), Nemat (MC) and weedsnem (CC). Crab fingergrass was observed in all the treatments except weeds (CC), and became dominant in the MC treatments of canola, Nemat and weeds. In weeds (MC), the stand of crab fingergrass was higher than that of the other weeds (Table 3), its dominance realising from a total absence during the previous season (Table 2). Crab fingergrass became the next to dominant species in white mustard (CC) (Table 3). Prostrate knotweed disappeared from all the treatments, except the CC treatments of oats and Caliente. Erect Boerhavia was observed in all the treatments, except Caliente (MC) and Nemat (CC), and was the next to dominant species in weedsnem (MC). Erect Boerhavia became the dominant species in oats (MC), with its stand being higher than that of all the other weeds.

The average total DMP of the weed stand measured post-harvest was 0.53 t/ha, which is only 9.58% of the weed stand measured post-harvest during 2009 (5.53 t/ha). This clearly illustrates the benefit of the weed control applied just before grapevine bud break and during grapevine berry set.

2011

Although Natal red-top was present in all the treatments, it did not dominate in any (Table 4). The *Conyza* species remained dominant in oats (CC) and became dominant in oats (MC) (Tables 3 and 4). It also remained the next to dominant species in Caliente (MC), and was observed to be the second most dominant in canola (MC), Nemat (CC) and weeds (MC) as well. Common dubbeltjie remained dominant in weeds (CC). This species, however, remained absent from Nemat (MC) and disappeared from canola (MC), Caliente (CC) and weedsnem (MC). Common couch disappeared from the nine treatments in which it was observed during April 2010. Although crab fingergrass remained absent in weeds (CC) and disappeared from weedsnem (CC) (Tables 3 and 4), it dominated the two treatments of white mustard, Caliente and Nemat, as well as the MC treatments of canola, weeds and weedsnem (Table 4). All the MC treatments were dominated by crab fingergrass, with the exception of oats (MC), in which it was the next to dominant species. Prostrate knotweed disappeared from the two treatments in which it was observed during April 2010 (Tables 3 and 4). Although erect Boerhavia was the next to dominant species in weeds (CC) and weedsnem (CC), it was not observed in oats (CC), white mustard (CC), canola (CC), Caliente (MC), Caliente (CC) and Nemat (CC) (Table 4). This is an indication that the mulch of the cover crops used in the trial did help to suppress this species effectively. *Anagallis arvensis* (pimpernel) appeared in all the treatments for the first time and dominated canola (CC) and weedsnem (CC) within one season. Pimpernel also became the next to dominant species in white mustard (MC), Caliente (CC), Nemat (MC) and weedsnem (MC).

The average total DMP of the weed stand measured post-harvest was 0.83 t/ha, which is approximately the same as that measured during 2010 (0.53 t/ha) and only 15% of the weed stand measured post-harvest during 2009 (5.53 t/ha). This confirms the benefit of the weed control applied just before grapevine bud break and during grapevine berry set to reduce the post-harvest weed stand.

2012

Natal red-top dominated oats (MC), but disappeared from white mustard (CC), white mustard (MC), canola (CC), weeds (MC) and weedsnem (MC) (Table 5). In contrast to the previous season, the *Conyza* species did not dominate

 DOI: http://dx.doi.org/10.21548/38-2-1354

TABLE 3
The effect of soil cultivation practices on the weed spectrum (species presenting 22% 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, as measured early April 2010.

	Weed stand in g/0.5 m^2								
Treatment	*Conyza bonariensis*	*Tribulus terrestris*	*Digitaria sanguinalis*	*Rhynchelytrum repens*	*Cynodon dactylon*	*Polygonum aviculare*	*Boerhavia erecta*	*Anagallis arvensis*	Other
1. *Avena sativa* cv. Pallinup (oats), CC[1]	9.13	1.97	0.37	0.17	0.10	0.03	0.23	0	9.30
2. Oats, MC[2]	3.87	1.73	3.30	2.07	2.23	0	20.10	0	17.97
3. *Sinapis alba* cv. Braco (white mustard), CC	7.73	0.03	1.73	0.60	0	0	0.03	0	5.00
4. White mustard, MC	2.63	0.23	0.73	0	11.37	0	0.50	0	3.47
5. *Brassica napus* cv. AVJade (canola), CC	7.00	0	0.03	2.63	5.33	0	3.40	0	5.20
6. Canola, MC	2.07	0.07	10.00	7.77	8.47	0	0.53	0	1.30
7. *Brassica juncea* cv. Caliente 199 (Caliente), CC	8.50	0.13	0.20	6.67	16.07	0.43	0.13	0	1.70
8. Caliente, MC	5.87	0.73	0.97	2.67	11.23	0	0	0	2.80
9. *Eruca sativa* cv. Nemat (Nemat), CC	11.30	2.47	1.67	0.60	0.03	0	0	0	2.00
10. Nemat, MC	4.00	0	7.67	1.33	0	0	0.13	0	3.87
11. No cover crop (weeds), CC	0.03	5.53	0	3.83	3.23	0	1.10	0	4.87
12. Weeds, MC	0.30	2.13	22.27	7.60	4.20	0	0.80	0	6.97
13. Weeds + nematicide (weedsnem), CC	0.43	0.87	0.03	2.97	0	0	0.47	0	6.30
14. Weedsnem, MC	0	18.70	4.13	1.47	1.97	0	4.53	0	11.97
LSD ($p = 0.05$)	11.75								

[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/10.21548/38-2-1354

TABLE 4
The effect of soil cultivation practices on the weed spectrum (species presenting 22% 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, as measured early April 2011.

	Weed stand in g/0.5 m^2								
Treatment	*Conyza bonariensis*	*Tribulus terrestris*	*Digitaria sanguinalis*	*Rhynchelytrum repens*	*Cynodon dactylon*	*Polygonum aviculare*	*Boerhavia erecta*	*Anagallis arvensis*	Other
1. *Avena sativa* cv. Pallinup (oats), CC[1]	1.27	0.57	0.03	0.19	0	0	0	0.67	0.35
2. Oats, MC[2]	16.13	0.13	12.96	0.15	0	0	0.17	1.56	5.64
3. *Sinapis alba* cv. Braco (white mustard), CC	2.77	0.10	24.15	2.94	0	0	0	0.67	0.13
4. White mustard, MC	0.13	3.31	11.26	2.65	0	0	0.28	9.41	2.31
5. *Brassica napus* cv. AVJade (canola), CC	0	0.23	0.09	0.33	0	0	0	9.20	0.90
6. Canola, MC	21.67	0	37.79	6.17	0	0	7.63	3.04	1.30
7. *Brassica juncea* cv. Caliente 199 (Caliente), CC	2.93	0	54.89	2.84	0	0	0	8.07	7.43
8. Caliente, MC	7.37	0.07	20.18	1.68	0	0	0	5.20	3.37
9. *Eruca sativa* cv. Nemat (Nemat), CC	12.23	0.03	25.09	1.73	0	0	0	5.93	0.07
10. Nemat, MC	1.17	0	10.20	0.30	0	0	5.46	9.20	0.94
11. No cover crop (weeds), CC	12.30	36.43	0	0.37	0	0	18.79	6.17	0.20
12. Weeds, MC	10.78	0.03	49.69	10.23	0	0	0.15	1.85	4.67
13. Weeds + nematicide (weedsnem), CC	0.17	1.23	0	0.27	0	0	3.06	6.80	1.19
14. Weedsnem, MC	3.41	0	21.81	0.32	0	0	0.13	10.94	3.16
LSD ($p = 0.05$)	21.39								

[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/10.21548/38-2-1354

TABLE 5
The effect of soil cultivation practices on the weed spectrum (species presenting 22% 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, as measured early April 2012.

	Weed stand in g/0.5 m^2								
Treatment	*Conyza bonariensis*	*Tribulus terrestris*	*Digitaria sanguinalis*	*Rhynchelytrum repens*	*Cynodon dactylon*	*Polygonum aviculare*	*Boerhavia erecta*	*Anagallis arvensis*	Other
1. *Avena sativa* cv. Pallinup (oats), CC[1]	0	19.78	9.36	0.39	0	1.10	0	0	5.10
2. Oats, MC[2]	0	3.50	13.98	14.34	0	0.44	0	0	137.90
3. *Sinapis alba* cv. Braco (white mustard), CC	0	0	91.32	0	1.05	1.89	0	0	7.94
4. White mustard, MC	0	14.20	41.74	0	1.02	8.22	0	0	12.94
5. *Brassica napus* cv. AVJade (canola), CC	0	20.98	47.61	0	45.29	0	0	0	6.65
6. Canola, MC	0	15.19	5.72	1.10	1.52	0	0	0	8.07
7. *Brassica juncea* cv. Caliente 199 (Caliente), CC	2.92	0	12.15	4.97	17.16	16.66	0	0	4.99
8. Caliente, MC	0.88	0.34	27.49	0.88	38.59	0	0	0	52.81
9. *Eruca sativa* cv. Nemat (Nemat), CC	0.42	1.15	39.05	4.65	13.60	2.66	0	0	21.28
10. Nemat, MC	0	1.53	10.07	1.27	57.23	0.36	0	0	7.16
11. No cover crop (weeds), CC	0.33	41.36	0	0.90	0	0	0	0	33.31
12. Weeds, MC	1.97	1.10	12.62	0	42.18	2.45	0	0	19.84
13. Weeds + nematicide (weedsnem), CC	0.36	0.53	0	6.69	41.61	1.00	0	0	39.42
14. Weedsnem, MC	5.58	1.77	1.97	0	41.40	0	0	0	39.96
LSD ($p = 0.05$)	34.42								

[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/10.21548/38-2-1354

any of the treatments (Tables 4 and 5). This species remained absent in canola (CC) and disappeared from the oats and white mustard treatments, as well as canola (MC) and Nemat (MC). Common dubbeltjie remained the dominant species in weeds (CC) for the third consecutive season (Tables 3, 4 and 5), started to dominate oats (CC) and canola (MC), and became next to dominant in white mustard (MC). This species remained absent from Caliente (CC) and disappeared from white mustard (CC) (Tables 4 and 5). In contrast to the 2011 season, common couch re-appeared and dominated Caliente (CC), Caliente (MC), Nemat (MC), weeds (MC), weedsnem (CC) and weedsnem (MC). However, it remained fully suppressed in oats (CC), oats (MC) and weeds (CC). Crab fingergrass remained absent in weeds (CC) for the third consecutive season (Tables 3, 4 and 5) and in weedsnem (CC) for the second consecutive season (Tables 4 and 5). This species remained dominant in the two white mustard treatments and Nemat (CC) (Tables 4 and 5), while becoming dominant in canola (CC) (Table 5). Crab fingergrass was also next to dominant in oats (CC), oats (MC), canola (MC), Caliente (MC), Nemat (MC) and weeds (MC) (Table 5). Although the trend was not as clear as during the 2011 season, it seemed that it was easier for crab fingergrass to establish itself in the MC treatments with no summer mulch (Tables 4 and 5). Prostrate knotweed re-appeared in the oats, white mustard and Nemat treatments, as well as in Caliente (CC), weeds (MC) and weedsnem (CC) (Table 5). With the exception of being the next to dominant species in Caliente (CC) and white mustard (CC), prostrate knotweed did not dominate any of the treatments in which it re-appeared. Both erect Boerhavia and pimpernel were not observed in any of the treatments.

The average total DMP of the weed stand measured post-harvest was 1.74 t/ha, which is approximately double the stand of 0.83 t/ha measured during 2011. The observed increase is attributed to the summer rainfall (September to March) being higher during the 2011/2012 season than during the 2010/2011 season (Table 6). This is an indication that weed control in the period from berry set to post-harvest should be considered, especially if the summer rainfall is relatively high.

2013

Natal red-top was observed in all the treatments, with the exception of oats (CC), but the species did not dominate in any of the treatments (Table 7). This was similar to the trend observed during 2011 (Table 4). As during the pre-treatment period (April 2009), the *Conyza* species were present in all the treatments during this season, but did not dominate in any of them (Table 7). Common dubbeltjie was observed in all the treatments for the first time and dominated the most treatments since the inception of the trial (Tables 2 to 5 and 7). It dominated oats (CC and MC), canola (CC and MC), Caliente (CC and MC), weeds (CC) and weedsnem (CC) (Table 7), while remaining next to dominant in white mustard (MC) (Tables 5 and 7). In contrast to the previous seasons, crab fingergrass was present in all the treatments (Tables 2 to 5 and 7). It remained dominant in white mustard (CC) and Nemat (CC). It was next to dominant in Nemat (MC) for the third consecutive season (Tables 4, 5 and 7). Crab fingergrass was also the next to dominant species in oats (CC), canola (CC) and Caliente (CC) (Table 7). Although common couch was observed in all the treatments except oats (CC), the species lost its dominance in the CC treatments of canola, Caliente and weedsnem (Tables 5 and 7). However, the species did become next to dominant in Nemat (CC), remained dominant in weeds (MC) and weedsnem (MC), and remained next to dominant in Caliente (MC). A trend was observed in which common couch seemed to establish better during late summer where mechanical cultivation was applied during grapevine bud break (MC), thereby leaving the soil mulch-free during the summer. Prostrate knotweed disappeared from oats (CC) and weedsnem (CC) and remained absent from weeds (CC). This species, however, started to dominate white mustard (MC) and Nemat (MC), and became next to dominant in oats (MC) and white mustard (CC) (Table 7). As in the case of common couch, a trend was observed in which prostrate knotweed seemed to establish better during late summer where MC was applied, leaving the soil bare. As observed during the 2012 season, both erect Boerhavia and pimpernel were not observed in any of the treatments (Tables 5 and 7).

The average total DMP of the weed stand measured post-harvest was 1.82 t/ha, which is again approximately double the stand of 0.83 t/ha measured during 2011. The observed increase is once again attributed to summer rainfall being higher during the 2012/2013 season than during the 2010/2011 season (Table 6). This confirms that weed control in the period from grapevine berry set to post-harvest should be considered, especially if the rainfall from December to March is relatively high.

It seems that the relatively low summer rainfall during the 2010/2011 season compared to that of the 2009/2010, 2011/2012 and 2012/2013 seasons (Table 6) allowed

TABLE 6
The seasonal rainfall as measured at a weather station near the trial site.

	Seasonal rainfall (mm)			
Treatment phase	2009/2010	2010/2011	2011/2012	2012/2013
April to August	456	414	404	595
September to November	281	132	142	247
December to March	53	42	90	104[1]
Total	790	588	636	946[1]

[1] Does not include the rainfall from 19 to 31 March.

 DOI: http://dx.doi.org/10.21548/38-2-1354

TABLE 7
The effect of soil cultivation practices on the weed spectrum (species presenting 22% 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, as measured early April 2013.

	Weed stand in g/0.5 m²								
Treatment	*Conyza bonariensis*	*Tribulus terrestris*	*Digitaria sanguinalis*	*Rhynchelytrum repens*	*Cynodon dactylon*	*Polygonum aviculare*	*Boerhavia erecta*	*Anagallis arvensis*	Other
1. *Avena sativa* cv. Pallinup (oats), CC[1]	2.68	19.46	3.93	0	0	0	0	0	26.55
2. Oats, MC[2]	3.32	33.38	16.05	0.14	13.71	23.16	0	0	21.97
3. *Sinapis alba* cv. Braco (white mustard), CC	3.11	2.02	19.38	1.78	2.51	10.63	0	0	25.31
4. White mustard, MC	4.69	23.09	4.55	0.82	5.40	53.72	0	0	33.66
5. *Brassica napus* cv. AVJade (canola), CC	0.86	22.58	10.60	4.08	1.52	1.16	0	0	34.66
6. Canola, MC	8.48	19.91	2.65	0.27	18.81	12.05	0	0	23.22
7. *Brassica juncea* cv. Caliente 199 (Caliente), CC	6.30	44.35	21.52	2.30	1.13	0.53	0	0	11.08
8. Caliente, MC	5.91	47.78	11.04	0.69	27.34	17.24	0	0	11.91
9. *Eruca sativa* cv. Nemat (Nemat), CC	6.64	5.27	28.78	1.28	8.32	2.06	0	0	29.87
10. Nemat, MC	10.29	3.78	18.80	11.28	4.66	25.53	0	0	10.33
11. No cover crop (weeds), CC	1.20	21.59	6.30	3.19	14.45	0	0	0	19.96
12. Weeds, MC	8.25	0.27	7.69	7.91	102.52	0.32	0	0	13.65
13. Weeds + nematicide (weedsnem), CC	7.99	12.80	3.13	1.95	4.11	0	0	0	27.89
14. Weedsnem, MC	2.99	6.33	6.14	7.86	71.38	4.60	0	0	20.67
LSD ($p \leq 0.05$)	27.03								

[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/10.21548/38-2-1354

pimpernel to appear in April 2011 and dominate some of the treatments (Table 4). This coincided with the disappearance of common couch and prostrate knotweed, which did not cope well with the drier summer. The relatively high summer rainfall during the 2011/2012 and 2012/2013 seasons (Table 6) seemed to allow these two perennials to recover and dominate in some of the treatments (Tables 5 and 7).

CONCLUSIONS

During the pre-treatment measurement at the end of summer 2009 (post-harvest), Natal red-top, a perennial grass, was the dominant species in all the treatments except Nemat (MC), in which it was absent. This species lost its post-harvest dominance once the treatments were applied. The mulch of the cover crops used in the trial did help to suppress erect Boerhavia effectively in April 2011. It seems that the relatively low summer rainfall during the 2010/2011 season compared to that of the 2009/2010, 2011/2012 and 2012/2013 seasons allowed pimpernel to appear in April 2011 and dominate some of the treatments. This coincided with the disappearance of common couch and prostrate knotweed, which did not cope well with the drier summer. The relatively high summer rainfall during the 2011/2012 and 2012/2013 seasons seemed to allow these two perennials to recover and dominate in some of the treatments. A trend was observed in which crab fingergrass, common couch and prostrate knotweed seemed to establish better during late summer where mechanical cultivation was applied during bud break (MC), thereby leaving the soil mulch-free during the summer. The average weed stand being reduced to less than 10% of the stand before the treatments were applied illustrates the benefit of full-surface chemical weed control applied during grapevine berry set. The doubling of the grapevine post-harvest weed stand from 2011 to 2013, despite full-surface weed control applied during grapevine bud break and berry set, is an indication that weed control in the period from berry set to post-harvest should be considered if the summer rainfall is relatively high.

This study confirmed the importance of not only determining the weed stand in general, but analysing the weed spectrum during different stages of the grapevine growing season. This will provide information on weed dominance and weed population shifts that can be used for decision making concerning weed control in the medium to long term.

LITERATURE CITED

Cousens, R. & Mortimer, M., 1995 (1st ed). Dynamics of weed populations. Cambridge University Press, Cambridge.

Fourie, J.C., 2005. Cover crop management in the vineyards of the Lower Orange River region, South Africa: 1. Performance of grass and broadleaf species. S. Afr. J. Enol. Vitic. 26, 140-146.

Fourie, J.C., 2010. Soil management in the Breede River Valley wine grape region, South Africa. 1. Cover crop performance and weed control. S. Afr. J. Enol. Vitic. 31, 14-21.

Fourie, J.C., Kruger, D.H.M. & Malan, A.P., 2015. Effect of management practices applied to cover crops with bio-fumigation properties on cover crop performance and weed control in a vineyard. S. Afr. J. Enol. Vitic. 36, 146-153.

Fourie, J.C., Kunjeku, E.C., Booyse, M., Kutama, T.G., & Sassman, L.W., 2017. 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. S. Afr. J. Enol. Vitic. 38, 167-181.

Fourie, J.C., Louw, P.J.E. & Agenbag, G.A., 2001. Effect of seeding date on the performance of grasses and broadleaf species evaluated for cover crop management in two wine grape regions of South Africa. S. Afr. J. Plant Soil 18, 118-127.

Fourie, J.C., Louw, P.J.E. & Agenbag, G.A., 2005. Cover crop management in a Sauvignon blanc/Ramsey vineyard in the semi-arid Olifants River Valley, South Africa. 1. Effect of management practices on selected grass and broadleaf species. S. Afr. J. Enol. Vitic. 26, 131-139.

Fourie, J.C., Louw, P.J.E. & Agenbag, G.A., 2006. Cover crop management in a Chardonnay/99 Richter vineyard in the Coastal wine grape region, South Africa. 1. Effect of two management practices on selected grasses and broadleaf species. S. Afr. J. Enol. Vitic. 27, 167-177.

Légère, A. & Samson, D.N., 1999. Relative influence of crop rotation, tillage and weed management on weed associations in spring barley cropping systems. Weed Sci. 47, 112-122.

Ott, R.L. & Longnecker M. 2001 (5th ed). An introduction to statistical methods and data analysis. Belmont, CA: Duxbury Press.

Shapiro, S.S. & Wilk, M.B., 1965. An analysis of variance test for normality (complete samples). Biometrika 52, 591-611.

Shrestha, A., Knezevic, S.Z., Roy, R.C. & Ball-Coelho, B.R., 2002. Effect of tillage, cover crop and crop rotation on the composition of weed flora in a sandy soil. Weed Res. 42, 76-87.

Westra, P., Wilson, R.G., Miller, S.D., Stahlman, P.W., Wicks, G.W., Chapman, P.L., Withrow, J., Legg, D., Alford, C. & Gaines, T.A., 2008. Weed population dynamics after six years under glyphosate- and conventional herbicide-based weed control strategies. Crop Sci. 48, 1170-1177.