Cover crop management in the vineyards of the Lower Orange River region, South Africa: 1. Performance of grass and broadleaf species

J.C. Fourie

ARC Infruitec-Nietvoorbij*, Private Bag X5026, Stellenbosch, 7599 Republic of South Africa

Submitted for publication: December 2004

Accepted for publication: October 2005

Key words: Cover crops, water requirements, re-establishment, management practices, weed control, grapevines

This trial was conducted over a period of four years on a sandy soil in a Sultanina vineyard on own roots in Keimoes (28°40'S, 20°54'E), situated in the semi-arid Lower Orange River region. Eighteen treatments, consisting of three cover crop management practices applied selectively to ten cover crop species, as well as two treatments in which the weeds were managed in accordance with two management practices generally applied by producers in the region, were applied. The average dry matter production (DMP) of the cover crop species sown annually (SA) and controlled chemically before bud break (BB), as determined during bud break (beginning of August) was: *Medicago truncatula* Gaertn. v. Paraggio > *Vicia dasycarpa* Ten. (grazing vetch) > *Secale cereale* L. v. Henog (rye) > *Ornithopus sativus* L. v. Emena > *Avena sativa* L. v. Overberg > *Lolium multiflorum* Lam. v. Midmar ('Midmar' ryegrass) > *Avena strigosa* L. v. Saia ('Saia' oats) > *Trifolium subterraneum* L. v. Woogenellup. 'Midmar' ryegrass and grazing vetch re-established successfully. Winter growing weeds were effectively suppressed (weed stand less than 10% of that of the control) by rye (BB/SA) and 'Saia' oats (BB/SA) for the duration of the trial. Weed growth from véraison to harvest (mid-November to the end of December) was effectively reduced in all the annual cover crop treatments compared with the treatment in which the weeds were controlled mechanically from bud break during the 1997/98 season. *Festuca arundinaceae* L. v. Cochise, slashed regularly throughout the season, suppressed the winter and summer growing weeds effectively during the trial, but eventually got infested with common couch.

The maintenance and improvement of soil quality is critical to sustaining agricultural productivity and environmental quality for future generations (Reeves, 1997). In this respect the use of cover crops has many advantages (Van Huyssteen *et al*., 1984; Khan *et al*., 1986, Radcliffe *et al.*, 1988; Roth *et al*., 1988; Louw & Bennie, 1992; Buckerfield & Webster, 1996). The number of weed species resistant to herbicides used in agriculture is increasing (LeBaron, 1991; Anonymous, 1997; Henkes, 1997). Cover cropping is a non-specific, biological method of weed control (Van Huyssteen *et al*., 1984). A selection of species suitable for cover crop management in the different grapevine regions is required to apply this environment-friendly practice in a sustainable manner, as part of an integrated production strategy (Fourie *et al*., 2001). Fourie *et al*. (2001) indicated that *Secale cereale* L. (rye), two Avena (oat) species, *Triticale* v. Usgen 18 (triticale), four Trifolium subterraneum (subterranean clover) species, four *Medicago* (medic) species, three *Vicia* (vetch) species and *Ornitopus sativus* L. v. Emena (pink Seradella) could be considered for cover crop management on the sandy soils of the warm and semi-arid Olifants River Valley in the winter rainfall region of South Africa. Although the long-term average annual rainfall of Lutzville (139 mm) in the Olifants River Valley is less than that of Keimoes (155 mm), situated in the Lower Orange River (summer rainfall region of South Africa), the average rainfall during the winter months (March to August) exceeds that of Keimoes by 29 mm. The average daily temperature in Lutzville is lower than that of Keimoes from March to April (on average 21.1°C and 21.3°C, respectively) and higher from May to July (on average 15.9°C and 12.5°C, respectively). It is, therefore, important to determine which of the above-mentioned cover crops would perform well under the edaphic conditions of the Lower Orange River.

This study was conducted to determine the suitability of selected species for cover crop management on the sandy soils adjacent to the flood plain of the Orange River under the edaphic conditions of the semi-arid Lower Orange River. The effect of three cover crop management practices on the weed control efficacy of these species was also investigated.

MATERIALS AND METHODS

The trial was conducted in an own-rooted Sultanina vineyard trained on a gable trellis system (Archer & Booysen, 1987) and established on a sandy soil at the farm Boomplaas in Keimoes (Table 1). The vines were spaced 2.25 m in the row and 3.25 m between rows. The soil was analysed for pH (1.0 M KCl), P and K (Bray no. 2), exchangeable cations, namely K, Ca, Mg and Na (extracted with 0.2 M ammonium acetate) and organic matter (The Non-affiliated Soil Analysis Work Committee, 1990). Keimoes (28°40'S, 20°54'E) is situated in the semi-arid Lower

E-mail address: FourieJ@arc.agric.za

**The Fruit, Vine and Wine Research Institute of the Agricultural Research Council.*

Acknowledgements: The author thanks the ARC and the Deciduous Fruit Producers' Trust for financial support, and the staff of the Soil Science Section of ARC Infruitec-Nietvoorbij for technical support.

Orange River region of the Northern Cape Province of South Africa, which receives an average annual rainfall of 155 mm.

Sixteen treatments, consisting of four annual grass species and four annual broadleaf species managed in accordance with two cover crop management practices (Table 2), as well as two treatments in which a perennial grass species was slashed during the growing season of the vines, were included in the trial. These treatments were compared with two treatments in which the weeds were managed in accordance with two management practices generally applied by producers in the region (Table 3). The different weed control actions were executed four times during the growing season of the grapevines, namely in the first week of August (just before bud break), in the first week of October (flowering), at véraison and in mid-February (seedbed preparation, annual cover crops).

The cover crops were sown on 28 March 1995 and during the second week of March in the following seasons. The annual species were sown at seeding rates recommended by Fourie *et al*. (2001) and the perennial species at 2.5 times the seed rates recommended for grazing crops (Table 2). Seedbed preparation was done with a spade plough. After sowing manually, the seeds were covered using a cultivator. The grass species received 28 kg N per hectare at the two-to-four-leaf growing stage, as proposed by Van Huyssteen & Van Zyl (1984). During the 1995/96 and 1996/97

TABLE 1

Analyses of the sandy soil in Keimoes determined before the treatments commenced (sampled 27 March 1995).

Soil depth (mm)	Clay (%)	Silt (%)	Sand (%)	pH (KCl)	Organic C (%)	P (mg/kg)	K (mg/kg)	Exchangeable cations (cmol(+)/kg)			
								Ca	Mg	K	Na
0-300	4.33	4.75	90.92	7.2	0.14	43.57	148	6.22	1.91	0.38	0.18
300-600	4.66	4.95	90.39	7.2	0.09	18.83	126	13.66	1.69	0.32	0.21

TABLE 2

The dry matter production (DMP) of cover crop species established on a sandy soil and managed according to different cover crop management practices, as measured before bud break in a Sultanina vineyard trained on a gable trellis system.

Treatment	Seeding density (kg/ha)	DMP (t/ha)				
		1995	1996	1997	1998	Average
Secale cereale L. v. Henog (rye), BB[1], SA[2]	100	3.53	2.75	4.28	3.22	3.45
Secale cereale, L. v. Henog (rye), AV[3], SB[4]	100	4.29	0.47	3.84	0.01	2.15
Avena sativa L. v. Overberg ('Overberg' oats), BB, SA	100	2.21	1.14	5.61	2.05	2.75
Avena sativa L. v. Overberg ('Overberg' oats), AV, SB	100	3.47	0.25	5.49	0.49	2.43
Avena strigosa L. v. Saia ('Saia' oats), BB, SA	100	2.19	1.09	4.15	2.36	2.45
Avena strigosa L. v. Saia ('Saia' oats), AV, SB	100	2.94	0.29	4.96	0.56	2.19
Lolium multiflorum Lam. v. Midmar ('Midmar' ryegrass), BB, SA	40	2.24	2.12	4.20	1.35	2.48
Lolium multiflorum Lam. v. Midmar ('Midmar' ryegrass), AV, SI[5]	40	2.43	2.28	3.17	0.64	2.13
Vicia dasycarpa Ten. (grazing vetch), BB, SA	50	3.99	3.73	3.58	2.91	3.55
Vicia dasycarpa Ten. (grazing vetch), AV, SI	50	3.50	3.86	2.90	1.84	3.03
Trifolium subterraneum L. v. Woogenellup ('Woogenellup' subterranean clover), BB, SA	35	0.82	1.90	3.60	2.95	2.32
Trifolium subterraneum L. v. Woogenellup ('Woogenellup' subterranean clover), AV, SB	35	0.41	0.85	1.77	2.93	1.49
Medicago truncatula Gaertn. v. Paraggio ('Paraggio' medic), BB, SA	25	3.24	3.23	5.25	3.25	3.74
Medicago truncatula Gaertn. v. Paraggio ('Paraggio' medic), AV, SB	25	2.95	2.63	7.18	2.57	3.83
Ornithopus sativus L.v. Emena (pink Seradella), BB, SA	25	1.88	2.22	5.29	4.01	3.35
Ornithopus sativus L. v. Emena (pink Seradella), AV, SB	25	2.01	0	3.87	1.06	1.74
LSD ($p \leq 0.05$)		1.97	1.78	2.15	1.64	1.04

[1]BB = controlled chemically before bud break and thereafter.
[2]SA = sown annually.
[3]AV = controlled chemically after véraison.
[4]SB = sown biennially.
[5]SI = sown initially.

TABLE 3

The effect of cover crop species established on a sandy soil and managed according to different cover crop management practices, on the dry matter production (DMP) of the winter growing weeds, as measured before bud break in a Sultanina vineyard trained on a gable trellis system.

Treatment	DMP (t/ha)			
	1996	1997	1998	Average
Secale cereale L. v. Henog (rye), BB[1], SA[2]	0.02	0.03	0.04	0.20
Secale cereale L. v. Henog (rye), AV[3], SB[4]	0.05	1.00	0.33	2.74
Avena sativa L. v. Overberg ('Overberg' oats), BB, SA	0.01	0.69	0.06	0.02
Avena sativa L. v. Overberg ('Overberg' oats), AV, SB	0	1.66	0.22	1.86
Avena strigosa L. v. Saia ('Saia' oats), BB, SA	0	0.08	0.02	0.03
Avena strigosa L. v. Saia ('Saia' oats), AV, SB	0.02	1.55	0.03	2.12
Lolium multiflorum Lam. v. Midmar ('Midmar' ryegrass), BB, SA	0.01	0.38	0.05	0.34
Lolium multiflorum Lam. v. Midmar ('Midmar' ryegrass), AV, SI[5]	0.09	0.54	0.69	1.62
Vicia dasycarpa Ten. (grazing vetch), BB, SA	0.02	0.02	0.02	0.70
Vicia dasycarpa Ten (grazing vetch), AV, SI	0.16	0.17	1.18	0.84
Trifolium subterraneum L. v. Woogenellup ('Woogenellup' subterranean clover), BB, SA	0.71	0.09	0.03	0.54
Trifolium subterraneum L. v. Woogenellup ('Woogenellup' subterranean clover), AV, SB	0.67	3.31	1.40	1.80
Medicago truncatula Gaertn. v. Paraggio ('Paraggio' medic), BB, SA	0.09	0.11	0.03	0.42
Medicago truncatula Gaertn. v. Paraggio ('Paraggio' medic), AV, SB	0.01	0.60	0.02	0.77
Ornithopus sativus L. v. Emena (pink Seradella), BB, SA	0.02	0.13	0.13	0.36
Ornithopus sativus L. v. Emena (pink Seradella), AV, SB	0.09	1.87	1.04	2.29
Weeds, slashed, AV	4.16	3.14	3.18	2.17
Weeds, MC[6] (control)	1.63	2.01	2.30	2.33
LSD ($p \leq 0.05$)	1.80	1.98	1.32	1.20

[1]BB = controlled chemically before bud break and thereafter.
[2]SA = sown annually.
[3]AV = controlled chemically after véraison.
[4]SB = sown biennially.
[5]SI = sown initially.
[6]MC = controlled mechanically from bud break

seasons, an irrigation of 16 mm per week was applied during the first six weeks after the cover crops were sown, using micro-sprinklers. The micro-sprinklers were mounted in the inverted position, they had a 360° wetting pattern and delivered 20 L/h.. This was followed by fortnightly irrigations of 16 mm each. Before the advent of the 1997/98 season, the micro-sprinklers were mounted on top of the irrigation line. During the 1997/98 and 1998/99 seasons, an irrigation of 8 mm was applied twice weekly for the first four weeks following the seeding date. This was followed by four weekly irrigations of 16 mm each. Thereafter fortnightly irrigations of 16 mm each were applied.

Dry matter production (DMP) of both the cover crops and the associated winter growing weeds was determined at the beginning of August, before the application of post-emergence weed control. The potential of the treatments to control summer growing weeds was determined by measuring the DMP of the growing weeds at the end of December (just before harvest). DMP was measured as described by Fourie *et al*. (2001).

Statistical procedures

The twenty treatment combinations were randomly allocated within each of three blocks. The treatment design was a (8x2) +4 factorial, the factors being eight cover crops, two management practices, plus four other practices. The experiment was repeated for four successive seasons (years). The size of each experiment unit (plot) was 114.4 m^2. All variables were measured at random sites within each experiment unit at the beginning of August and the end of December. Analyses of variance were performed separately for each season, using SAS (SAS, 1990). Student's *t* least significant difference (LSD) was calculated at a 5% significance level to compare treatment means. The Shapiro-Wilk test was performed to test for non-normality (Shapiro & Wilk, 1965).

RESULTS AND DISCUSSION

DMP of cover crops

The DMP of the cover crops sown annually (SA) and controlled chemically before bud break (BB) varied considerably between seasons (Table 2). During 1995 the grass species produced less than five tons and the broadleaf species less than half of the eight tons of dry matter considered necessary for the effective suppression of summer growing weeds under conditions of intensive irrigation (Van Huyssteen *et al.*, 1984). In an attempt to increase the DMP at bud break, the seeding date was advanced from 28 March in 1995 to 13 March in 1996. Although the growing period was thereby increased from 127 to 140 days, which is similar to the cover crop growing period allowed in Lutzville (Fourie *et al*., 2005), *Trifolium subterraneum* L. v. Woogenellup ('Woogenellup' subterranean clover) was the only species to show a significant increase in DMP (Table 2). The increase of 131% was attributed to, *inter alia,* the longer growing period, the warmer initial growing period in comparison to that of 1995 (Table 4), as well as the fact that the species could establish itself before the local winter growing weeds started germinating. In contrast, the DMP measured in the BB/SA treatment of the two oat varieties during 1996 was approximately half of that measured in 1995 (Table 2). This indicated that the oats seedlings were more sensitive to the higher temperatures prevalent during the first two weeks after sowing in 1996, compared with the lower temperatures in 1995 (Table 4). This supported the data of Fourie *et al*. (2001). A similar trend was observed with the BB/SA treatment of rye; the DMP was 22% less than that of the previous season (Table 2). Although weekly irrigations of 16 mm each were applied during the first six weeks after the cover crops were sown, visual observation revealed that the top soil in the middle of the working row dried out quickly between irrigations during both the 1995/96 and 1996/97 seasons. This was attributed to the fact that the micro-sprinklers were mounted in the inverted position on the irrigation line and could not wet the entire soil surface properly. After changes were made to the irrigation system and schedule, the DMP of all the species, with the exception of *Vicia dasycarpa* Ten. (grazing vetch), was higher in 1997 compared with that in the previous two seasons. Grazing vetch produced the highest amount of dry matter during both 1995 and 1996, which was similar to that of 1997. It seemed, therefore, that the spreading habitus of grazing vetch enabled it to adjust better to the poor distribution pattern of the irrigation system than did the other species. The cover crops produced less dry matter during 1998 than during 1997. This was caused by a broken irrigation pump, which resulted in a dry period of six weeks during June/July 1998. Despite this, the DMP of the BB/SA treatments measured during 1998 was, with the exception of *Lolium multiflorum* Lam. v. Midmar ('Midmar' ryegrass) and grazing vetch, similar to (or more than) that of 1995 and 1996. Although not within the scope of this investigation, these results imply that these species, with the exception of grazing vetch, need full surface irrigation to maximise DMP. These results support the earlier findings of Fourie *et al*. (2005) and show the importance of maintaining full surface fortnightly irrigations during winter on sandy soils in the semi-arid grapevine regions.

The DMP of *Lolium perenne* L. v. Derby Supreme ('Derby Supreme' perennial ryegrass) and *Festuca arundinaceae* L. v. Cochise (Fescue grass) showed that the latter was the stronger grower of the two perennial species (Fig. 1). The adjustments made to the irrigation system and irrigation scheduling in 1997 resulted in a drastic increase in the growth of Fescue grass during the winter of 1997. The reduction in DMP measured in December 1997 was attributed to the cover crop being slashed in the beginning of August, early October and mid-November, to prevent the weeds from producing seeds. The inability to irrigate for six weeks during the winter of 1998 caused the Fescue grass to die back, showing the importance of regular irrigation during winter in order to maintain a permanent cover crop in this region.

TABLE 4
The daily rainfall and average daily temperature for Keimoes recorded during March and April in 1995 and 1996.

Date	Average daily temperature (°C)		Rainfall (mm)	
	1995	1996	1995	1996
13 March	25.9	20.1	0	0
14 March	24.8	21.2	0	0
15 March	27.8	23.3	0	0
16 March	27.0	24.8	0	0
17 March	28.3	26.1	0	0
18 March	27.8	29.4	0	3.7
19 March	24.0	26.5	0	0
20 March	22.4	26.7	0	0
21 March	23.6	27.4	0	1.0
22 March	25.4	26.8	0.6	0
23 March	23.4	25.4	12.2	0
24 March	20.8	22.6	0	0
25 March	20.6	23.5	26.0	0
26 March	20.7	24.6	0	0
27 March	20.6	23.8	0	0
28 March	25.1	28.3	18.3	0
29 March	22.3	27.6	16.0	0
30 March	18.9	24.4	0	0
31 March	19.0	24.9	0	0
1 April	21.2	24.1	0	0
2 April	21.9	24.3	0	0
3 April	23.1	24.0	0	0
4 April	22.1	21.5	0	0
5 April	22.4	22.5	0	0
6 April	24.3	24.3	0	0
7 April	24.0	24.6	0	0
8 April	24.1	24.5	0	0
9 April	23.9	17.9	0	0
10 April	23.8	18.0	0	0

Potential of species to re-establish themselves

The ability of the species to re-establish was determined by comparing the DMP of the treatments in which the cover crops were sown biennially (SB) and controlled chemically after véraison (AV), or AV treatment in which the seeds were only sown initially (SI), with that of the BB/SA treatment of the same species. 'Midmar' ryegrass and grazing vetch re-established successfully during 1996 (Table 2). These two species were, therefore, left to re-establish themselves during 1997 as well. The DMP of 'Midmar' ryegrass and grazing vetch in the AV/SI treatments was 75% and 81% of that of the BB/SA treatment, respectively. In the following season the success rate was reduced to 47% for 'Midmar' ryegrass and 63% for grazing vetch. These results indicated that for both these species 25% of the suggested seeding density should be sown from the third season onwards to maintain the seed population in the top soil at a level that will help ensure successful establishment. *Medicago truncatula* Gaertn. v. Paraggio ('Paraggio' medic) did not re-establish successfully during 1996, as indicated by the DMP in the AV/SB treatment being

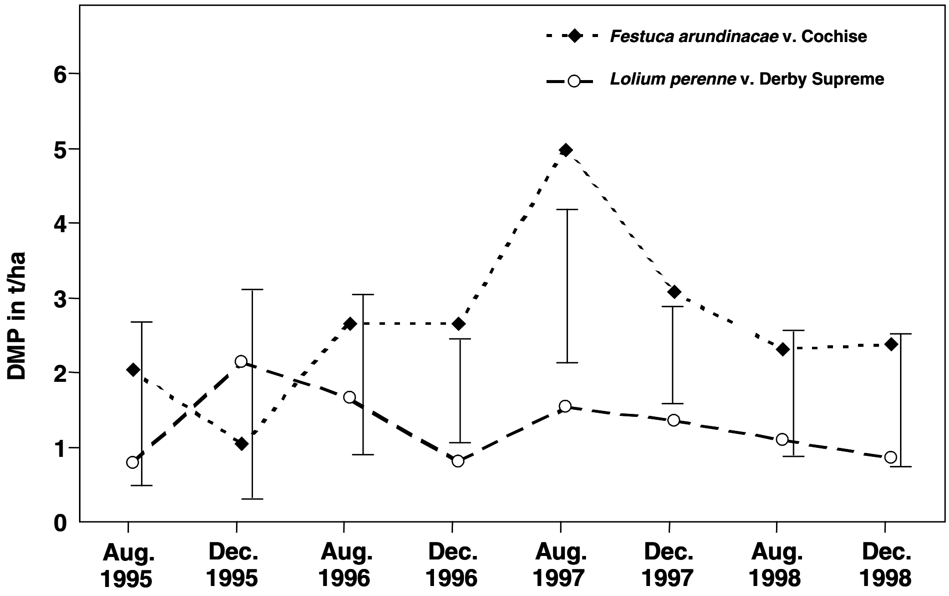

FIGURE 1

Dry matter production (DMP) of two perennial grass species on a sandy soil in a Sultanina vineyard trained on a gable trellis system.

only 81% compared with that of the BB/SA treatment of the species. A similar result was obtained during 1998. 'Paraggio' medic should, therefore, be sown annually. The seeding density, however, could be reduced to 20% of the normal seeding density every alternative year. 'Woogenellup' subterranean clover re-established successfully during 1998, indicating that it should be sown for three consecutive years before it will re-establish successfully in this region. The re-establishment of grazing vetch and 'Paraggio' medic was much more successful in this region than in the Olifants River Valley (Fourie *et al.*, 2005). This could be ascribed to, *inter alia,* the warmer temperatures during summer and early autumn of the former area, compared with that of the latter (data not shown), promoting the weathering of the seed coats of these hard-seeded species.

Weed control

The annual cover crop species, with the exception of 'Woogenellup' subterranean clover, suppressed the winter growing weeds effectively (less than 10% of the weed stand in the control treatment) during 1995 (Table 3). The winter growing weeds were suppressed effectively in the BB/SA treatments of rye and *Avena strigosa* L. v. Saia ('Saia' oats) for the duration of the trial. In the case of 'Saia' oats this could lead to a reduction in the amount of herbicide used for post-emergence weed control in the vineyards at the end of July. Grazing vetch needed a minimum vegetative growth of approximately 3.5 t/ha to suppress weed growth effectively during winter. The erect habitus of the grain species seemed to necessitate less growth to achieve the same result.

The DMP of the summer growing weeds determined just before harvest (end of December) showed that weed growth from véraison to harvest differed significantly between treatments during 1995, 1996 and 1997 (Table 5). The mulches of the annual cover crops, with the exception of 'Midmar' ryegrass (AV, SI) and 'Woogenellup' subterranean clover (BB/SA), significantly reduced the weeds growing from véraison to harvest during 1996, compared with that of the control. These weeds were reduced effectively in all the annual cover crop treatments in comparison with the control, during 1997. In the case of rye (BB/SA) and grazing vetch (BB/SA) this level of weed control was achieved, despite the fact that full surface chemical weed control was not applied during véraison. The improved level of weed control could be attributed to the quality of the mulches produced by the annual cover crops (Table 2). The following season (1998/99) weed control efficacy was not significantly different between treatments, although full surface, chemical weed control was not applied in any of the BB/SA treatments during véraison (Table 5). As the weed pressure was low in this specific season, the sustainability of reducing the amount of weed control actions between bud break and harvest must still be verified.

Initially, the Fescue grass did not effectively suppress the winter and summer growing weeds (Fig. 2). The poor weed control achieved in this treatment could be attributed to the spectrum of weeds consisting mainly of annual broadleaf species with an erect habitus, as well as the cover crop not being dense enough to cover the whole soil surface. In the following three seasons both the winter and summer growing weeds were controlled effectively, with the exception of the summer growing weeds during 1996. The perennial ryegrass did not control the weeds effectively. *Cynodon dactylon* (L.) Pers. (common couch) became problematic in this treatment making full surface, chemical control necessary at the end of the 1998/99 season (mid-February). Although not necessitating such drastic measures, common couch contaminated the Fescue grass as well. It is, therefore, uncertain whether this treatment will be sustainable in the long term.

TABLE 5

The effect of cover crop species established on a sandy soil and managed according to different cover crop management practices, on the dry matter production (DMP) of the weeds growing between véraison and harvest, as measured just before harvest in a Sultanina vineyard trained on a gable trellis system.

Treatment	DMP (t/ha)			
	1995	1996	1997	1998
Secale cereale L. v. Henog (rye), BB[1], SA[2]	0.02	0.40	0.06	0.23
Secale cereale L. v. Henog (rye), AV[3], SB[4]	0.01	0.75	0.02	0.06
Avena sativa L. v. Overberg ('Overberg' oats), BB, SA	0.21	0.18	0.01	0.01
Avena sativa L. v. Overberg ('Overberg' oats), AV, SB	0.03	1.20	0.01	0.13
Avena strigosa L. v. Saia ('Saia' oats), BB, SA	0.03	0.86	0.01	0.36
Avena strigosa L. v. Saia ('Saia' oats), AV, SB	0.02	0.62	0.01	0.70
Lolium multiflorum Lam. v. Midmar ('Midmar' ryegrass), BB, SA	0.05	0.57	0.01	0.70
Lolium multiflorum Lam. v. Midmar ('Midmar' ryegrass), AV, SI[5]	0.20	2.25	0.01	0.22
Vicia dasycarpa, Ten. (grazing vetch), BB, SA	0.03	0.07	0.04	0.14
Vicia dasycarpa, Ten. (grazing vetch), AV, SI	0	0.37	0.01	0.43
Trifolium subterraneum L. v. Woogenellup ('Woogenellup' subterranean clover), BB, SA	0.54	1.49	0.01	0.19
Trifolium subterraneum v. L. Woogenellup ('Woogenellup' subterranean clover), AV, SB	0.13	0.66	0.01	0.02
Medicago truncatula Gaertn. v. Paraggio ('Paraggio' medic), BB, SA	0.02	0.45	0.03	0.26
Medicago truncatula Gaertn. v. Paraggio ('Paraggio' medic), AV, SB	0.06	0.27	0.01	0.12
Ornithopus sativus L. v. Emena (pink Seradella), BB, SA	0.05	0.98	0.01	0.23
Ornithopus sativus L. v. Emena (pink Seradella), AV, SB	0.07	0.56	0.01	0
Weeds, slashed, AV	0.57	0.75	0.01	0.26
Weeds, MC[6](control)	0.64	2.26	1.32	1.60
LSD ($p \leq 0.05$)	0.63	0.98	0.26	NS[7]

[1]BB = controlled chemically before bud break and thereafter.
[2]SA = sown annually.
[3]AV = controlled chemically after véraison.
[4]SB = sown biennially.
[5]SI = sown initially.
[6]MC = controlled mechanically from bud break
[7]NS = data does not differ significantly on the 5% level.

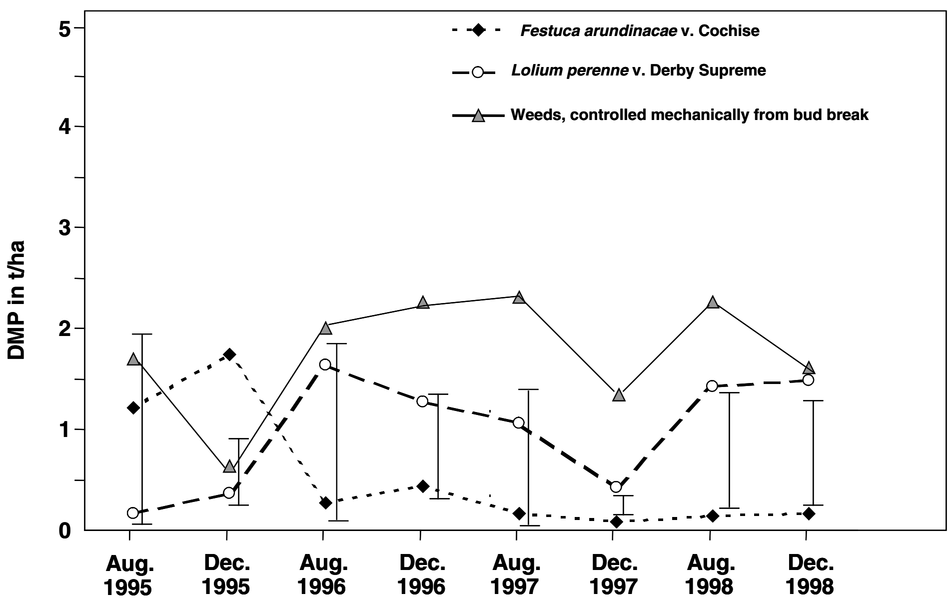

FIGURE 2

Weed dry matter production (DMP) as affected by two perennial grass cover crops compared with a control treatment in which the weeds were controlled mechanically from bud break.

CONCLUSIONS

In this semi-arid region, full surface irrigation, applied regularly, may help to maximise the DMP of the cover crops. Although not within the scope of this investigation, it seems that under these conditions 'Paraggio' medic, the two oat species, and pink Seradella should preferably be used as cover crops in this region. If the micro-sprinkler irrigation system does not allow for full surface wetting, it is suggested that grazing vetch, 'Paraggio' medic and rye should rather be used as cover crops. A study in which the effect of different irrigation schedules and different irrigation application techniques on the performance of the above-mentioned species will be determined should be executed in order to verify the perceived tendencies mentioned above.

Two species, namely grazing vetch and 'Midmar' ryegrass, showed the ability to re-establish successfully. This may be sustainable in the medium to long-term, if 25% of the normal seeding density is sown from the third season onwards, to maintain a viable seed population in the top soil layer. It should also be possible to reduce the seeding density of 'Paraggio' medic to 20% of that of the normal seeding density every alternate year, without impacting on the amount of dry matter produced. 'Woogenellup' subterranean clover could re-establish after being sown for three consecutive seasons.

'Saia' oats and rye had the ability to suppress the winter growing weeds effectively throughout the study, while the most effective control of the summer growing weeds was achieved with the treatments in which rye and grazing vetch were sown annually and controlled chemically just before bud break.

Although one of the perennial cover crops, namely Fescue grass suppressed the winter and summer growing weeds effectively, it became contaminated with common couch during the trial. The sustainability of this soil cultivation practice is, therefore, uncertain.

LITERATURE CITED

Anonymous, 1997. Onkruide se weerstand teen middels wek kommer. Landbouweekblad 7 November, 95.

Archer, E. & Booysen, J.H., 1987. Prieelstelsels vir wingerd. Wynboer Tegnies 21, 3-14.

Buckerfield, J.C. & Webster, K.A., 1996. Earthworms, mulching, soil moisture and grape yields. Wine Indust. J. 11, 47-53.

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. The effect of cover crop management practices on the performance of selected grass and broadleaf species in a Sauvignon Blanc/Ramsey vineyard in the semi-arid Olifants River Valley, South Africa. S. Afr. J. Enol. Vitic. 26, 44-52.

Henkes, R., 1997. Handling herbicide resistance. The furrow. 102, 8-11.

Khan, M.J., Monke, E.J. & Foster G.R., 1986. Mulch cover and canopy effect on soil loss. Pap. ASAE no 86-253. Dept of Agric. Eng. Purdue Univ. West Lafayette, In. 47907, USA.

LeBaron, H.M., 1991. Distribution and seriousness of herbicide-resistant weed infestations worldwide. In: Caseley, J.C., Cussans, G.W. & Atkin, R.K. (Eds). Herbicide resistance in weeds and crops. Butterworth-Heinemann, Boston. pp. 27-43.

Louw, P.J.E. & Bennie, A.T.P., 1992. Water runoff and soil erosion in vineyard soils. Austr. Grapegrower & Winemaker Annual Technical Issue, 100-113.

Radcliffe, D.E., Tollner, E.W., Hargrove, W.L., Clark, R.L. & Colabi, M.H., 1988. Effect of tillage practices on infiltration and soil strength of a Typic Hapludult soil after ten years. Soil Sci. Soc. Am. J. 52, 798-804.

Reeves, D.W., 1997. The role of organic matter in maintaining soil quality in continuous cropping systems. Soil & Tillage Res. 43, 131-167.

Roth, C.H., Meyer, B., Frede, G. & Derpsch, R., 1988. Effect of mulch rates and tillage systems on infiltrability and other soil physical properties of an Oxisol in Parana, Brazil. Soil & Tillage Res. 11, 81-91.

SAS, 1990. SAS/STAT users guide, version 8, first edition, volume 2. SAS Institute Inc., Campus drive, Cary NC 27513.

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

The Non-affiliated Soil Analysis Work Committee, 1990. Handbook of standard soil testing methods for advisory purposes. Soil Sci. Soc. South Africa, P.O. Box 30030, Sunnyside, Pretoria.

Van Huyssteen, L. & Van Zyl, J.L., 1984. Mulching in vineyards. Farming in South Africa E. 12.

Van Huyssteen, L., Van Zyl, J.L. & Koen, A.P., 1984. The effect of cover crop management on soil conditions and weed control in a Colombar vineyard in Oudtshoorn. S. Afr. J. Enol. Vitic. 5, 7-17.