Effect of Seeding Date on the Performance of Grasses and Broadleaf Species Evaluated for Cover Crop Management in the Breede River Valley Wine Grape Region of South Africa

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The trial was conducted over a period of two years on a medium-textured soil near Robertson (33°50'S, 19°54'E), situated in the Breede River Valley of the Western Cape. The effect of seeding date on the dry matter production (DMP) and weed control efficacy of eight grasses and sixteen N-fixing broadleaf species, as well as varieties of three of these species, were determined. The decomposition rate of the surface mulches during summer (from the end of August to the end of January) was measured to determine the persistence of the fibre of the different species. Seeding date had a significant effect on most of the species. *Triticale* v. Usgen 18 (triticale), *Avena sativa* L. v. Overberg ('Overberg' oats), *Avena strigosa* L. v. Saia ('Saia' oats) and *Secale cereale* L. v. Henog (rye) effectively suppressed the winter-growing weeds of the region and produced more than the five tons of dry matter per hectare deemed necessary for effective cover crop management with a grass species. These species produced the highest amount of dry matter if sown in early April (mid-autumn). *Vicia faba* L. v. Fiord (faba bean) and *Medicago truncatula* v. Paraggio ('Paraggio' medic) controlled the winter-growing weeds acceptably, while producing more than the six tons of dry matter per hectare suggested to be necessary for the prevention of erosion in most vineyard soils. *Vicia dasycarpa* Ten. (grazing vetch) suppressed the winter-growing weeds acceptably. Although these legumes did not produce more than the eight tons of dry matter per hectare deemed necessary for effective control of summer growing weeds under intensive full-surface irrigation, they should still be considered for cover crop management on soils with a low organic matter content in the region, because of their ability to supply nitrogen to the grapevines. A highly significant correlation was found between the decomposition rate of the surface mulch and the initial amount of dry matter present on the soil surface.

The number of susceptible weed species that, over time, become resistant to herbicides or groups of herbicides with different modes of action is increasing exponentially (LeBaron, 1991; Anonymous, 1997; Henkes, 1997). It is, therefore, important to restrict the use of herbicides to the necessary minimum, and to implement alternatives. Long-term, intensive clean cultivation reduces the organic matter content of the top soil layer, promoting soil surface crusting during irrigation or rainfall, which leads to water runoff and erosion (Laker, 1990). Although a surface crust can be broken by mechanical cultivation it may re-appear after a single irrigation (Moore *et al*., 1989). The 29 751 ha under grapevines in the Breede River Valley (Anonymous, 2002) are intensively irrigated. Mechanical clean cultivation does not, therefore, seem to be an environment-friendly alternative to full surface chemical weed control. Cover crop management has many advantages (Van Huyssteen *et al*., 1984; Freebairn *et al*., 1986; Khan *et al*., 1986; Shribbs & Skroch, 1986; Radcliffe *et al*., 1988; Roth *et al*., 1988; Louw & Bennie, 1992; Buckerfield & Webster, 1996), which makes it an environment-friendly alternative to mechanical soil cultivation and full surface chemical weed control. A selection of species suitable as cover crops in the different grapevine regions is, however, required to enable producers to apply this practice in a sustainable manner, as part of an integrated production strategy (Fourie *et al*., 2001).

A cover crop should be able to compete effectively with the winter growing weeds prevalent in the region, as well as produce enough dry matter to create a surface mulch that will effectively control the summer growing weeds. The effect of seeding date on the performance of a cover crop species differs between species, as well as among varieties of the same species (Van Heerden, 1984; Harris, 1986; Moulds, 1986; Schultz *et al*., 1999; Fourie *et al*., 2001). The difference in climate between regions, as well as the winter weed spectrum growing in a specific region, have an effect on the performance of a cover crop species and cause the preferred seeding date of a species to vary between regions (Fourie *et al*., 2001).

This study was conducted to determine the suitability of a variety of species for cover crop management in the Breede River

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TABLE 1

Analyses of the medium-textured soil on the Nietvoorbij research farm in Robertson determined before the treatments commenced, but after 19.5 kg of P was applied during seedbed preparation (sampled 26 March 1991).

Soil depth (mm)	Clay (%)	Silt (%)	Sand (%)	pH (KCI)	Electrical conductivity (mS/m)	Total N (%)	Organic C (%)	P (mg/kg)	K (mg/kg)	Exchangeable cations (cmol(+)/kg)			
										Ca	Mg	K	Na
0-300	25.41	11.1	63.49	7.4	55	0.07	0.66	45	231	5.89	2.72	0.56	0.32
300-600	27.32	11.4	61.32	7.5	111	0.05	0.51	13	134	12.37	4.24	0.45	0.70

Valley and to determine the effect of seeding date on the performance of these species within the framework of the minimum tillage practices presently applied in the vineyards of the region. In doing so, guidelines for the application of sustainable cover crop management (an integral part of the Integrated Production of Wine) in this region can be developed.

MATERIALS AND METHODS

The trial was conducted on a medium-textured soil on open land at the Nietvoorbij research farm near Robertson (see Table 1). Robertson (33° 50'S, 19° 54'E) is situated in the Breede River Valley and has an average rainfall of 278 mm per annum, of which 178 mm falls from March to August (see Table 2). Soil samples were drawn randomly on the trial site, after the full surface application of 19.5 kg of P per hectare during seedbed preparation. 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 ammonium acetate), and organic matter (The Non-affiliated Soil Analysis Work Committee, 1990). The percentage total N was determined by means of a Kjehldahl digestion (Bremner, 1965).

The potential cover crop species were sown at three seeding dates (see Table 3). Twenty-four species, as well as varieties of three of these species, were sown at the seeding rates suggested by Fourie *et al*. (2001). A control treatment (for each seeding date), in which no cover crop was sown, was included in the trial. Seedbeds were prepared with a disc harrow approximately six weeks before each seeding date. Before sowing, the surface crust of the soil was broken with a tine cultivator and the seeds were covered afterwards using the same cultivator.

All the treatments received 19.5 kg of P per hectare during seedbed preparation to meet the high P requirement of the broadleaf species (Moulds, 1986; Wooldridge & Harris, 1987), while adhering to the fertilizer norms for grapevines (Conradie, 1994). The grass species received 28 kg of N per hectare at the two- to four- leaf stages, as proposed by Van Huyssteen & Van Zyl (1984).

The potential cover crop species received an irrigation of 18 mm per week up to 10 weeks after seeding, followed by a fortnightly irrigation of 18 mm until the end of August. The irrigation was applied by means of overhead sprinklers delivering 9 mm water per hour. Rainfall that occurred during this period was subtracted from the amount of irrigation that was to be applied.

Measurements

The dry matter production (DMP) of both the potential cover crops and the associated winter growing weeds was determined at the end of August, whereafter full surface chemical control was applied with a 3% glyphosate (360 g/l formulation) solution. The potential of the cover crop mulches to control the summer growing weeds was determined by measuring the weed dry matter at the end of November and at the end of January. DMP was estimated from a sample by harvesting the above-ground vegetative growth in a 0.5 m^2 sub-plot randomly chosen in the experimental plot. Samples were oven-dried for 48 hours at 105°C. To determine the decomposition rate of the cover crop residue from the end of August to the end of January, five of the fifteen replications (five replications x three seeding dates) in which the percentage contribution of the cover crop to the mulch was the highest, were selected. The rate was calculated for each cover crop and expressed as the slope of the decline in dry matter over time, as determined at the end of August, the end of November and the end of January.

TABLE 2

Average daily temperature and monthly rainfall for Robertson as measured from March 1991 to February 1993.

Month	Average daily temperature (°C)			Total monthly rainfall (mm)		
	1991	1992	1993	1991	1992	1993
January		23.8	23.6		0	2.5
February		24.0	23.1		6.8	36.5
March	22.2	22.3		11.8	3.4	
April	19.5	18.1		7.7	28.3	
May	16.4	14.8		9.0	29.6	
June	12.1	12.5		48.6	55.6	
July	12.4	12.0		44.7	57.0	
August	11.6	12.1		1.6	15.5	
September	15.3	14.7		11.1	16.5	
October	17.8	17.0		41.7	36.8	
November	20.5	20.1		1.0	15.5	
December	22.6	22.3		6.4	0	

Statistical procedures

The experiment design was a randomised complete block design. The treatment layout was a split-plot design with seeding date the main factor and species the sub-factor. Each treatment was replicated five times. The experiment was repeated for two successive seasons (years). The plots were fully randomised between seasons. The size of each experimental unit (plot) was 21 m^2. All variables were measured at random sites within each experimental unit at the end of August, the end of November and the end of January.

TABLE 3

Effect of seeding date on the dry matter production (DMP) of potential cover crops, determined at the end of August 1991 and 1992 on the Nietvoorbij research farm in Robertson.

Species	Sowing density (kg/ha)	DMP (t/ha) Seeding date: 24–26 March[1]		Seeding date: 8–11 April[1]		Seeding date: 1–4 May[1]	
		1991	1992	1991	1992	1991	1992
N-fixing broadleaf species:							
Trifolium subterraneum L. v. Trikkala	35	0.24	0.47	0.80	0.94	0.54	1.24
Trifolium subterraneum L. v. Woogenellup	35	1.00	0.98	0.79	0.43	0.14	0.13
Trifolium subterraneum L. v. Clare	35	1.23	1.27	1.67	1.43	0.96	0.96
Trifolium subterraneum L. v. Mount Barker	35	1.20	0.00	1.20	0.27	1.71	1.21
Trifolium repens L. v. Haifa	12	0.12	0.00	0.10	0.03	0.04	0.03
Trifolium resupinatum L. v. Maral	16	1.41	1.88	1.20	1.49	0.98	0.53
Trifolium hirtum All. v. Kondinin	16	0.53	0.72	0.32	0.04	0.32	0.18
Trifolium balansae Boass. v. Patrick	4	0.15	0.22	0.14	0.01	0.09	0.38
Trifolium vesiculosum Savi. v. Zulu	16	0.56	0.98	0.23	0.21	0.55	0.28
Trifolium fragiferum L. v. Palestine	12	0.01	0.94	0.17	0.00	0.05	0.00
Lotus hispidus Desf. ex DC. v. Campbell	10	0.05	0.00	0.04	0.06	0.00	0.11
Lotus corniculatus L. v. SOA Gabriel	12	1.38	0.57	0.01	0.01	0.05	0.08
Medicago truncatula Gaertn. v. Paraggio	25	6.18	5.15	3.59	2.04	2.80	1.12
Medicago truncatula Gaertn. v. Parabinga	25	4.16	3.40	3.63	1.13	3.21	1.00
Medicago scutellata (L.) Mill. v. Kelson	25	3.91	2.68	3.64	2.88	1.55	1.32
Medicago littoralis Rodes ex Loisel. v. Harbinger	25	1.15	0.78	1.03	0.00	0.60	0.20
Ornithopus sativus L. v. Emena	25	1.05	1.67	0.89	0.22	0.48	0.28
Vicia faba L. v. Fiord	120	4.46	5.45	7.48	6.71	4.95	4.32
Vicia dasycarpa Ten.	50	4.81	4.30	4.49	4.14	3.98	3.82
Vicia sativa L. v. Lima	50	5.76	1.70	4.46	1.37	3.82	0.68
Grasses:							
Lolium multiflorum Lam. v. Energa	40	3.58	2.80	4.19	4.77	3.10	1.94
Lolium multiflorum Lam. v. Midmar	40	4.14	4.18	4.27	5.38	3.02	3.00
Lolium perenne L. v. Nui	40	1.48	0.16	2.42	2.68	1.38	1.26
Phalaris aquatica L. v. Sirosa	25	1.16	1.33	1.79	1.72	2.27	2.23
Avena sativa L. v. Overberg	100	4.23	4.74	6.52	7.61	5.55	6.24
Avena strigosa L. v. Saia	100	4.17	5.00	6.48	7.29	5.69	6.33
Secale cereale L. v. Henog	100	4.34	5.89	5.56	7.32	5.43	6.99
Triticale v. Usgen 18	100	3.89	6.22	7.22	10.36	6.33	7.58
Hordeum vulgare L	100	2.35	2.47	2.94	3.78	3.59	4.02
Weeds (Control)		-2.92	2.80	4.61	4.28	4.07	3.34
LSD ($p \leq 0.05$)				0.75			

[1] Sowing of seeds done on one day during this period.

Analyses of variance were performed for each season separately, using SAS (SAS, 1990). Student's *t* least significant difference (LSD) was calculated at the 5% significance level to compare treatment means. The residual variances of each season were tested for comparable precision using Bartlett's test (John & Quenouille, 1977). These tests showed that the results of the two seasons, as far as the DMP of the cover crops at the end of August was concerned, were of comparable accuracy ($P > 0.05$). The Shapiro-Wilk test was performed to test for normality (Shapiro & Wilk, 1965). A linear regression was fitted for the decomposition rate over the three measuring dates. The coefficients were subjected to an appropriate analysis of variance with twenty-nine treatments and five replications. A correlation analysis was performed between the decomposition rate and the initial DMP.

RESULTS AND DISCUSSION

Dry matter production and control of winter growing weeds

The effect of seeding date on the cover crop DMP varied between species, as well as between varieties of a species (see Table 3). Seeding date had a significant effect on the growth of the weeds in the control as well. Despite the shorter growing periods, the weed growth in the control treatments of seeding dates 2 (8-11 April) and 3 (1-4 May) was significantly more than that of seeding date 1 (24-26 March). This phenomenon did not support the results of

Fourie *et al*. (2001). This could, however, be attributed to the dominant weed species present at the trial site in Robertson (see Table 5) germinating and completing the initial growth phase under the more moderate climatic conditions prevalent from mid-April to late May (seeding dates 2 and 3) compared with that during late March and early April (seeding date 1), as shown in Table 2.

Broadleaf species

The DMP of the *Trifolium* and *Lotus* species (see Table 3) was much lower than that reported by Fourie *et al*. (2001) for the same species in Stellenbosch (33° 55'S, 18° 52'E) and Lutzville (31° 35'S, 18° 22'E), situated in the Coastal region and the semi-arid Olifants River Valley, respectively. This is attributed to the relatively cold average daily temperatures in Robertson (see Table 2) compared with that of Stellenbosch (from June to August) and Lutzville (from April to August), respectively (Fourie *et al*., 2001). A variety of competitive weed species (see Table 5) also grew exuberantly in Robertson (see Table 4) in comparison with the weed growth in Stellenbosch and Lutzville (Fourie *et al*., 2001). Comparing the *Trifolium* and *Lotus* species to the control, only *Trifolium subterraneum* v. Clare ('Clare' subterranean clover) produced sufficient amounts of vegetative growth to sup-

TABLE 4

Effect of seeding date and potential cover crops on the dry matter production (DMP) of the winter growing weeds, determined at the end of August 1991 and 1992 on the Nietvoorbij research farm in Robertson.

Species	**DMP (t/ha)**					
	Seeding date: 24–26 March[1]		**Seeding date: 8–11 April[1]**		**Seeding date: 1–4 May[1]**	
	1991	**1992**	**1991**	**1992**	**1991**	**1992**
N-fixing broadleaf species:						
Trifolium subterraneum L. v. Trikkala	2.86	3.11	3.67	3.31	3.84	2.21
Trifolium subterraneum L. v. Woogenellup	1.97	2.64	3.49	4.01	3.57	3.34
Trifolium subterraneum L. v. Clare	2.17	2.52	3.04	3.02	3.73	2.49
Trifolium subterraneum L. v. Mount Barker	3.19	3.11	3.93	3.88	3.74	2.48
Trifolium repens L. v. Haifa	4.34	3.79	3.78	4.26	3.83	2.60
Trifolium resupinatum L. v. Maral	1.98	3.12	3.87	3.96	3.72	2.44
Trifolium hirtum All. v. Kondinin	1.69	3.56	3.69	4.80	3.25	2.68
Trifolium balansae Boass. v. Patrick	3.45	4.24	3.41	3.66	3.87	2.96
Trifolium vesiculosum Savi. v. Zulu	2.77	3.24	3.54	5.06	3.24	2.66
Trifolium fragiferum L. v. Palestine	2.53	2.89	3.97	3.67	3.80	4.02
Lotus hispidus Desf. ex DC. v. Campbell	2.76	3.34	3.99	3.63	3.76	2.27
Lotus corniculatus L. v. SOA Gabriel	1.92	2.98	3.91	4.66	5.01	2.51
Medicago truncatula Gaertn. v. Paraggio	0.41	0.42	1.45	2.18	2.57	3.25
Medicago truncatula Gaertn. v. Parabinga	1.10	1.30	1.95	4.18	1.22	2.24
Medicago scutellata (L.) Mill. v. Kelson	1.22	1.12	1.88	2.18	2.14	2.20
Medicago littoralis Rodes ex Loisel. v. Harbinger	2.42	3.31	3.30	5.73	3.16	2.62
Ornithopus sativus L. v. Emena	2.21	2.39	3.49	4.38	2.99	2.18
Vicia faba L. v. Fiord	1.65	1.01	0.40	0.37	2.42	1.71
Vicia dasycarpa Ten.	0.60	0.80	0.58	0.69	0.67	0.39
Vicia sativa L. v. Lima	0.47	2.93	0.43	2.85	1.15	3.81
Grasses:						
Lolium multiflorum Lam. v. Energa	1.10	1.03	0.84	0.54	0.94	0.95
Lolium multiflorum Lam. v. Midmar	0.57	0.48	0.51	0.42	1.34	0.97
Lolium perenne L. v. Nui	1.76	2.83	1.88	2.63	3.01	2.31
Phalaris aquatica L. v. Sirosa	2.46	3.22	3.41	3.59	2.80	1.83
Avena sativa L. v. Overberg	0.79	0.37	0.21	0.32	0.69	0.21
Avena strigosa L. v. Saia	0.50	0.38	0.39	0.06	0.02	0.15
Secale cereale L. v. Henog	0.99	1.02	0.33	0.00	0.63	0.08
Triticale v. Usgen 18	1.49	1.02	0.32	0.08	0.39	0.17
Hordeum vulgare L.	1.82	1.89	1.27	1.50	1.82	0.70
Weeds (Control)	2.92	2.80	4.61	4.28	4.07	3.34
LSD ($p \leq 0.05$)			1.24			

[1] Sowing of seeds done on one day during this period.

press the winter growing weeds significantly (see Table 4). This was only true for seeding date 2, indicating that the species should be established during early April in the Breede River Valley. This differs from the findings of Harris (1986) and Fourie *et al*. (2001) who found that 'Clare' subterranean clover should preferably be sown during early May in Stellenbosch to maximise its efficiency as a cover crop. This difference in seeding date can be attributed to the difference in climate, the weed spectrum and the amount of weed growth between the two regions.

Seeding date had a significant effect on the vegetative growth of the *Medicago* species, with the exception of *Medicago littoralis* Rodes ex Loisel. v. Harbinger ('Harbinger' medic), probably because of the poor performance of the latter species (see Table 3). All the *Medicago* species produced the highest amount of dry matter if sown during the last week of March. This may be attributed to a longer growing period, as well as to the warmer average daily temperatures that prevailed during March and April, supporting the results of Fourie *et al*. (2001), and indicating that the *Medicago* species preferred the warmer climatic conditions. The difference in the average daily temperatures and, to a lesser extent, the difference in the monthly rainfall between the two seasons (see Table 2) impacted significantly on the DMP of these species (see Table 3). The *Medicago* species preferred the warmer climate of the 1991 autumn and winter (March to August), producing significantly more dry matter than in the colder 1992 season. The warmer climate enabled *Medicago truncatula* Gaertn. v. Paraggio ('Paraggio' medic) to produce the six to eight tons of dry matter per hectare deemed necessary by Louw & Bennie (1992) to effectively reduce water runoff in most vineyard soils, if sown during late March. The *Medicago* species reduced the weed stand significantly if it produced more than 1.5 tons of dry matter per hectare at the end of August. 'Paraggio' medic, however, was the only *Medicago* species that produced significantly more dry matter than the winter growing weeds and suppressed the winter growing weeds acceptably (less than 20% of the weed stand in the control), and then only if sown at the end of March.

Ornithopus sativus L. v. Emena (pink Seradella) could not produce significant amounts of dry matter irrespective of seeding date (see Table 3). This could be attributed to, *inter alia*, the species not being able to outgrow the variety of competitive weed species (see Table 5) that showed exuberant growth (see Table 4). Although *Vicia sativa* L. v. Lima (broadleaf purple vetch) showed the ability to produce nearly six tons of dry matter per hectare and suppress the winter growing weeds effectively (less than 10% of the weed stand in the control) when sown in late March (see Tables 3 & 4, respectively), the performance of the species was inconsistent between years, making it risky to use it as a cover crop in the Breede River Valley. The DMP of *Vicia faba* L. v. Fiord (faba bean) was significantly affected by seeding date (see Table 3). Both the DMP (see Table 3) and level of winter weed suppression (see Table 4) indicated that this species should be sown during early April. In doing so, faba bean produced the six to eight tons of dry matter per hectare deemed necessary, by Louw and Bennie (1992), to effectively reduce water runoff from most vineyard soils. Faba bean also effectively suppressed the winter growing weeds (see Table 4). *Vicia dasycarpa* Ten. (grazing vetch) was not affected by seeding date, despite the difference in growing periods. This indicated that the relatively cold winter months caused the grazing vetch to proliferate during its early growing stages (see Table 3). Although grazing vetch did not produce significantly more dry matter than the winter growing weeds, it performed consistently over the two seasons (see Table 3) and suppressed the winter growing weeds acceptably, if sown not earlier than the second week of April (see Table 4). This weed suppression was attributed to the spreading and dense habitus of this species.

Grasses

Seeding date had a significant effect on the DMP of the three *Lolium* species (see Table 3). *Lolium multiflorum* Lam. v. Energa

TABLE 5

Weed species found at the trial site in Robertson.

Weed Species		Habitus	Root system	Strong competitor[1]
Scientific name	Common name			
Bromus unioloides H.B.K.	Rescue grass	erect	adventitious	N
Chenopoduim album L.	White goosefoot	erect	stout tap root	Y
Convolvulus arvensis L.	Field bindweed	prostrate	spreading	Y
Emex australis Steinh.	Spiny Emex	prostrate to semi-erect	stout tap root	N
Euphorbia chamaesyce L.	Hairy creeping milkweed	prostrate	tap root	N
Hordeum murinum L.	Wild barley	erect	adventitious	N
Lactuca serriola L.	Wild lettuce	erect	tap root	N
Lolium multiflorum Lam.	Italian ryegrass	erect	adventitious	Y
Malva parviflora L.	Small mallow	erect	stout tap root	Y
Oxalis pes-caprae L.	Yellow sorrel	erect	vertical rhizomes	N
Picris echioides L.	Bristly ox-tongue	erect	stout tap root	Y
Raphanus raphanistrum L.	Wild radish	erect	stout tap root	Y
Rapistrum rugosum (L.)	Wild mustard	erect	stout tap root	Y
Sonchus oleraceus (L.) Hill.	Sowthistle	erect	stout tap root	N
Veronica persica Desf.	Field speedwell	prostrate to semi-erect	tap root	N

[1] Classified according to Grabandt (1985).

(‘Energa’ ryegrass) and *Lolium perenne* L. (perennial ryegrass) produced significantly more DMP if sown in early April, while *Lolium multiflorum* Lam. v. Midmar (‘Midmar’ ryegrass) produced significantly less dry matter if sown later than early April. Although only ‘Midmar’ ryegrass could produce significantly more DMP than the weeds in the region (see Table 3), all the *Lolium* species reduced the stand of the winter growing weeds significantly compared with that of the control (see Table 4), if the DMP exceeded two tons per hectare (see Table 3). Acceptable suppression of the winter growing weeds was achieved when ‘Midmar’ and ‘Energa’ ryegrass produced in excess of four tons of dry matter per hectare, while effective winter weed suppression was achieved with ‘Midmar’ ryegrass producing in excess of five tons of dry matter per hectare (see Tables 3 & 4). Although both *Lolium multiflorum* varieties could be considered for use as cover crops in this region, preference should be given to ‘Midmar’ ryegrass. *Phalaris aquatica* L. v. Sirosa (reed canary grass) could not suppress the winter growing weeds significantly and should, therefore, not be considered for cover crop management in the Breede River Valley.

The grain species, with the exception of *Hordeum vulgare* L. (barley), showed the ability to produce significantly more dry matter than the weeds in the control (see Table 3). To maximize DMP (see Table 3), as well as to consistently ensure effective suppression of the winter growing weeds (see Table 4), the two *Avena* (oats) species, *Secale cereale* L. v. Henog (rye) and *Triticale* v. Usgen 18 (triticale), should preferably be sown during early April in the Breede River Valley. Rye and triticale produced significantly more dry matter during the colder and slightly wetter 1992 season in comparison to the warmer and slightly drier 1991 season (see Table 3). The same phenomenon was detected in the two oats species, although it was not as pronounced as with rye and triticale. This corresponded with the findings of studies carried out in Stellenbosch and Lutzville (Fourie *et al.,* 2001). The two oats species and triticale consistently produced more than the six tons of dry matter per hectare (see Table 3) deemed necessary to effectively reduce water runoff from most vineyard soils (Louw & Bennie, 1992), when sown in early April. These results indicated that the two oats species, as well as rye and triticale, should be considered for cover crop management in the Breede River Valley.

Control of summer growing weeds

The DMP of the summer growing weeds measured at the end of November and at the end of January was very low in all plots, making the differences between the control and cover crop treatments insignificant (data not shown). The ability of the different mulches to control the summer growing weeds could, therefore, not be evaluated. Van Huyssteen *et al*. (1984) indicated that *Lolium multiflorum* Lam. v. Wimmera (‘Wimmera’ ryegrass) and broadleaf purple vetch, with DMPs of five and eight tons per hectare, respectively, should prevent the establishment of summer growing weeds in an intensely irrigated vineyard. These values were taken as norms to determine which species considered in the present study have the potential to control summer growing weeds effectively. According to this norm, only triticale, the two oats species and rye had the potential to control summer growing weeds effectively.

Taking into account the above-mentioned norms of Van Huyssteen *et al.* (1984) and Louw & Bennie (1992), as well as the ability of the species to suppress the winter growing weeds acceptably, triticale, the two oats species and rye should definitely be considered for cover crop management on the medium-textured soils of the Breede River Valley. ‘Midmar’ ryegrass could be considered as a viable alternative if these four species are not available. None of the broadleaf species reached the norm proposed by Van Huyssteen *et al*. (1984). Faba bean and ‘Paraggio’ medic did, however, produce more than the six tons per hectare deemed necessary by Louw & Bennie (1992) to prevent water runoff from most soils, while faba bean, ‘Paraggio’ medic and grazing vetch showed the ability to control the winter growing weeds acceptably. These three broadleaf species should, therefore, be included in further studies to determine if the norm of eight tons per hectare is applicable to these species under the edaphic conditions prevalent in the Breede River Valley.

Decomposition rate of the different mulches

The decomposition rate of the different mulches differed significantly between species and years (data not shown). The decomposition rate of different groups of species also varied between years (see Table 6). The decomposition rate of some of the groups, namely the *Trifolium subterraneum* L. varieties, the *Medicago* species, as well as the *Vicia* species and pink Seradella was higher in the summer (from the end of August to the end of January) of the 1991/92 season than in the summer of the 1992/93 season. This could be attributed to the higher temperatures that prevailed during the summer of the 1991/92 season compared with that of the 1992/93 season (see Table 2). This supports the findings of Jenkinson & Ayanaba (1977) and Ladd *et al*. (1985), who suggested that the decomposition rates of plant material added to the top soil doubles with an 8°C to 9°C increase in mean annual air temperature.

TABLE 6

The decomposition rate (from the end of August to the end of January – growing season of the grapevines) and the dry matter production (end of August) of the different cover crop groups measured during 1991 and 1992 on the Nietvoorbij research farm in Robertson.

Group of species	Decomposition rate in t/ha/month		Dry matter production (DMP) in t/ha	
	1991	1992	1991	1992
Trifolium subterraneum L. varieties	0.61	0.53	4.15	3.82
Trifolium species	0.56	0.58	3.77	3.86
Lotus species	0.60	0.60	3.80	3.72
Medicago species	0.66	0.58	4.76	4.46
Vicia species and *Ornithopus sativus* L. v. Emena	0.72	0.59	5.11	4.92
Lolium species and *Phalaris aquatica* L. v. Sirosa	0.45	0.48	4.36	4.28
Grain species	0.62	0.66	5.95	6.68
LSD ($p \leq 0.05$)	0.09	0.09	0.42	0.40
Correlation between decomposition rate and DMP	$r = 0.74$, $p \leq 0.0001$			

A significant positive correlation was found between the rate of decomposition and the amount of dry matter present on the soil surface at the end of August (see Table 6), which supports the findings of Fourie *et al*. (2001). This phenomenon could also have contributed towards the difference between the decomposition rate of the same group of species between the two seasons, as detected for the *Trifolium subterraneum* L. varieties, the *Medicago* species, the *Vicia* species and pink Seradella, as well as for the grain species.

The decomposition rate of the group consisting of the *Lolium* species and reed canary grass was significantly lower than that of the group of *Trifolium* species and the group of *Lotus* species, while the DMP was significantly higher (see Table 6). This contradicted the positive correlation between decomposition rate and the amount of dry matter on the soil surface at the end of August. According to Amato *et al.* (1987), the C/N ratio of the two legumes 'Harbinger' medic and *T. subterraneum* v. Bacchus Marsh is approximately 13:1, while that of mature *Triticum aestivum* L. v. Condor (wheat) straw is 73:1. This resulted in the decomposition rate of the plant material from the legumes being higher and more extensive than that of the wheat straw. This might explain why the group consisting of *Lolium* species and reed canary grass did not conform to the correlation found in the present study.

CONCLUSIONS

The ability of the two oats species, triticale and rye, to suppress the winter-growing weeds effectively, as well as to produce in excess of the five tons of dry matter per hectare suggested to be necessary for effective control of summer-growing weeds by a grass species, indicated that these species should be suitable for cover crop management in the vineyards of the Breede River Valley. These species should be sown during early April to optimise their performance.

The broadleaf species could not produce the minimum norm of eight tons of dry matter per hectare suggested to be necessary for effective control of summer growing weeds by broadleaf species. Faba bean and 'Paraggio' medic, however, controlled the winter growing weeds acceptably, while producing more than the six tons of dry matter per hectare suggested to be necessary for the prevention of erosion in most vineyard soils. Although not able to produce a sufficient amount of dry matter, grazing vetch showed the ability to suppress the winter growing weeds acceptably. These broadleaf species have the ability to fix nitrogen and should, therefore, as potential suppliers of nitrogen to the vine, be considered for cover crop management on soils with low organic matter content in the Breede River Valley.

The above-mentioned variety of species that performed well as cover crops give producers the opportunity to alternate species as cover crops in their vineyards, and should contribute towards sustainable cover crop management in this region.

This work confirmed that the decomposition rate of the different mulches during summer is significantly affected by the initial amount of dry matter present on the soil surface.

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