The Production Potential of Red Clover, White Clover, Strawberry Clover and Trefoil Culivars

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Introduction

Grain and forage legumes occupy 12% to 15% of the Earth's arable land (Graham and Vance 2003). Mixed pastures containing legumes have the advantage over grass pastures in that they are often of high quality and add N to the cropping system (Brock and Hay 2001, Graham and Vance 2003, Dahlin and Stenberg 2010). Biologically fixed nitrogen is derived from solar energy, whereas N fertilizer requires significant amounts of fossil fuels and other commercial energy sources to produce, with perennial legumes the most economical way of decreasing the reliance on these expensive sources of inorganic nitrogen (Neal *et al*. 2009). The inclusion of perennial legumes and grasses is thus the most likely base whereby to improve the sustainability and long term survival of pasture systems (Cransberg and McFarlane 1994).

Clovers and trefoil are some of the most important forage legumes worldwide (Graham and Vance 2003). The variation in the spread of seasonal production between different cultivars and species, accompanied by the broad range of genetic resources available necessitate different cultivars of perennial clovers and trefoil under the local climatic and environmental conditions of the Western Cape. The aim of this study was to evaluate and compare the production potential of different perennial legumes such as white clover, red clover, strawberry clover and birdsfoot trefoil.

Materials and Methods

The study was carried out on the Outeniqua Research farm near George (Altitude 201 m, 33° 58' 38" S and 22° 25' 16" E, rainfall 728 mm year^{-1}) in the Western Cape of South Africa on an Witfontein soil form (Soil Classification Workgroup 1991).

The study area was under permanent overhead sprinkler irrigation, with irrigation scheduling undertaken by means of a tensiometer. Irrigation commenced at a tensiometer reading of -25 kPa and was terminated at a reading of -10 kPa (Botha 2002). Soil samples were taken prior to establishment to a depth of 150mm and analysed for Ca, Mg, Na, K, P, Cu, Zn, Mn, B, S, and C levels. Fertiliser was applied according to the soil analysis to raise soil P level to 35 mg kg^{-1}, K level to 80 mg kg^{-1} and pH (KCl) to 5.5 (Beyers 1973).

Table 1. The scientific name, common name, cultivar name and seeding rate of perennial legumes that were evaluated

	Scientific name	Common name	Cultivar name	Seeding rate (kg ha^{-1})
1	*Trifolium repens*	White clover	Haifa	6
2	*Trifolium repens*	White clover	Huia	6
3	*Trifolium repens*	White clover	Agrimatt	6
4	*Trifolium repens*	White clover	Agridan	6
5	*Trifolium repens*	White clover	Riesling	6
6	*Trifolium repens*	White clover	Dusi	6
7	*Trifolium repens*	White clover	Klondike	6
8	*Trifolium repens*	White clover	Alice	6
9	*Trifolium pratense*	Red clover	Quinequeli	8
10	*Trifolium pratense*	Red clover	Tropero	8
11	*Trifolium pratense*	Red clover	Amos	8
12	*Trifolium pratense*	Red clover	Red gold	8
13	*Trifolium pratense*	Red clover	Kenland	8
14	*Trifolium pratense*	Red clover	Suez	8
15	*Trifolium pratense*	Red clover	Rajah	8
16	*Trifolium pratense*	Red clover	Lemmon	8
17	*Lotus corniculatis*	Trefoil	Sao Gabriel	5
18	*Trifolium fragiferum*	Strawberry clover	Palestine	6

Table 2. The mean monthly growth rate (kg DM ha^{-1} day^{-1}) of perennial legume cultivars during year 1.

Species	Cultivar	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
WC	Haifa	6.83^{a}	37.1^{fgh}	55.9^{defg}	44.4^{bc}	75.7^{abcd}	6.29^{b}	3.31^{abc}	21.6^{b}	20.9^{d}	18.2^{bc}
WC	Huia	3.89^{abcde}	49.8^{bcde}	56.6^{defg}	52.1^{abc}	59.3^{cd}	14.5^{b}	7.70^{a}	33.9^{a}	22.8^{cd}	26.6^{ab}
WC	Agrimatt	5.95^{abcd}	42.2^{efg}	57.2^{defg}	50.8^{abc}	61.9^{bcd}	12.7^{b}	3.74^{abc}	24.7^{b}	34.0^{a}	24.9^{ab}
WC	Agridan	6.51^{ab}	45.9^{def}	64.0^{bcde}	46.0^{bc}	78.1^{abcd}	13.9^{b}	7.92^{a}	27.6^{ab}	25.0^{cd}	25.5^{ab}
WC	Riesling	5.18^{abcd}	49.1^{bcdef}	60.3^{cdef}	54.0^{ab}	62.4^{bcd}	11.7^{b}	1.54^{bc}	22.0^{b}	27.5^{bc}	25.7^{ab}
WC	Dusi	6.77^{a}	60.7^{abc}	77.6^{a}	62.1^{a}	74.7^{abcd}	14.9^{b}	4.20^{abc}	26.0^{b}	23.1^{cd}	19.6^{abc}
WC	Klondike	5.04^{abcd}	56.0^{abcd}	52.8^{efg}	43.3^{bc}	57.5^{d}	1.71^{b}	2.00^{bc}	27.4^{ab}	26.4^{bcd}	28.1^{a}
WC	Alice	6.32^{abc}	59.7^{abc}	61.6^{bcdef}	55.6^{ab}	66.4^{bcd}	11.0^{b}	6.61^{ab}	28.2^{ab}	31.2^{ab}	27.9^{a}
RC	Quinequeli	2.97^{cde}	61.3^{ab}	65.0^{bcd}	37.7^{c}	82.1^{abcd}	8.60^{b}	3.07^{abc}	2.53^{d}	2.74^{f}	3.95^{d}
RC	Tropero	5.40^{abcd}	59.1^{abc}	71.1^{abc}	51.9^{abc}	73.1^{abcd}	6.65^{b}	3.30^{abc}	2.35^{d}	2.70^{f}	6.06^{d}
RC	Amos	2.72^{de}	29.7^{gh}	58.9^{def}	38.0^{c}	62.3^{bcd}	3.89^{b}	0.74^{c}	0^{d}	0^{f}	0.25^{d}
RC	Red gold	5.82^{abcd}	63.2^{a}	58.0^{def}	47.8^{abc}	76.0^{abcd}	7.68^{b}	4.89^{abc}	2.78^{d}	2.61^{f}	2.85^{d}
RC	Kenland	5.05^{abcd}	58.9^{abc}	65.1^{bcd}	51.2^{abc}	87.9^{ab}	12.6^{b}	5.22^{abc}	4.69^{cd}	3.11^{f}	4.23^{d}
RC	Suez	3.58^{abcde}	53.5^{abcde}	71.3^{abc}	53.6^{ab}	99.0^{a}	9.67^{b}	1.30^{bc}	0.54^{d}	0.49^{f}	0.51^{d}
RC	Rajah	3.71^{abcde}	48.9^{bcdef}	72.5^{ab}	53.1^{ab}	80.2^{abcd}	14.1^{b}	1.90^{bc}	4.59^{cd}	2.72^{f}	2.47^{d}
RC	Lemmon	5.21^{abcd}	48.6^{cdef}	64.9^{bcd}	48.5^{abc}	77.8^{abcd}	15.4^{b}	6.02^{abc}	5.06^{cd}	3.95^{f}	4.44^{d}
Trefoil	Soa Gabriel	0.85^{e}	28.3^{h}	51.3^{fg}	46.7^{bc}	79.0^{abcd}	40.3^{a}	2.09^{bc}	6.26^{cd}	0.57^{f}	0^{d}
SC	Palestine	3.25^{bcde}	45.4^{def}	46.1^{g}	16.6^{d}	84.2^{abc}	10.0^{b}	1.69^{bc}	11.4^{c}	14.9^{e}	15.7^{c}
		3.357	12.69	11.89	15.04	26.41	13.71	5.423	7.429	5.899	9.181

WC: white clover
RC: Red clover
SC: Strawberry clover
LSD (0.05) compares over cultivars within months
^{abc}Means with no common superscript differ significantly

The species that were evaluated include white clover (*Trifolium repens*), red clover (*Trifolium pratense*), Strawberry clover (*Trifolium fragiferum*) and Birdsfoot trefoil (*Lotus corniculatis*). A total of 18 cultivars were evaluated in the form of a randomized block design, with three replicates per cultivar (total of 54 plots). The scientific name, common name, cultivar name and seeding rate of the legumes evaluated are given in Table 1.

The trial was established on the 5th of May 2011 on a paddock previously planted to perennial ryegrass-clover pastures. The paddock was sprayed with herbicide during January and tilled during February to remove the existing sward. Three subsequent herbicide applications (up to establishment) were aimed at eradication of emerging weeds. Prior to establishment the trial area was tilled with a disk harrow and kongskilde and rolled with a light landroller to create a firm seedbed and eradicate any remaining weeds. The various cultivars/species were planted according to commercially recommended seeding rates and adapted for germination percentages. Plots were 2.1 m x 6 m per treatment (12.6 m^2), with 14 rows that were 15 cm apart. All seed was inoculated with species specific *Rhizobium* a maximum of 2 hours before planting and kept in a cool place until it could be planted. Seed was also treated with pesticide and fungicide prior to establishment. Immediately after establishment, each plot was raked lightly to cover seeds and maintain inoculant activity. Plots were harvested using quadrats every 28 days to determine growth rate (kg DM ha^{-1} day^{-1}) and dry matter (DM) production (kg DM ha^{-1}). Three quadrats of 0.25 m^2 were randomly placed per plot and cut to a height of 50 mm. The samples were pooled and weighed. A grab sample of approximately 500g green material was taken from the pooled sample, weighed, dried at 60^0C for 72 hours and weighed to determine DM content. After sampling plots were cut to a uniform height of 50 mm above ground level using a Honda Lawnmower. Plots were only fertilised when deficiency symptoms become apparent or if deficiencies were identified in the soil analysis. Weed control was exercised mainly by mechanical means. A Student LSD (least significant difference) at 5 % significance level was performed to compare the treatment means (Ott 1998). The STATS module of SAS version 9.2 (2008) was used to analyze the data. Data from various cultivars were also combined according to species to determine the mean production of the different species.

Results and discussion

The mean monthly growth rate of perennial legume cultivars during year 1 and year 2 is shown in Table 2 and Table 3 respectively. During year 1 the white clover cultivar Dusi and red clover cultivars Tropero and Suez had the highest ($P<0.05$) or similar ($P>0.05$) to the highest growth rate from August to December. From March to May during year 1 all the red clover cultivars had the lowest ($P<0.05$) or similar ($P>0.05$) to the lowest growth rate. Red clover and trefoil cultivars were terminated after year 1 due to low production. During year 2 the strawberry clover cultivar Palestine had the highest ($P<0.05$) or similar ($P>0.05$) to

Table 3. The mean monthly growth rate (kg DM ha^{-1} day^{-1}) of perennial legume cultivars during year 2.

Species	Cultivar	June	July	Aug	Sept	Oct	Nov	Dec	Jan
WC	Haifa	8.00^{cd}	11.1^{cd}	14.3^{bc}	23.7^{bc}	24.3^{c}	29.0^{bc}	18.5^{c}	5.27^{bc}
WC	Huia	10.4^{b}	6.88^{de}	7.46^{d}	24.1^{bc}	29.1^{bc}	28.7^{bc}	30.7^{a}	7.21^{abc}
WC	Agrimatt	18.2^{a}	15.5^{bc}	18.4^{ab}	20.6^{bc}	28.6^{bc}	34.1^{b}	16.3^{c}	8.82^{ab}
WC	Agridan	18.0^{a}	16.9^{b}	17.8^{ab}	22.9^{bc}	24.1^{c}	28.2^{bc}	15.7^{c}	6.29^{abc}
WC	Riesling	8.72^{bc}	6.34^{e}	8.01^{d}	14.8^{d}	28.2^{bc}	26.5^{c}	31.0^{a}	13.4^{a}
WC	Dusi	6.88^{cd}	8.74^{de}	14.0^{bc}	17.9^{cd}	27.7^{bc}	31.9^{bc}	35.1^{aa}	11.7^{ab}
WC	Klondike	8.85^{bc}	6.84^{de}	2.97^{de}	19.5^{bcd}	27.3^{bc}	25.9^{c}	17.1^{c}	7.00^{abc}
WC	Alice	10.8^{b}	10.6^{de}	8.36^{cd}	26.7^{b}	32.1^{b}	28.4^{bc}	33.6^{aa}	12.3^{ab}
RC	Quineiqueli	0^{e}	0^{f}	0^{e}	0^{e}	0^{d}	0^{d}	0^{d}	0^{c}
RC	Tropero	0^{e}	0^{f}	0^{e}	0^{e}	0^{d}	0^{d}	0^{d}	0^{c}
RC	Amos	0^{e}	0^{f}	0^{e}	0^{e}	0^{d}	0^{d}	0^{d}	0^{c}
RC	Red gold	0^{e}	0^{f}	0^{e}	0^{e}	0^{d}	0^{d}	0^{d}	0^{c}
RC	Kenland	0^{e}	0^{f}	0^{e}	0^{e}	0^{d}	0^{d}	0^{d}	0^{c}
RC	Suez	0^{e}	0^{f}	0^{e}	0^{e}	0^{d}	0^{d}	0^{d}	0^{c}
RC	Rajah	0^{e}	0^{f}	0^{e}	0^{e}	0^{d}	0^{d}	0^{d}	0^{c}
RC	Lemmon	0^{e}	0^{f}	0^{e}	0^{e}	0^{d}	0^{d}	0^{d}	0^{c}
Trefoil	Soa Gabriel	0^{e}	0^{f}	0^{e}	0^{e}	0^{d}	0^{d}	0^{d}	0^{c}
SC	Palestine	5.87^{d}	22.7^{a}	22.8^{a}	36.7^{a}	40.1^{a}	48.3^{a}	41.1^{a}	11.1^{ab}
		2.387	4.503	5.950	7.388	6.247	7.485	9.127	7.385

WC: white clover

RC: Red clover

SC: Strawberry clover

LSD (0.05) compares over cultivars within season

^{abc}Means with no common superscript differ significantly

Table 4. Total seasonal and annual dry matter production (kg DM ha^{-1}) of perennial legume cultivars during year 1

Species	Cultivar	Winter	Spring	Summer	Autumn	Annual
WC	Haifa	758^{a}	3879^{ef}	2502^{bcd}	1874^{a}	9014^{bcde}
WC	Huia	432^{abcde}	4495^{bcde}	2432^{bcd}	2332^{ab}	9690^{abcd}
WC	Agrimatt	660^{abcd}	4263^{def}	2319^{bcd}	2341^{ab}	9583^{abcd}
WC	Agridan	722^{ab}	4427^{bcde}	2965^{abc}	2187^{abc}	10302^{abc}
WC	Riesling	575^{abcd}	4636^{bcd}	2233^{bcd}	2107^{abc}	9550^{abcd}
WC	Dusi	752^{a}	5689^{a}	2778^{abcd}	1926^{bc}	11145^{a}
WC	Klondike	560^{abcd}	4313^{cdef}	1785^{d}	2294^{abc}	8952^{bcde}
WC	Alice	702^{abc}	5016^{abc}	2488^{bcd}	2444^{a}	10649^{ab}
RC	Quineiqueli	329^{cde}	4657^{bcd}	2754^{abcde}	258^{e}	7999de
RC	Tropero	599^{abcd}	5168^{ab}	2437^{bcd}	311^{e}	8515^{cde}
RC	Amos	302de	3605^{fg}	1955^{cd}	6.90^{e}	5868^{f}
RC	Red gold	646^{abcd}	4791^{bcd}	2605^{abcd}	231^{e}	8273de
RC	Kenland	560^{abcd}	4971^{abcd}	3119^{ab}	337^{e}	8986^{bcde}
RC	Suez	398^{abcde}	5068^{abc}	3222^{ab}	43.0^{e}	8730^{bcde}
RC	Rajah	412^{abcde}	4961^{abcd}	2839^{abc}	274^{e}	8486^{cde}
RC	Lemmon	579^{abcd}	4601^{bcde}	2939^{abc}	376^{e}	8495^{cde}
Trefoil	Soa Gabriel	94^{e}	3589^{fg}	3648^{a}	191^{e}	7522^{ef}
SC	Palestine	361^{bcde}	3071^{g}	2815^{abcd}	1175^{d}	7422^{ef}
LSD (0.05)		372.6	740.7	1053	452.4	1939

WC: white clover

RC: Red clover

SC: Strawberry clover

LSD (0.05) compares over cultivars within season

^{abc}Means with no common superscript differ significantly

Table 5. Total seasonal and annual dry matter production (kg DM ha^{-1}) of perennial legume cultivars during year 2

Species	Cultivar	Winter	Spring	Summer	Annual
WC	Haifa	865^{b}	2443^{bc}	679^{bc}	3987^{bc}
WC	Huia	694^{bc}	2579^{bc}	1085^{ab}	4358^{bc}
WC	Agrimatt	1464^{b}	2625^{bc}	712^{bc}	4801^{b}
WC	Agridan	1477^{b}	2383^{bc}	625^{c}	4484^{b}
WC	Riesling	649^{bc}	2166^{c}	1261^{a}	4077^{bc}
WC	Dusi	840^{b}	2438^{bc}	1335^{a}	4612^{b}
WC	Klondike	515^{c}	2279^{bc}	679^{bc}	3473^{a}
WC	Alice	829^{b}	2742^{b}	1306^{a}	4877^{b}
RC	Quineiqueli	0^{d}	0^{d}	0^{d}	0^{d}
RC	Tropero	0^{d}	0^{d}	0^{d}	0^{d}
RC	Amos	0^{d}	0^{d}	0^{d}	0^{d}
RC	Red gold	0^{d}	0^{d}	0^{d}	0^{d}
RC	Kenland	0^{d}	0^{d}	0^{d}	0^{d}
RC	Suez	0^{d}	0^{d}	0^{d}	0^{d}
RC	Rajah	0^{d}	0^{d}	0^{d}	0^{d}
RC	Lemmon	0^{d}	0^{d}	0^{d}	0^{d}
Trefoil	Soa Gabriel	0^{d}	0^{d}	0^{d}	0^{d}
SC	Palestine	1439^{b}	3963^{a}	1492^{a}	6895^{a}
LSD (0.05)		257.8	509.8	420.3	975.8

WC: white clover

RC: Red clover

SC: Strawberry clover

LSD (0.05) compares over cultivars within season

^{abc}Means with no common superscript differ significantly

The total seasonal and annual DM production of perennial legume cultivars during year 1 and year 2 is shown in Table 4 and Table 5 respectively. During year 1 the white clover cultivar Dusi and red clover cultivars Kenland, Suez and Rajah had the highest ($P<0.05$) or similar ($P>0.05$) to the highest seasonal DM production from winter to summer. During autumn of year 1 all the red clover cultivars and the trefoil cultivar Soa Gabriel had the lowest ($P<0.05$) DM production. The white clover cultivar Dusi had a similar ($P>0.05$) annual DM to other white clover cultivars Huia, Agrimatt, Agridan, Riesling and Alice, but higher ($P<0.05$) than the rest during year 1. During year 2 the strawberry clover cultivar Palestine had the highest ($P<0.05$) or similar ($P>0.05$) to the highest seasonal DM production from winter to summer and the highest ($P<0.05$) total annual DM production.

Conclusions

1. The red clover cultivars Tropero, Suez and Rajah had high growth rates from August to December, but showed a marked decline in growth from January to May during year 1.

2. The white clover cultivars Dusi had the highest annual dry matter production during year 1 and also maintained a high growth rate from August to December. During year 2 the growth rate of white clover cultivars was lower than strawberry clover during all months except June, August and January.

3. White and red clover had the same production from winter to early summer, but red clover production declined from late summer during year 1 to very low rates during autumn.

4. Due to the ability of white clover to remain productive during autumn, it achieved a higher total annual dry matter production than red clover during year 1.

5. The majority of white clover cultivars showed a higher persistence than red clover. If planted in mixtures the early growth of red clover and persistence of white clover could complement each other in the fodder flow program.

6. Strawberry clover was more productive than white clover in year 2.

7. Perennial legumes show poor persistence in this region.

Message to the Farmer

- The white clover cultivar Dusi had the a similar total annual dry matter production to that of Huia, Agrimatt, Agridan, Riesling and Alice during year 1, but higher than the rest.
- The poor persistence of red clover indicates that its growth pattern represents that of an annual in this region.
- Strawberry clover has the potential to out-yield white clover during the second year of production.
- The selection of complementary species and cultivars can improve fodder flow.

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Strawberry Clover