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Productivity of Alfalfa, Rhodes Grass and Their Mixtures in Arid Conditions Under Sprinklers

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إنتاجية البرسيم وحشيشة رودس وخلطاتهما في المناطق الجافة تحت نظام الري بالرش

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خلاصة: تم دراسة الأعلاف المهيمنة في الوقت الحاضر مثل حشيشة رودس والبرسيم (القت) وخلطاتهما لتقيم معدل إنتاجهما في الفترة من يناير ١٩٩٨ إلى أغسطس ١٩٩٩ من خلال برنامج شبه الجزيرة العربية-إيكاردا (APRP) في الرميس في ساحل الباطنه من سلطنة عمان. أشارت النتائج إلى أن أصناف حشيشة رودس كان انتاجها أعلى بشكل ملحوظ من العلف الأخضر (٢٣٠,٥٠ - ٣٠٦,١٠ طن/هكتار) والمادة الجافة (٥٢,٣٩ - ٦٧,٤٨ طن/هكتار) ، تلى ذلك الخلطات (البرسيم:حشيشة رودس) (مادة خضراء: ٢٢٣,٥١-٢٤١,٧٦ طن/هكتار ومادة جافة: ٤٩,٠٢-٥٣,١١ طن/هكتار) ثم أصناف البرسيم (القت) (مادة خضراء: ١٨٢,٠٥ - ١٨٤,٠٤ طن/هكتار ومادة جافة: ٤٠,٨٣ - ٤٤,٦٧ طن/هكتار) بين أصناف حشيشة رودز. كان للصنف كالايد انتاجية عالية جدا من المادة الخضراء والجافّة تلاه الصنف كاتامبورا ثم الصنف توبكت، الذي تم ادخاله حديثا. بالنسبة للبرسيم، كان كلا الصنفين متماثلين في إنتاج المادة الخضراء (١٨٢,٠٥ - ١٨٤,٠٤ طن/هكتار) والمادة الجافة (٤٠,٨٣ -٤٤,٦٧ طن/هكتار) أما بين الخلطات، كان خليط البرسيم وحشيشة رودس ١: ٢ أعلى جدا في انتاج المادة الخضراء والجافّة من الخليطين الآخرين: ١:١ و١:٢.

ABSTRACT: The presently existing dominant perennial forages like Rhodes grass, alfalfa and their mixtures were investigated from January 1998 to August 1999 for their productivity as a part of ICARDA's Arabian Peninsula Research Program (APRP) at Rumais in the Batinah Coast of the Sultanate of Oman. The results indicated that the Rhodes grass varieties produced significantly ($P< 0.01$) higher green (230.50 - 306.10 t/ha^{-1}) and dry matter yields (52.39 - 67.48 t/ha) during the period, followed by the mixture treatments (green matter: 223.51 - 241.76 t/ha^{-1} and dry matter: 49.02 - 53.11 t/ha^{-1}) and alfalfa cultivars (green matter: 182.05 - 184.04 t/ha^{-1} and dry matter: 40.83 - 44.67 t/ha^{-1}). Among the Rhodes grass varieties, Callide had a very high significant yield potential ($P<0.05$) in terms of both green and dry matter yields followed by Katambora and Topcut, a newly introduced variety. In alfalfa, both cultivars produced similar ($P> 0.05$) green matter (182.05 - 184.04 t/ha^{-1}) and dry matter (40.83 -44.67 t/ha^{-1}) yields. Among the mixtures, both green and dry matter yields of 1: 2 mixture of Alfalfa and Rhodes grass were significantly higher than the other two mixture proportions i.e. 1:1 and 2:1 ($P<0.05$).

Keywords: Alfalfa, Rhodes grass, mixtures, productivity, nutrient composition, Sultanate of Oman.

The Sultanate of Oman, the third largest country in the Arabian Peninsula, has 72,864 ha^{-1} of agricultural land under cultivation of which fruits occupy as much as 58 %, followed by perennial fodders (24 %), vegetables (10 %) and grain crops (8%) (MAF, 2000). The Sultanate is an arid country with low rainfall and high evapo-transpiration (ET). Rainfall varies from less than 50 mm in central Oman to more than 300 mm in the mountains. Ground water is the main source for both domestic and agriculture use. The fodder demand in the Sultanate is mostly met by the local production of alfalfa, Rhodes grass and some annual forage cereals and legumes. Alfalfa (*Medicago sativa*), the queen of forage crops, forms an integral part of farm life in the Sultanate, as every farmer desires to grow it at least on a small piece of land depending on his holding, to feed goats, cattle or camels. It occupies about 11,398 ha^{-1} or 15.64 % of the total cultivated area with annual production of 446,000 tons of green forage (MAF, 2000). Among the agro-ecotypes of Oman, perennial

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locals viz Interior local and Batinah local are popular as they are persistent owing to their adaptability to the normal practice of ground level cutting by the farmers. Rhodes grass (*Chloris gayana* L.), on the other hand, is a popular grass species in the Sultanate, second only to alfalfa, because of its drought and salinity stress tolerance and better stand persistency under unfavorable edaphic and climatic conditions (Stephens, 1993). Rhodes grass has occupied a cultivated area of 6,484 ha^{-1} or 8.90 % of the total cultivated area, with annual production of 246,000 tons of green forage (MAF, 2000).

Alfalfa is frequently sown in mixture with grasses like rye grass (Novy *et al.*, 1995), tall fescue (Hoveland *et al.*, 1995), reed canary grass (Shaeffer *et al.*,1988) and Bermuda grass (Stringer *et al.*, 1994) to ensure against failure, to combine in one sward the different seasonal growth patterns of the constituents and/or improve the quality of forage. Similarly, Rhodes grass has also been cultivated in association with number of legumes like alfalfa, Stylo, cowpea, white clover, Centrosema, etc. (Chatterjee and Dass, 1989). Inter-cropping is also practiced in Oman, as the farmers grow legumes like alfalfa and barley together for maximizing forage production in the first cut harvest of alfalfa. However, cropping perennial legumes with grasses is not known. It is well known that alfalfa yields have always been high during winter, while Rhodes grass produces high forage during summer, thus affecting their forage supply during their lean period. An inconclusive study on mixed cropping of alfalfa and Rhodes grass conducted up to five cuts and showed 1:1 proportion of alfalfa and Rhodes grass to give higher forage yield than either pure stands or other mixtures (Anonymous, 1994).

The present paper discusses the nature of forage productivity and growth attributes as well as nutrient composition of alfalfa, Rhodes grass and their mixtures based on the results of the investigations conducted for a period covering 20 months (January 1998-August 1999).

Materials and Methods

The present investigations were undertaken as a part of ICARDA's Arabian Peninsula Research Program at the Livestock Research Center, Rumais located in the South Batinah Coast of Oman, where the land is characterized by sandy soil. The trial was laid in Randomized Complete Block Design with four blocks each having eight treatments consisting of two alfalfa cultivars, viz. Batinah local and Interior local (Nos. 1 and 2), three Rhodes grass cultivars, viz. Katambora, Callide and Top cut (Nos. 3, 4 and 5), and three mixtures of Alfalfa (Batinah local) and Rhodes grass (Katambora) in the proportions of 1:1 (No. 6), 1:2 (No. 7) and 2:1 (No. 8), on 26 January 1998. The alfalfa and Rhodes grass cultivars were planted by the broadcast method, at the seed rates of 40 and 15 kg/ha^{-1} respectively in 8 x 10 m moist soiled plots of their sole and mixed treatments, that were located in the middle of sprinkler lines. The plots of pure alfalfa and Rhodes grass were fertilized with 200 kg N/ha^{-1}: 120 kg P_2O_5/ha^{-1}: 250 kg K_2O/ha^{-1} and 1200 kg N/ha^{-1}: 150 kg P_2O_5/ha^{-1}: 150 kg K_2O/ha^{-1}, respectively as per the recommended doses per year while the plots of their mixtures were fertilized with 900 kg N/ha^{-1}: 150 kg P_2O_5/ha: 150 kg K_2O/ha^{-1} per year (according to our experience with similar experiments conducted during 1993-94) in the form of urea, triple super phosphate and potassium sulphate, respectively. The entire quantities of phosphatic fertilizer along with 1/10 of nitrogen and potash fertilizers were applied before sowing while the remaining nitrogen and potash fertilizers were applied in ten equal splits corresponding to ten probable cuts during the year. The crop was irrigated with water from 1.99 dS/m in the beginning (January 1998) to 2.45 dS/m at the last cut (August 1999), under sprinklers daily according to ETo computed by the Pen Mann-Monteeth method (Doorenbos and Pruitt, 1977) using parameters of meteorological data available from time to time. Catch cans were placed randomly throughout the experimental area and the water was measured from the catch cans after irrigation at frequent intervals to determine the irrigation uniformity, which was found to vary from 50 to 85%. Alfalfa cultivars showed satisfactory germination, ranging from 75 to 95% in all the plots and emerged four days after planting while Rhodes grass cultivars, except Top cut (75-85%), failed to germinate because of low temperatures. Rhodes grass cultivars, viz. Katambora (18-30%) and Callide (5-10%), showed very low germination and required re-sowing during the last week of March 1998 when the day and night temperatures were favorable. The first cut was taken only for the treatment nos. 1, 2, 6, 7 and 8 that involved alfalfa and subsequent cuts were taken in all the treatments at 20-50% blooming from three random sites of 1 m^2 in each plot as fresh fodder recorded in kg. Plant samples of two replications were taken to the laboratory to estimate dry matter for each treatment (Chapman and Pratt, 1961).

The observations on plant height (cm), number of tillers or stem branches/plant, number of leaves/tiller or stem branch and plant density/m^{-2} (number of crowns of alfalfa or hills of Rhodes grass) were recorded at the time of cutting and total water (mm) applied was recorded for growth period of each cut. Plant samples of the first and seventh cuts were taken to the Animal Nutrition Laboratory of the Livestock Research Center, Rumais, for proximate analyses (AOAC, 1984) where Crude Protein (CP), Crude Fiber (CF), Ethyl Extract (EE), Ash and Nitrogen Free Extract (NFE) were estimated. The data on green and dry matter yield were subjected to ANOVA for all treatments, considering treatments and cuts as factors, according to the methods of Gomez and Gomez (1984) using MSTAT-C. The

data on agronomic characters, however, were subjected to ANOVA separately for treatments of alfalfa and alfalfa component in mixtures, and for treatments of Rhodes grass and Rhodes grass components in mixtures. The data on nutrient composition were subjected to ANOVA for all treatments considering stage of sampling and treatments as factors.

Results and Discussion

The mean data on green matter yields (t/ha^{-1}) and dry matter yields (t/ha^{-1}) for each of eighteen cuts are presented respectively in Tables 1 and 2 along with the required statistical parameters, while the data on means of four agronomic characters, viz. plant height (cm), number of tillers or stem branches/plant, number of leaves/tiller or stem branch and plant density/m^2, are presented respectively in Tables 3 to 6 for alfalfa and in Tables 7 to 10 for Rhodes grass.

GREEN AND DRY MATTER YIELDS: The results indicated that the Rhodes grass varieties produced significantly ($P<0.01$) higher green (230.50 - 306.10 t/ha^{-1}) and dry matter yields (52.39 - 67.48 t/ha^{-1}) from thirteen cuts during the period, followed by both mixture treatments (green matter: 223.51 - 241.76 t/ha^{-1} and dry matter: 49.02 - 53.11 t/ha^{-1}) and alfalfa varieties (green matter: 182.05-184.04 t/ha^{-1} and dry matter: 40.83 - 44.67 t/ha^{-1}) from eighteen cuts (Tables 1 and 2). Assuming that 9-10 cuts can be obtained every year, green matter yields in the present experiment would be 159.57 to 177.30 t/ha^{-1}/y^{-1} from 9 cuts or 211.95 to 235.50 t/ha^{-1}/y^{-1} from 10 cuts. The dry matter yields would be 36.27 to 46.71 t/ha^{-1}/y^{-1} from 9 cuts or 40.30 to 51.90 t/ha^{-1}/y^{-1} from 10 cuts. Among the Rhodes grass varieties, Callide had a significantly higher yield ($P<0.05$) in respect of green and dry matter yields, followed by Katambora and Topcut. In our earlier investigations, Callide also out-yielded (222.67 t/ha^{-1} from 13 cuts) Katambora (213.30 t/ha^{-1}) and other varieties in

TABLE 1

Means of green forage yield (t.ha^{-1}) of eight treatments of forage and forage mixtures for the growth period January 1998 to August 1999.

Cut / Treatment		A1	A2	R1	R2	R3	1:1	1:2	2:1	Mean
1	Apr 98	4.40	4.48	-	-	-	4.83	4.77	5.27	4.75
2	May 98	4.50	5.31	20.35	11.85	8.98	5.22	6.15	5.93	8.54
3	Jun 98	3.35	4.58	26.83	35.00	25.33	12.33	13.54	9.71	16.34
4	Jul 98	15.17	14.92	37.50	33.42	35.17	35.42	36.58	32.17	30.04
5	Aug 98	17.93	16.96	26.42	35.75	25.85	21.13	18.06	18.68	22.60
6	Sep 98	15.38	16.75	28.25	31.63	20.88	15.75	16.13	16.00	20.09
7	Sep 98	14.75	11.75	-	-	-	13.75	12.75	13.50	13.30
8	Nov 98	10.15	10.29	25.83	29.58	15.17	9.96	10.85	10.04	10.26
9	Nov 98	14.50	14.50	-	-	-	16.75	19.00	17.75	16.50
10	Dec 98	14.44	12.81	21.13	17.25	15.63	15.63	14.19	15.63	14.54
11	Jan 99	10.63	10.96	-	-	-	12.15	11.94	12.03	11.54
12	Feb 99	13.81	13.16	22.06	23.38	23.63	14.38	13.81	14.63	13.96
13	Mar 99	11.81	11.31	19.94	22.50	6.75	13.38	13.50	11.31	13.81
14	Apr 99	7.50	8.75	-	-	-	7.88	7.75	8.38	8.05
15	May 99	10.25	12.00	30.25	28.75	20.00	13.00	16.50	13.25	18.00
16	Jun 99	7.25	8.00	14.63	16.25	14.63	9.88	10.88	8.75	11.28
17	Jul 99	4.50	4.25	12.00	13.25	12.00	8.00	9.88	6.50	8.80
18	Aug 99	1.75	3.25	6.50	7.50	6.50	3.00	5.50	4.00	4.75
Mean		10.11	10.22	22.44	23.55	17.73	12.91	13.43	12.42	
Total		182.05	184.04	291.68	306.10	230.50	232.40	241.76	223.51	

Statistical Parameters	F-Test	
Treatments	**	(LSD at p=0.05 = 1.00 t.ha^{-1})
Cuts	**	(LSD at p=0.05 = 1.50 t.ha^{-1})
Interaction	**	(LSD at p=0.05 = 4.23 t.ha^{-1})
CV %	23.27	

A1- Batinah; A2- Interior; R1- Katambora; R2- Callide; R3- Topcut; 1:1 (Alfalfa: Rhodes grass); 1:2 (Alfalfa: Rhodes grass); 2:1 (Alfalfa: Rhodes grass).

+ For Rhodes grass varieties means are computed for 13 cuts.

TABLE 2

Means of dry matter yield (t.ha^{-1}) of eight treatments of forage and forage mixtures for the growth period January 1998 to August 1999.

Cut / Treatment		A1	A2	R1	R2	R3	1:1	1:2	2:1	Mean
1	Apr 98	1.52	1.44	-	-	-	1.18	1.33	1.50	1.39
2	May 98	1.55	1.70	3.76	2.19	1.66	1.28	1.71	1.69	1.94
3	Jun 98	1.70	2.46	7.37	9.52	8.15	4.25	4.47	3.67	5.20
4	Jul 98	2.77	2.99	5.67	4.94	5.96	5.69	5.82	5.66	4.94
5	Aug 98	3.93	5.00	5.47	5.81	4.07	4.72	4.21	4.10	4.66
6	Sep 98	3.08	3.79	5.79	5.72	4.76	3.12	3.40	3.34	4.12
7	Sep 98	2.63	2.39	-	-	-	2.65	2.40	2.36	2.49
8	Nov 98	2.01	1.86	5.94	5.56	3.57	2.11	2.06	2.06	2.02
9	Nov 98	2.59	2.95	-	-	-	3.23	3.58	3.10	3.09
10	Dec 98	2.64	2.56	4.12	3.55	3.01	2.47	2.37	2.50	2.51
11	Jan 99	1.66	1.74	-	-	-	1.97	1.95	1.90	1.84
12	Feb 99	2.52	2.43	5.13	5.45	4.81	2.60	2.54	2.95	2.61
13	Mar 99	2.92	2.49	4.65	5.45	1.56	2.66	2.92	2.98	3.20
14	Apr 99	2.11	2.90	-	-	-	1.97	2.87	2.44	2.46
15	May 99	3.26	3.53	9.37	9.36	5.45	4.58	4.99	3.90	5.55
16	Jun 99	2.00	2.24	3.27	4.40	4.09	2.57	2.26	1.97	2.85
17	Jul 99	1.29	1.40	3.45	3.84	3.57	2.36	2.79	1.98	2.58
18	Aug 99	0.66	0.80	1.87	1.70	1.73	0.82	1.45	0.93	1.24
Mean		2.27	2.48	5.06	5.19	4.03	2.79	2.95	2.72	
Total		40.83	44.67	65.84	67.48	52.39	50.23	53.11	49.02	

Statistical Parameters	F-Test	
Treatments	**	(LSD at p=0.05 = 0.24 t/ ha^{-1})
Cuts	**	(LSD at p=0.05 = 0.36 t/ ha^{-1})
Interaction	**	(LSD at p=0.05 = 1.00 t/ ha^{-1})
CV %	24.73	

A1- Batinah; A2- Interior; R1- Katambora; R2- Callide; R3- Topcut; 1:1 (Alfalfa: Rhodes grass); 1:2 (Alfalfa: Rhodes grass); 2:1 (Alfalfa: Rhodes grass).

+ For Rhodes grass varieties means are computed for 13 cuts.

TABLE 3

Means of plant height (cm) of alfalfa and alfalfa component in mixtures for the growth period January 1998 to August 1999.

Cut / Treatment		A1	A2	1:1	1:2	2:1	Mean
1	Apr 98	44.50	48.00	51.42	47.33	48.25	47.90
2	May 98	30.67	41.92	37.00	38.17	34.17	36.38
3	Jun 98	36.58	40.33	34.42	37.83	33.42	36.52
4	Jul 98	49.25	53.25	50.75	53.92	53.00	52.03
5	Aug 98	64.75	70.00	68.25	68.00	69.25	68.05
6	Sep 98	66.25	68.75	66.25	65.63	63.13	66.00
7	Sep 98	69.38	72.50	67.50	76.13	71.38	71.38
8	Nov 98	75.75	80.00	75.00	69.50	71.50	74.35
9	Nov 98	84.25	84.75	86.50	80.50	85.00	84.20
10	Dec 98	86.25	84.75	85.50	87.25	83.00	85.35
11	Jan 99	69.00	70.75	68.75	69.25	67.25	69.00
12	Feb 99	75.25	72.13	75.38	74.00	78.88	75.13
13	Mar 99	73.25	72.50	69.50	74.25	72.75	72.45
14	Apr 99	72.50	71.50	69.25	75.25	74.75	72.65
15	May 99	51.25	55.75	54.25	62.25	58.75	56.45
16	Jun 99	52.25	56.75	45.50	46.00	45.50	49.20
17	Jul 99	42.50	32.75	41.63	41.75	34.25	38.58
18	Aug 99	26.50	28.63	37.63	33.25	42.75	33.75
Mean		59.45	61.39	60.25	61.13	60.39	

Statistical Parameters	F-Test	
Treatments	NS	
Cuts	**	(LSD at p=0.05 = 3.24 cm)
Interaction	**	(LSD at p=0.05 = 7.24 cm)
CV %	8.64	

A1- Batinah; A2- Interior; 1:1 (Alfalfa: Rhodes grass); 1:2 (Alfalfa: Rhodes grass); 2: 1 (Alfalfa: Rhodes grass).

TABLE 4

Means of number of branches/crown of alfalfa and alfalfa component in mixtures for the growth period January 1998 to August 1999.

Cut / Treatment		A1	A2	1:1	1:2	2:1	Mean
1	Apr 98	6.42	5.67	4.75	5.42	5.25	5.50
2	May 98	6.25	6.50	6.08	6.33	6.09	6.25
3	Jun 98	7.67	9.08	7.59	8.17	8.00	8.10
4	Jul 98	13.13	7.25	7.13	9.25	10.50	9.45
5	Aug 98	12.50	11.50	8.88	9.75	11.50	10.83
6	Sep 98	9.75	9.00	8.88	12.13	11.00	10.15
7	Sep 98	9.13	8.63	8.00	10.50	8.50	8.95
8	Nov 98	11.00	10.50	11.00	10.75	13.50	11.35
9	Nov 98	7.25	6.50	9.25	9.25	6.00	7.65
10	Dec 98	11.00	7.25	10.50	9.75	11.50	10.00
11	Jan 99	10.75	8.75	10.00	8.75	8.75	9.40
12	Feb 99	20.50	14.75	12.75	11.25	19.00	15.65
13	Mar 99	20.50	15.00	12.25	11.75	18.00	15.50
14	Apr 99	20.50	15.50	14.00	12.25	15.50	15.55
15	May 99	18.50	16.50	15.00	16.25	15.50	16.35
16	Jun 99	15.25	18.00	17.00	16.50	15.25	16.40
17	Jul 99	3.75	4.00	7.00	7.00	5.25	5.40
18	Aug 99	4.00	4.50	4.50	5.00	5.00	4.60
Mean		11.55	9.94	9.70	10.00	10.78	

Statistical Parameters	F-Test	
Treatments	**	(LSD at p=0.05 = 0.79)
Cuts	**	(LSD at p=0.05 = 1.50)
Interaction	**	(LSD at p=0.05 = 3.35)
CV %	23.25	

A1- Batinah; A2- Interior; 1:1 (Alfalfa: Rhodes grass); 1:2 (Alfalfa: Rhodes grass); 2: 1 (Alfalfa: Rhodes grass).

green matter yield (Anonymous, 1994). In the Sultanate, dry matter yields of Rhodes grass from 36 to 41 t/ha^{-1}/y^{-1} have been also reported earlier by Weber (1989) and Ali and El Hag (1991). Stephens (1993) reported dry matter yields in Rhodes grass from 30 to 53 t/ha^{-1}/y^{-1}with 120 kg N/ha^{-1}/cut and from 20 to 43.50 t/ha^{-1}/y^{-1} in the farmer managed plots. The South Batinah Integrated Study had also reported the achievable green matter yield of Rhodes grass as 154.70 t/ha^{-1}/year (Anonymous, 1993). In alfalfa, both the cultivars produced similar (P>0.05) green matter (182.05 - 184.04 t/ha^{-1}) and dry matter (40.83 - 44.67 t/ha^{-1}) yields. Assuming that 9-10 cuts are realized every year, green matter yields in the present experiment would be 90.99 to 91.98 t/ha^{-1}/y^{-1} from 9 cuts or 101.10 to 102.20 t/ha^{-1}/y^{-1} from 10 cuts. The dry matter yields would be 20.43 to 22.32 t/ha^{-1}/y^{-1} from 9 cuts or 22.70 to 24.80 t/ha^{-1}/y^{-1} from 10 cuts. In our earlier studies, Interior local produced 210.12 t/ha^{-1} of green matter from 19 cuts (Anonymous, 1994). The South Batinah Integrated Study had also reported the achievable green matter yield of alfalfa as 100 t/ha^{-1}/y^{-1} (Anonymous, 1993). Among the mixtures, green and dry matter yields of 1:2 (Alfalfa and Rhodes grass) were significantly higher than the other two mixtures (P<0.05). Earlier workers have also observed such superiority of the grass component in mixtures in similar studies of alfalfa with other grass species (Cooper, 1970; McCloud and Mott, 1953). However, recent

TABLE 5

Means of number of leaves/branch or branch of alfalfa and alfalfa component in mixtures for the growth period (January 1998 to August 1999).

Cut / Treatment		A1	A2	1:1	1:2	2:1	Mean
1	Apr 98	15.00	16.00	13.17	13.59	12.84	14.12
2	May 98	12.25	15.67	14.00	15.92	12.67	14.10
3	Jun 98	14.75	14.50	12.50	13.75	13.50	13.80
4	Jul 98	19.25	20.00	18.00	17.75	18.50	18.70
5	Aug 98	12.25	12.25	14.25	13.75	15.25	13.55
6	Sep 98	20.50	21.00	23.50	23.00	21.75	21.95
7	Sep 98	19.63	21.25	19.00	19.38	19.50	19.75
8	Nov 98	14.75	17.50	12.75	13.25	12.75	14.20
9	Nov 98	14.75	17.25	17.00	16.25	16.50	16.35
10	Dec 98	19.75	21.00	18.25	18.25	19.00	19.25
11	Jan 99	15.50	18.25	16.25	18.75	17.75	17.30
12	Feb 99	13.38	14.38	12.50	12.75	11.13	12.83
13	Mar 99	18.00	16.00	19.25	22.25	17.00	18.50
14	Apr 99	18.00	14.75	17.50	22.25	14.50	17.40
15	May 99	14.25	12.75	16.00	16.00	17.50	15.30
16	Jun 99	15.00	16.00	14.75	15.25	14.50	15.10
17	Jul 99	17.50	15.00	14.75	13.00	17.00	15.45
18	Aug 99	14.25	16.00	14.75	17.25	19.00	16.25
Mean		16.04	16.64	16.01	16.80	16.15	

Statistical Parameters	F-Test	
Treatments	NS	
Cuts	**	LSD at p=0.05 = 1.7)
Interaction	**	(LSD at p=0.05 = 3.8)
CV %	16.81	

A1- Batinah; A2- Interior; 1:1 (Alfalfa: Rhodes grass); 1:2 (Alfalfa: Rhodes grass); 2: 1 (Alfalfa: Rhodes grass).

TABLE 6

Means of plant density/0.1 m^{-2} of alfalfa and alfalfa component in mixtures for the growth period January 1998 to August 1999.

Cut /	Treatment	A1	A2	1:1	1:2	2:1	Mean
1	Apr 98	16.09	13.83	10.42	6.34	10.34	11.40
2	May 98	20.42	19.75	10.42	8.67	13.50	14.55
3	Jun 98	14.33	13.17	7.25	8.67	11.50	10.98
4	Jul 98	14.00	10.88	6.50	6.0	11.25	9.73
5	Aug 98	8.38	5.75	8.63	7.38	8.50	7.73
6	Sep 98	6.88	6.63	5.63	5.50	5.75	6.08
7	Sep 98	6.63	6.63	5.50	4.25	5.38	5.68
8	Nov 98	7.00	7.00	8.50	5.50	8.75	7.35
9	Nov 98	11.50	10.75	9.00	8.25	9.75	9.85
10	Dec 98	10.50	9.25	5.75	6.00	6.25	7.55
11	Jan 99	9.75	8.75	6.25	5.75	6.25	7.35
12	Feb 99	6.75	6.25	5.25	5.25	5.25	5.75
13	Mar 99	7.25	6.50	5.50	5.50	5.75	6.10
14	Apr 99	7.50	6.75	6.50	5.75	6.50	6.60
15	May 99	8.00	6.00	5.75	5.75	5.50	6.20
16	Jun 99	6.25	6.75	5.75	6.25	7.00	6.40
17	Jul 99	2.25	2.50	3.25	2.75	3.00	2.75
18	Aug 99	2.00	2.00	1.75	1.75	2.00	1.90
Mean		9.19	8.29	6.53	5.85	7.35	

Statistical Parameters	F-Test	
Treatments	**	(LSD at p=0.05 = 0.59)
Cuts	**	(LSD at p=0.05 = 1.11)
Interaction	**	(LSD at p=0.05 = 2.49)
CV %	24.17	

A1- Batinah; A2- Interior; 1:1 (Alfalfa: Rhodes grass); 1:2 (Alfalfa: Rhodes grass); 2: 1 (Alfalfa: Rhodes grass).

TABLE 7

Means of plant height (cm) of Rhodes gass and Rhodes grass component in mixtures for the growth period January 1998 to August 1999.

Cut/	Treatment	R1	R2	R3	1:1	1:2	2:1	Mean
1	Apr 98	-	-	-	53.08	52.24	56.92	54.08
2	May 98	131.34	95.17	97.50	44.33	47.75	46.25	77.06
3	Jun 98	89.17	96.00	84.09	66.92	75.17	67.00	79.72
4	Jul 98	95.17	97.75	98.83	92.42	91.08	90.50	94.29
5	Aug 98	96.00	116.00	97.00	106.75	105.25	95.75	102.79
6	Sep 98	145.63	124.38	112.00	100.63	99.38	105.63	114.60
7	Sep 98	-	-	-	91.25	86.25	90.00	89.17
8	Nov 98	150.75	137.00	116.75	101.25	101.75	104.00	118.58
9	Nov 98	-	-	-	17.75	19.75	16.50	18.00
10	Dec 98	113.00	107.50	88.00	52.00	50.75	43.75	75.83
11	Jan 99	-	-	-	33.50	30.00	31.75	31.75
12	Feb 99	120.13	114.00	94.50	85.75	83.13	80.13	96.27
13	Mar 99	-	-	-	94.25	80.75	93.00	89.33
14	Apr 99	96.25	87.00	77.00	44.25	55.25	65.50	70.88
15	May 99	116.25	98.50	82.00	52.75	59.75	60.00	78.21
16	Jun 99	93.00	88.75	73.25	50.00	56.25	45.75	67.83
17	Jul 99	47.25	76.00	69.75	62.25	62.38	57.38	62.50
18	Aug 99	69.75	58.00	68.38	56.13	68.13	72.50	65.48
Mean		104.90	99.70	89.16	66.96	68.06	67.91	

Statistical Parameters	F-Test	
Treatments	**	(LSD at p=0.05 = 4.57 cm)
Cuts	**	(LSD at p=0.05 = 6.22 cm)
Interaction	**	(LSD at p=0.05 = 15.24 cm)
CV %	15.91	

R1- Katambora; R2- Callide; R3- Topcut; 1: 1 (Alfalfa: Rhodes grass); 1: 2 (Alfalfa: Rhodes grass); 2: 1 (Alfalfa: Rhodes grass).
+ For Rhodes grass varieties means are computed for 13 cuts.

studies indicated that alfalfa monoculture with new varieties and mixtures were superior to grass monoculture (tall fescue, *Festuca arundinacea L.*) (Hoveland *et al.*,1995).

GROWTH ATTRIBUTES:

(a) Alfalfa vs Alfalfa component:

The performance of alfalfa was, in general, improved cut after cut with respect to plant height (Table 3) and number of branches/crown (Table 4). There was a significant increase in the number of leaves/main branch in cuts- 4, 6, 7, 9, 10, 11, 13, 14 and 15 as compared to rest of the cuts (Table 5). The plant density significantly ($P<0.05$) increased initially up to cut-2 but later on decreased significantly ($P<0.05$) with inconsistency up to cut-8. The plant density had a significant rise and fall in subsequent cuts depending upon favorable (winter) and unfavorable (summer) climatic conditions for the crop (Table 6). Batinah local was found to be significantly ($P<0.05$) superior to either Interior local or the alfalfa crop in mixtures with respect to number of branches/crown.

(b) Rhodes grass vs Rhodes grass component:

In the case of Rhodes grass, although plant height differed significantly ($P<0.05$) among the cultivars over cuts, in pure crop it improved significantly cut after cut (Table 7). In mixtures it improved only up to cut-8 taken during early November, but later it was reduced significantly up to cut-12 due to unfavorable conditions (low temperature). Plant density was significantly ($P<0.05$) decreased cut after cut (Table 10) with a significant ($P<0.05$) increase in the number of tillers/plant (Table 8) up to cut-12 in pure crop irrespective of varieties contributing to productivity. In mixtures the plant density was also significantly ($P<0.05$) decreased with significant ($P<0.05$) increase in the number of tillers/plant only up to cuts 7 and 8. Subsequently, these characters were adversely affected due to low temperature in the winter (Tables 8 and 10). The number of leaves in the main tillers of pure Rhodes grass crop varied significantly from 4.5 to 7.0 during summer and from 4.0 to 5.0 in the winter, while that in the Rhodes grass component in mixtures was at 4 to 7 leaf stage during summer as compared to 2-4 leaf stage during winter (Table 9). This is because mixed treatments were harvested along with alfalfa treatments when they attained the stage of cutting, at which time Rhodes grass growth was slow during winter.

Rhodes grass crop was slow and steady in its growth time in winter, from October to February, during which time only three cuts in pure crop were taken

TABLE 8

Means of number of tillers/plant of Rhodes gass and Rhodes component grass in mixtures for the growth period January 1998 to August 1999.

Cut / Treatment		R1	R2	R3	1:1	1:2	2:1	Mean
1	Apr 98	-	-	-	9.25	11.92	10.33	10.50
2	May 98	9.17	8.58	9.50	9.08	8.42	8.67	8.90
3	Jun 98	8.33	7.42	10.50	12.25	8.17	9.08	9.29
4	Jul 98	15.38	10.13	17.13	11.63	8.63	12.38	12.54
5	Aug 98	13.00	12.75	13.00	7.38	6.13	6.75	9.83
6	Sep 98	12.00	11.50	12.25	11.13	12.25	16.63	12.63
7	Sep 98	-	-	-	9.00	11.63	7.65	9.43
8	Nov 98	12.25	11.75	18.50	4.25	5.50	5.50	9.63
9	Nov 98	-	-	-	3.25	3.50	2.25	3.00
10	Dec 98	15.00	16.75	17.25	6.00	6.25	6.50	11.29
11	Jan 99	-	-	-	7.00	4.75	5.50	5.75
12	Feb 99	21.75	18.25	30.75	5.75	5.25	5.50	14.54
13	Mar 99	-	-	-	4.75	4.25	4.00	4.33
14	Apr 99	22.00	19.50	10.50	5.00	6.25	5.00	11.38
15	May 99	25.75	17.50	19.50	10.50	7.25	7.25	14.63
16	Jun 99	23.25	19.25	16.75	8.25	7.25	8.25	13.83
17	Jul 99	16.75	15.75	14.25	6.75	7.00	6.50	11.17
18	Aug 99	16.50	15.50	18.00	7.50	6.00	6.25	11.63
Mean		16.24	14.20	15.99	7.71	7.24	7.44	

Statistical Parameters	F-Test	
Treatments	**	(LSD at p=0.05 = 0.79)
Cuts	**	(LSD at p=0.05 = 1.38)
Interaction	**	(LSD at p=0.05 = 3.38)
CV %	26.12	

R1- Katambora; R2- Callide; R3- Topcut; 1: 1 (Alfalfa: Rhodes grass); 1: 2 (Alfalfa: Rhodes grass); 2: 1 (Alfalfa: Rhodes grass).
+ For Rhodes grass varieties means are computed for 13 cuts.

TABLE 9

Means of number of leaves per tiller of Rhodes grass and Rhodes grass component in mixtures for the growth period January 1998 to August 1999.

Cut / Treatment		R1	R2	R3	1:1	1:2	2:1	Mean
1	Apr 98	-	-	-	4.58	4.75	4.09	4.47
2	May 98	6.09	6.25	5.42	5.92	6.00	6.08	5.96
3	Jun 98	4.75	4.75	4.50	4.00	4.50	4.25	4.46
4	Jul 98	6.75	5.75	4.75	4.75	5.50	5.25	5.46
5	Aug 98	6.25	6.25	6.00	6.75	6.50	5.75	6.25
6	Sep 98	6.38	5.88	5.00	4.50	6.63	6.25	5.77
7	Sep 98	-	-	-	7.00	6.88	6.13	6.67
8	Nov 98	6.75	6.00	5.75	4.75	5.00	4.75	5.50
9	Nov 98	-	-	-	2.50	2.75	3.00	1.38
10	Dec 98	5.25	4.75	4.50	4.00	3.75	3.50	4.29
11	Jan 99	-	-	-	4.50	4.75	4.75	4.67
12	Feb 99	5.88	5.63	4.50	4.00	4.00	4.38	4.73
13	Mar 99	-	-	-	5.00	4.50	4.75	4.75
14	Apr 99	5.25	5.50	4.50	4.00	4.75	5.50	4.92
15	May 99	6.00	5.25	4.75	4.50	4.50	4.75	4.96
16	Jun 99	6.00	5.50	4.50	4.25	5.00	4.75	5.00
17	Jul 99	3.25	4.00	3.50	3.50	3.25	3.50	3.50
18	Aug 99	4.50	3.75	3.75	3.00	3.00	3.25	3.54
Mean		5.62	5.33	4.72	4.53	4.78	4.70	

Statistical Parameters	F-Test	
Treatments	**	(LSD at p=0.05 = 0.24)
Cuts	**	(LSD at p=0.05 =0.42)
Interaction	**	(LSD at p=0.05 = 1.03)
CV %	17.58	

R1- Katambora; R2- Callide; R3- Topcut; 1: 1 (Alfalfa: Rhodes grass); 1: 2 (Alfalfa: Rhodes grass); 2: 1 (Alfalfa: Rhodes grass).
+ For Rhodes grass varieties means are computed for 13 cuts.

as compared to five cuts taken from early April, when satisfactory germination of Rhodes grass was realized until September. Thus, Rhodes grass was cut only thirteen times during the period of experiment. Rhodes grass proportion in the mixtures was reduced gradually and significantly ($P<0.05$) initially up to cut-4, because of farmers' method of hand-cutting adapted for the mixtures, which was not favorable for regeneration of the Rhodes grass component. This reduction was rapid from cut-5 through cut-18 due to the combined effect of shading by vigorous alfalfa plants to slow growing Rhodes grass culms, especially during winter. This was also noticed in the studies of Davis and Tyler (1962) for alfalfa-orchard grass mixture and Stringer *et al.* (1994) for alfalfa-Bermuda grass mixture.

NUTRIENT COMPOSITION: The studies on nutrient composition of the treatments at two different sampling stages revealed that effects of treatments, sampling stages and their interaction were significantly different ($P<0.01$). Among the treatments, alfalfa and alfalfa mixtures were rich in % CP (Crude Protein) and % EE (Ethyl Extract) as compared to Rhodes grass varieties ($P<0.05$) while Rhodes grass varieties were significantly richer in CF (Crude Fiber) ($P<0.05$) in comparison with alfalfa and mixed treatments. Exceptionally, Top cut variety of Rhodes grass was significantly higher in % CP than Alfalfa-Interior ($P<0.05$). However, differences between treatments with respect to starch (Nitrogen Free Extract, NFE) and ash were significant ($P<0.05$) but inconsistent (Table 11).

TABLE 10

Means of plant density/ 0.1 m^{-2} of Rhodes gass and Rhodes grass component in mixtures for the growth period January 1998 to August 1999.

Cut / Treatment		R1	R2	R3	1:1	1:2	2:1	Mean
1	Apr 98	-	-	-	6.75	10.25	4.83	7.28
2	May 98	24.92	16.33	31.33	12.09	13.42	8.25	17.72
3	Jun 98	13.92	8.42	15.67	7.25	9.42	6.84	10.25
4	Jul 98	11.75	8.50	17.63	7.38	8.38	5.63	9.88
5	Aug 98	6.75	7.00	6.38	3.38	3.63	2.75	4.98
6	Sep 98	6.75	7.88	6.38	3.25	3.63	3.50	5.23
7	Sep 98	-	-	-	2.88	1.50	1.93	2.10
8	Nov 98	8.25	7.25	5.75	2.00	2.50	1.50	4.54
9	Nov 98	-	-	-	1.25	1.25	0.75	1.08
10	Dec 98	7.00	7.00	5.50	1.00	1.50	1.25	3.88
11	Jan 99	-	-	-	1.25	1.25	1.25	1.25
12	Feb 99	7.25	6.00	4.75	1.00	1.00	1.00	3.50
13	Mar 99	-	-	-	1.25	1.25	1.25	1.25
14	Apr 99	6.00	6.00	4.50	2.25	3.00	2.50	4.04
15	May 99	8.00	6.75	4.50	2.75	4.00	2.25	4.71
16	Jun 99	7.00	6.25	4.25	3.50	2.50	2.25	4.29
17	Jul 99	6.75	5.75	5.25	2.50	3.00	3.00	4.38
18	Aug 99	6.50	5.50	4.75	3.00	3.00	2.00	4.13
Mean		9.30	7.59	8.97	3.60	4.14	2.93	7.28

Statistical Parameters	F-Test	
Treatments	**	(LSD at p=0.05 = 0.48)
Cuts	**	(LSD at p=0.05 = 0.83)
Interaction	**	(LSD at p=0.05 = 2.04)
CV %	30.19	

R1- Katambora; R2- Callide; R3- Topcut; 1: 1 (Alfalfa: Rhodes grass); 1: 2 (Alfalfa: Rhodes grass); 2: 1 (Alfalfa: Rhodes grass).
+ For Rhodes grass varieties means are computed for 13 cuts.

TABLE 11

Nutrient composition of eight treatments of forage and forage mixtures for two sampling stages (April 98 = stage 1, first cut; Sept 98 = stage 2, seventh cut).

Treatments	Sampling Stage	Nutrient Composition (%)				
		CP	CF	EE	Ash	NFE
Alfalfa – Batinah	1	16.80	19.30	2.20	14.50	47.20
	2	14.45	29.10	3.00	11.05	42.40
	Average	15.63	24.20	2.60	12.78	44.80
Alfalfa – Interior	1	14.60	28.60	2.50	12.30	42.00
	2	14.30	29.10	2.90	10.75	42.95
	Average	14.45	28.85	2.70	11.53	42.48
Rhodes Grass - Katambora	1	12.15	29.05	1.95	12.25	44.60
	2	6.95	29.10	1.95	12.28	49.73
	Average	9.55	29.08	1.95	12.26	47.17
Rhodes Grass - Callide	1	10.70	26.90	1.80	14.00	43.30
	2	8.40	26.90	1.85	13.90	47.15
	Average	9.55	26.90	1.83	13.95	45.23
Rhodes Grass - Top cut	1	15.40	31.30	1.80	13.10	43.10
	2	14.70	31.30	1.80	13.25	45.25
	Average	15.05	31.30	1.80	13.18	44.18
Alfalfa : Rhodes Grass (1:1)	1	15.40	21.65	3.40	13.20	46.35
	2	14.70	21.65	2.55	11.60	49.50
	Average	15.05	21.65	2.98	12.40	47.93
Alfalfa : Rhodes Grass (1:2)	1	16.55	24.90	2.80	13.00	42.75
	2	17.60	24.90	2.90	10.99	43.61
	Average	17.08	24.90	2.85	12.00	43.18
Alfalfa : Rhodes Grass (2:1)	1	15.90	24.05	2.80	14.20	43.05
	2	15.00	24.10	2.90	10.40	47.60
	Average	15.45	24.08	2.85	12.30	45.33

Statistical Parameters

		%CP	%CF	%EE	%Ash	%NFE
Treatments	F-Test	**	**	**	**	**
	LSD at p=0.05	0.20	0.40	0.03	0.09	0.50
Cuts	F-Test	**	**	**	**	**
	LSD at p=0.05	0.40	0.80	0.07	0.18	1.01
Interaction	F-Test	**	**	**	**	**
	LSD at p=0.05	0.56	1.13	0.09	0.26	1.42
	CV%	1.93	2.01	1.79	0.97	1.48

† CP- Crude Protein; CF- Crude Fiber; EE- Ethyl Extract; NFE (Nitrogen Free Extract).

Conclusions

The results of these investigations indicated that Rhodes grass produces highest green and dry matter yields/ha^{-1}/y^{-1}, of which a major share comes during summer. Among the mixtures, the mixture having a high proportion of Rhodes grass would give high mean yield. Alfalfa, however, would produce less green or dry matter yields than either Rhodes grass or mixtures.

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