American-Eurasian J. Agric. & Environ. Sci., 8 (2): 189-196, 2010
ISSN 1818-6769

Estimation Yield and Quality of Alfalfa and Clover for Mixture Cropping Pattern at Different Seeding Rates

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Abstract: Mixing cropping of two or more crop species sown in the same time and grow with each other is one of the common methods of multiple cropping which encourage sustainability in agriculture through increasing plant diversity (biodiversity). Field experiments were carried out over two seasons at Agricultural and Research Station, College of Food and Agriculture Sciences, Derab, Riyadh, King Saud University. The main objective of this study was to evaluate the productivity and quality of alfalfa and berseem clover in sole crops compared with mixture cropping at different seeding rates. The study included four different combinations of seeding rate of alfalfa and clover. Data recorded forage and dry yield, land equivalent ratio, agressivity value and quality traits viz., crude protein and carbohydrate contents. Mixture of 80 % alfalfa+20% clovers surpassed the other check treatments and recorded the highest fresh and dry yield, followed by mixture of 70 % alfalfa +30% clover. In the same times, land use efficiency was increased by 18-12 % in the first and second season, respectively. Confirmed these obtained, mixing cropping had significant increase in protein and carbohydrate yield. Finally, mixing cropping had benefits for low input conditions like our environment and more suitability than pure stand.

Key words: Mixing cropping system · Intercropping alfalfa with clover · Alfalfa (*Medicago sativa* L.)

INTRODUCTION

Forage which either directly or indirectly consumes by cattle and poultries, play tremendous important roles in animal production. Medics and clovers including berseem clover (*Trifolium alexandrinum* L.) and Alfalfa (*Medicago sativa* L.) have constituted backbone of forage production crops. Intercropping is practiced by majority of farmers in many regions of the world. Intercropping has since long been used as mean to cover the risk of failure of base crop and maintain the net return. This system can lead to increasing final yield without decreasing the sustainability of soil, suppresses weeds, reduces pest disease infestation and gives stable yield over time. Berseem clover, as an annual leguminous forage species well adapted to semi-arid conditions. It is grown in both spring and fall growing seasons as direct cropping, intercropping or in crop rotation with many other crops province conditions. Berseem cultivars also differ in number of harvested cuts, with cultivars being grouped into three types: single cut, intermediate and multiple cut. In field experiment, Ranjbar [1] compared forage and hay yield performance of 10 berseem clover genotypes. Who reported that, fresh and dry forage yield of cultivars were significantly different.

Most of recent researches on berseem clover have focused on intercropping system with annual forage grasses. Berseem clover's behavior in intercropping system is one of attractive scientific findings of a number of researches [2-8]. By definition of potential benefits of intercropping berseem clover with cereal crops include, increased total dry matter yields, improved forage quality, reduced fertilizer needs and increased subsequent crop yield, many researchers pointed berseem clover as one of suitable forage crop [1,3].

Alfalfa (*Medicago sativa* L.) is one of the most important forage crops grown over a wide range of sod and climatic conditions and it is able to produce high yields without nitrogen fertilization. It has the highest yield potential and one of the highest feeding values of all adapted perennial forage legumes. Its high level of digestible protein makes it an extremely valuable feed. Thus, it can be used successfully in many types of livestock feeding programs as pasture, hay, silage, green chop and as a cash crop.

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From last decade, interest in increasing forage production through cultivation forage crop in mixtures has been increased. This in turn may increase forage quality improvement, livestock bloat avoidance, increase water use efficiency, fertilizer requirements reduction and chare in solving the animal production problem.Several investigations concluded that mixing legumes with grasses increased forage production and protein content and thus, increased valuable feed ratio. Under low-input agricultural systems especially in arid and semi-arid regions, whereas water is the most limiting factor for plant production, recommendation of mixing cropping system is an important role in profitability and sustainability in crop production. If the system well adapted considering morphological and physiological properties, mixing cropping system will be enhanced compared to pure stand of each crop [9, 10]. Abdel Magid *et al.* [11], in field experiments carried out under irrigation in Central Saudi Arabia reported that intercropping had benefits for alfalfa, increasing its protein content, green chop and hay yield.

Available review of literature shows that, in many experiments conducted at different countries the performance of mixing cropping systems was better than the sole crops. For instance mixing cropping of berseem clover/lolium [12], alfalfa/timouthy [13], barley/pea [14], wheat/pea [15], cowpea/maize [14], sorghum/alfalfa Chaichi *et al.* [10] and berseem/barley [16,17] could be mentioned. One of the most important reasons to grow two or more crops together is the increase in productivity per unit of land [18].

More production of protein and minerals was obtained in legume plants than its mixtures with grass plants as well as pure stands of grasses Abd El-Gawad *et al*. [19] and Deljoo and Sepehri [20], showed that protein content of clover mixtures with rye grass was higher than in their pure stands; more production was obtained as clover rates increased.

Mixed cropping of legumes and grasses for high forage production is not a common practice among many farmers, however, it is necessary to investigate the potential forage production in mixed and sole cropping. Therefore, the main objective of this study was to gain a better understanding of the complementarily of the two crops in intercropping systems at different seeding rates under arid environment of Saudi Arabia, by estimating yield and quality and water use efficiency in sole crops compared to intercrops.

MATERIALS AND METHODS

Field experiments were carried out under flood irrigation system in Central Saudi Arabia, at Agricultural and Research Station, College of Food and Agriculture Sciences, Derab, near Riyadh, King Saud University (24°42N latitude and 46 ° 44 E Longitudes, Altitude 600 m), during the winters seasons of 2004–05 and 2005 /06 to evaluate forage yield and quality of clover and alfalfa under mixture cropping systems compared to pure stand of each. Treatments included 6 treatments (2 pure stand and 4 mixture treatments), as follows:

Table 1: Chemical properties of the irrigation water during the growing seasons of 2004–05 and 2005 /06)

Chemical properties	2004–05	2005 /06
pH	7.10	7.17
EC(dS/m^{-1})	1.45	1.73
O.M %	0.02	0.02
Soluble cations (meq./l)		
Ca^{+}	6.30	5.50
Mg^{+}	1.75	1.87
Na^{+}	7.35	7.65
K^{+}	0.44	0.46
Soluble anions (meq./l)		
HCO_3^{-}	2.40	2.60
Cl^{-}	4.85	4.80
SO_3^{-}	9.14	8.56
Total N PK (ppm)		
N	10.50	11.01
P	9.23	9.42
K	17.00	17.12

- 100 % pure clover (*Trifolium alexandrinum* L.) (40 kg/ha. the recommended seeding rate).
- 100 % pure alfalfa (*Medicago sativa* L.) (40 kg/ha the recommended seeding rate).
- 90% of seeding rate/ha of alfalfa + 10 % of seeding rate/ha of clover.
- 80% of seeding rate/ha of alfalfa + 20 % of seeding rate/ha of barley.
- 70% of seeding rate/ha of alfalfa + 30 % of seeding rate/ha of clover.
- 50 % of seeding rate/ha of alfalfa + 50 % of seeding rate/ha of clover.

Before commencement the field experiment, sample from soil sites was taken for physical and chemical analyses (Table 2) by the methods described by Cottenie *et al.* [21] and But [22]. Sample of water irrigation was also analyzed (Table 1) according to the methods described by APHA [23]. Treatments were arranged in a randomized complete block design in four replications. Seed bed was prepared before sowing as recommended, according to the conventional production practices

Table 2: Physical and chemical properties of the experimental soil site during the growing seasons of 2004–05 and 2005 /06)

Properties	2004–05	2005 /06
Saturation percentage (%)	29.70	28.12
pH (soil paste 1:5)	7.86	7.81
EC (dS/m^{-1})	3.88	3.91
Organic matter (%)	0.46	0.47
$CaCO_3$ (%)	29.42	29.63
Field capacity (%)	16.30	16.42
Wilting point (%)	7.67	7.71
Sand (%)	57.92	57.82
Silt(%)	27.20	27.25
Clay (%)	14.88	14.90
Soil texture (%)	Sandy loam	Sandy loam
Available macro. and micro nutrients (ppm)		
N	35.40	35.80
P	14.80	12.76
K	243.50	251.42
Fe	3.27	3.24
Mn	2.44	2.61
Zn	6.07	6.13
Cu	0.70	0.74

followed at the central region of Saudi Arabia. Experimental soil sites were divided into plots, each plot consisted of 8 lines 15 cm apart, 4m in length. Plot area was (4.80 m^2). Phosphorus and potassium fertilizers were applied broadcasting during soil bed preparation in the form of calcium super phosphate (15.5 % P_2O_5) by the rate of 300 kg/ha, whereas potassium was applied by the rate of 200 kg/ha in the form of potassium sulphate (K_2O 48%). Nitrogen fertilizer was added as ammonium nitrate (33.3 %N) in five split equal doses, after every cut and before irrigation.

Seeds of the two crops viz., clover (cv.Miskawai), alfalfa (cv. Cuf 101) were sown according to the seed rate of the experimented treatments on 28 and 26 October, in the first and second seasons, respectively, using hand drilled method in lines. Irrigation took place as recommend during the growing season, using flooding irrigation system through line pipe provide with meter gages. First, second, third, fourth and fifth cuts were taken at the age of 70, 120,145,170 and 200 days after sowing. One square meter from each treatment for determines forage and dry matter yield for every cut in pure stand and mixtures. Yield per hectare was calculated. Crude protein was determined as described by Koch and McMeeking [24] and total carbohydrate according to Shaffer and Hartmann [25] (1921). The competition relationships between the two crops were also determinated viz., land equivalent ratio (LER), according to the method suggested by DeWit and Den Bergh [26] and has become common practiced in intercropping studies by Willey [27], aggressively values (A), according to formula described by Mc Gilchrists [28] and increasing/ decreasing percentage, were calculated as follows:

A = (Intercropping yield - pure clover yield) divided by Intercropping yield and multiplying by 100

B = (Intercropping yield - pure alfalfa yield) divided by Intercropping yield and multiplying by 100

Analysis of variance analysis, for the data obtained in the two seasons was carried out according to procedures outlined by Gomez and Gomez [29]. Differences between means were compared using the Least Significant Differences (LSD) values, at 5% level according to Waller and Duncan [30].

RESULTS AND DISCUSSION

The present results obtained herein included the effect of mixing alfalfa with clover by different seeding rates on fresh and dry yield, competition relationships between the two crops, crude protein and total carbohydrate yield compared to pure stand of each.

Mixtures Effect on Fresh and Dry Forage Yield: Data manifested in Tables 3 and 4 showed that mixture resulted higher forage yield than their pure stand. This was true in the 3rd, 4th and 5th cuts and the total of all cuts under the different seeding rates in both seasons. In the same table, noticeable that sharp decrement was detected in the yield of clover in pure stand compare to alfalfa as well as their mixture in the fifth cut.

Table 3: Mean of fresh weight, (ton/ha) of alfalfa and clover in pure stand and its mixtures at different seeding rates in 2004–05 season)

	Cut number,(days after sowing)						
Treatments	1st(70)	2nd(120)	3rd(145)	4th(170)	5th(200)	Total	General mean
Clover pure	21.57	27.38	22.82	19.08	0.99	91.84	18.37
Alfalfa pure	9.93	17.83	21.24	20.20	12.37	81.57	16.31
90 % alfalfa +10% clover	14.14	21.88	26.19	24.22	11.18	97.61	19.52
80 % alfalfa +20% clover	14.62	26.88	32.15	28.82	11.43	113.90	22.78
70 % alfalfa +30% clover	13.64	22.89	28.88	26.70	8.08	100.19	20.04
50 % alfalfa +50% clover	12.87	23.44	29.74	25.32	8.12	99.49	19.90
LSD at 0.05 level	1.25	0.46	0.54	1.12	0.78	1.63	--

Table 4: Mean of fresh weight, (ton/ha) of alfalfa and clover in pure stand and its mixtures at different seeding rates in 2005 /06 season)

	Cut number,(days after sowing)						
Treatment	1st(70)	2nd(120)	3rd(145)	4th(170)	5th(200)	Total	General mean
Clover pure	21.12	19.95	13.02	5.37	0.87	60.33	12.07
Alfalfa pure	13.83	22.49	15.68	17.33	13.85	83.18	16.64
90 % alfalfa +10% clover	14.95	24.05	20.12	18.31	14.72	92.15	18.43
80 % alfalfa +20% clover	17.14	24.97	21.66	18.78	13.35	95.90	19.18
70 % alfalfa +30% clover	15.04	25.61	20.74	18.37	13.41	93.17	18.63
50 % alfalfa +50% clover	15.12	25.98	19.84	16.42	10.22	87.58	17.52
LSD at 0.05 level	0.89	0.54	0.72	1.24	0.76	0.98	--

This is mainly due to the ability of alfalfa to continue in production until this time and after that. However, due to the previous reason the mixture of 80 % alfalfa +20% clovers recorded the highest fresh forage yield and surpassed the other treatments in both seasons. It could be concluded that mixing alfalfa with clover by seeding rates 80 % alfalfa and 20% clovers increased the forage production more than their pure stands and other check mixtures treatments, followed by the mixture of mixing alfalfa with clover by seeding rates 70 and 30%. Similar results were reported by Fukai and Trenbath[2], Ghaffarzadeh [3], Holland and Brummer [4], Juskiw *et al.* [5,6], Ross *et al.* [7,8], they reported the benefits of intercropping berseem clover with cereal crops, include increased total dry matter yields, improved forage quality, reduced fertilizer needs and increased subsequent crop yield. Moreover, in the same concern Morris and Garrity [9], Chaichi *et al.* [10] and Abdel Magid *et al.* [11], concluded that mixing cropping system is an important role in profitability and sustainability in crop production. Such effect might be due to the more efficient use of the surround environmental condition such as more occupation of deeper layers of the soil by the different root systems of alfalfa and clover as well as the foundation of more canopy cover in the space as a result of the different vegetation types of both alfalfa and clover. This in turn will result in more efficient absorption of nutrients from the soil, more interception of light energy at different layers and finally more photosynthetic rate, better translocation of photosynthates from source to sink. This is causally the favorably influenced the higher dry matter accumulation.

Data presented in Tables 5 and 6, worthy indicated that, dry matter production increased steadily up to the third and fourth cuts for clover and alfalfa as well as their mixture in both seasons, respectively with advancement in age and nearly attained its peak at the third cut. Such effect was auspiciously influenced by the same factors affected early in the fresh yield. Thus, such effect was expected since the early effect was detected on fresh yield. Among the experimented treatments under the present investigation, the same treatments effect on fresh yield, (the mixture of 80 % alfalfa +20% clovers) also recorded the highest dry yield, in both seasons followed by mixture of (70 % alfalfa +30% clovers) in the first seasons, whereas in the second season the picture was changed mixture seeding by the rate of (90 % alfalfa +10% clovers) and (70 % alfalfa +30% clovers) recorded the same values of dry yield and occupied the second series. This is in consonance with the findings of Abdel Magid *et al.* [11] and Zaeifizadeh *et al.* [13].

Table 5: Mean of dry weight, (ton/ha) of alfalfa and clover in pure stand and its mixtures in at different seeding rates in 2004 /05 season)

	Cut number,(days after sowing)						
Treatments	1st(70)	2nd(120)	3rd(145)	4th(170)	5th(200)	Total	General mean
Clover pure	3.15	4.35	4.84	3.93	0.198	15.77	3.15
Alfalfa pure	3.12	3.21	4.25	4.84	2.97	16.36	3.27
90 % alfalfa +10% clover	2.55	3.94	5.24	5.09	2.46	19.28	3.86
80 % alfalfa +20% clover	2.32	4.12	5.76	5.34	2.70	20.24	4.05
70 % alfalfa +30% clover	2.18	3.98	5.49	5.26	1.62	18.53	3.71
50 % alfalfa +50% clover	2.03	3.10	5.65	4.99	1.43	17.20	3.44
LSD at 0.05 level	0.37	0.47	0.51	0.86	0.52	0.67	--

Table 6: Mean of dry weight, (ton/ha) of alfalfa and clover in pure stand and its mixtures at different seeding rates in 2005 /06 season)

	Cut number,(days after sowing)						
Treatments	1st(70)	2nd(120)	3rd(145)	4th(170)	5th(200)	Total	General mean
Clover pure	3.38	3.39	2.47	1.13	0.18	10.55	2.11
Alfalfa pure	2.35	3.05	3.14	3.64	2.91	16.09	3.22
90 % alfalfa +10% clover	2.54	4.33	4.02	3.85	3.09	17.83	3.57
80 % alfalfa +20% clover	3.09	4.79	4.96	4.45	3.20	20.49	4.10
70 % alfalfa +30% clover	2.48	4.08	4.84	3.95	2.88	17.83	3.57
50 % alfalfa +50% clover	1.06	2.43	3.24	2.89	1.83	11.45	2.29
LSD at 0.05 level	0.60	0.42	0.55	0.34	0.16	0.87	--

Table 7: Competition relationships between alfalfa and clover in mixtures cropping system under different seeding rates, in (2004 /05 season)

	Land equivalent ratio (LER)			Aggressivity value (A_{total})		Increasing, decreasing % in forage yield, of mixture cropping over pure stand of	
Treatments	L_{clover}	$L_{alfalfa}$	Total	A_{clover}	$A_{alfalfa}$	Clover	Alfalfa
90 % alfalfa +10% clover	0.103	0.988	1.091	-0.885	0.885	6.28	19.66
80 % alfalfa +20% clover	0.224	0.959	1.183	-0.735	0.735	24.02	39.63
70 % alfalfa +30% clover	0.204	0.779	0.983	-0.575	0.575	9.12	22.83
50 % alfalfa +50% clover	0.102	0.715	0.817	-0.613	0.613	7.65	17.92
LSD at 0.05 level	0.10	0.17	ns	--	--	--	--

Mixtures Effect on the Competition Relationships Between the Two Crops

Land Equivalent Ratio (LER): Land equivalent ratio (LER) is the phenomenon of over yielding which was reported by DeWit and Den Bergh [26] and Willey [27]. It means that if LER was more than the unity (LER $\geq$ 1) an over yielding phenomenon is occurred and land usage increased and vice versa. Data presented in Tables 7 and 8 indicated that total LER was greater than the unity (LER $\geq$ 1) under the mixing cropping pattern in both seasons The value of LER of each component of alfalfa ($L_{alfalfa}$) and clover (L_{clover}) were significant affected by mixture cropping systems, whereas, the combined LER was not significant affected. Mixing alfalfa and clover at seeding rates of 80 % alfalfa +20% clovers followed by 90 % alfalfa +10% clovers in the first season and both treatments of 80 % alfalfa +20% clovers and 70 % alfalfa +30% clover recorded the same values, in the second season. It can be concluded that mixing cropping pattern is compatible for sowing alfalfa with clover and led to increase land use efficiency by 18-12 % in the first and second season.

Aggressively for Forage Yield: During both seasons, the treatments exerted significant influence on the aggressivity value due to changing in seeding rates. Generally, aggressivity values were positive for alfalfa and in contrast were negative for clover under the different seeding rates. Such effect was expected, because the highest seeding rates of all tested treatments in line with alfalfa compared to clover.

Increasing/ Decreasing Percentage: With regard to the increasing or decreasing percent, data presented in Tables 7 and 8 indicated that, mixing alfalfa with clover caused an increase over pure stand of each crop in both seasons. Results also showed that, more or less values were recorded in the increment of mixing cropping system

Table 8: Competition relationships between alfalfa and clover in mixtures cropping system under different seeding rates, in (2005 /06 season)

	Land equivalent ratio (LER)			Aggressivity value (A_{total})		Increasing, decreasing % in forage yield, of mixture cropping over pure stand of	
Treatments	L_{clover}	$L_{alfalfa}$	Total	A_{clover}	$A_{alfalfa}$	clover	alfalfa
90 % alfalfa +10% clover	0.129	0.949	1.078	-0.820	0.820	52.74	10.78
80 % alfalfa +20% clover	0.259	0.861	1.120	-0.602	0.602	58.96	15.29
70 % alfalfa +30% clover	0.382	0.742	1.120	-0.360	0.360	54.49	12.01
50 % alfalfa +50% clover	0.265	0.765	1.030	-0.500	0.500	45.17	5.29
LSD at 0.05 level	0.12	0.06	Ns	--	--	--	--

Table 9: Mean values of total crude protein yield, (kg/ha) of alfalfa and clover in pure stand and its mixtures at different seeding rates (Average of 2004 /05 and 2005 /06 seasons)

	Cut number(days after sowing)						
Treatments	1st(70)	2nd(120)	3rd(145)	4th(170)	5th(200)	Total	General mean
Clover pure	614.85	646.41	577.07	435.29	485.61	2759.28	551.86
Alfalfa pure	688.31	667.99	598.72	491.67	473.75	2920.44	584.09
90 % alfalfa +10% clover	1220.76	1501.77	1776.40	1187.06	573.71	6259.70	1251.94
80 % alfalfa +20% clover	1213.40	1098.07	969.35	1075.44	544.76	4901.02	980.20
70 % alfalfa +30% clover	1084.63	1088.06	894.78	957.66	657.25	4682.38	936.48
50 % alfalfa +50% clover	987.45	899.78	876.95	788.45	532.47	4085.10	817.02
LSD at 0.05 level	33.76	20.86	66.89	54.68.	84. 28	211.45	--

Table 10: Mean values of total carbohydrate yield, (Kg/ha) of alfalfa and clover in pure stand and its mixtures at different seeding rates (Average of 2004 /05 and 2005 /06 seasons)

	Cut number(days after sowing)						
Treatments	1st(70)	2nd(120)	3rd(145)	4th(170)	5th(200)	Total	General mean
Clover pure	473.34	494.26	652.19	493.73	677.75	2791.27	558.25
Alfalfa pure	429.28	552.10	689.60	791.92	501.19	2964.09	592.82
90 % alfalfa +10% clover	1007.86	1177.57	1140.77	1260.18	518.42	5104.80	1020.96
80 % alfalfa +20% clover	1126.95	1231.37	1253.98	1322.07	537.86	5472.23	1094.45
70 % alfalfa +30% clover	861.62	1142.84	1313.87	1366.34	545.29	5229.96	1045.99
50 % alfalfa +50% clover	675.82	786.92	997.74	1162.53	472.91	4095.92	819.18
LSD at 0.05 level	133.45	50.98	48.75	98.45	18.94	120.56	--

over pure stand of alfalfa and clover .In the first season the increment of mixture over pure stand of alfalfa was greater than of clover, where as the picture was changing in the second season, the increment over clover was greater than alfalfa. Among the treatments mixing alfalfa and clover at seeding rates of 80 % alfalfa +20% clovers registered the highest increment in both seasons. In nutshell, such increment may be attributed to the increasing in land equivalent ratio.

Influence of Mixing Cropping on Crude Protein and Carbohydrate Yield: Among the treatments tried, alfalfa/clover mixture sowing produce more crude protein yield in comparison with that of their pure stand of each, in five cuts taken and their total (Table 9). The highest crude protein yield was obtained from the mixture of seeding rates of 90 % alfalfa +10% clover and followed by the rate of 80 % alfalfa +20% clover .Whereas, the lowest value recorded by the rate of 50 % alfalfa +50% clover .It could be concluded that increasing the rate of clover in mixture decreased protein yield .Also it could be concluded that mixing alfalfa with clover by the rate of 90 % alfalfa +10% clover stimulated the production of more crude protein. These results are in concordance with the findings of Abd El-Gawad *et al.* [20] and Deljoo and Sepehri [21]. Moreover, in field experiments carried out under irrigation condition in Central Saudi Arabia Abdel Magid *et al*. [11], reported that mixing cropping had benefits for high forage yield of alfalfa and increasing its protein content.

Carbohydrate yield presented in Table 10, worthy clear that alfalfa/clover mixtures outweighed those of their pure stand. The highest increase was at the rate of 80 % alfalfa +20% clovers. This was in all cuts taken and the total of the five cuts. This may be due to the ability to produce high dry yield production in comparison with the other treatments.

CONCLUSIONS

The finally augmented of crop yield under mixing cropping system, as a result of complementary land use efficiency, highlight that, mixing cropping techniques under low input condition is considerable recommendation ,due to its low farm costs and high net income.

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