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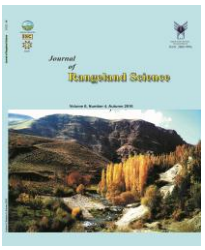

Research and Full Length Article:

Effects of Mixed and Row Intercropping on Yield and Quality Traits of Alfalfa and Three Grass Species in Rainfed Areas of Northern Khorasan, Iran

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Abstract. Strong benefits of species diversity have been demonstrated in mixed cropping on rangelands. In order to determine the best composition of mixed cropping of alfalfa (*Medicago sativa*) with three cool season grass species (*Agropyron elongatum*, *Agropyron desertorum* and *Festuca arundinacea)*, on yield and quality traits, an experiment was conducted during two years (2009 and 2010) in Bojnourd, Iran. The used experimental design was a split plot based on randomized complete block design with three replications. Main factor was different compositions of alfalfa and grasses and sub factor were two intercropping methods (Mixed intercropping and Row intercropping). Dry matter (DM) yield, Land Equivalent Ratio (LER) and quality traits including Crude Protein (CP), Water Soluble Carbohydrates (WSC), Dry Matter Digestibility (DMD) and Acid Detergent Fiber (ADF) were determined. Results showed that the effects of treatments were significant for all of traits. The highest DM yield was obtained in mixed intercropping ratio of alfalfa 25% +*A.elongatum* 75% (2317 kg.ha^{-1}) that increased 23.3% compared with alfalfa monoculture treatment. The effects of cropping method were significant for all of traits. The highest CP was obtained by mixed intercropping of alfalfa 75% + *Festuca* 25% (14.51%). In conclusion, mixed intercropping of alfalfa and *Festuca arundinacea* produced moderate DM yield coupled with higher quality traits. Whereas, mixed intercropping of alfalfa and *A. elongatum* produced highest DM yield but lower forage quality.

Key words: Digestibility, Crude protein, Land equivalent ratio, Water soluble carbohydrates

Introduction

It has been suggested that the targeted use of functional biodiversity, in particular grass-legume mixtures, could play an important role as it has the potential to increase productivity, forage quality, resources efficiency and environmental-friendliness (Peyraud *et al.,* 2009). One of the components of a sustainable rangeland management is intercropping of two or more grass-legume species simultaneously on a piece of land. This application would be maximum use of soil and water resources, soil conservation and soil fertility due to provide better soil protection (Poormoradi and Jafari, 2009). Mixed cultures patterns derived from natural sustainable systems including pastures and forests. The correlation between the profitability of production systems, ecological sustainability and environmental quality comprehensively defined (Ghaffari *et al.,* 1998). The success of legume-grass mixtures depends crucially on their development after sowing and sown species must establish properly and weeds must be successfully suppressed (Sanderson, 2010). It has been considered that the different methods of intercropping uptake more water from the soil compared with cultivation of individual plants, because the difference in rooting patterns. A combination of increased light, water and nutrients absorption, and better use of resources in a well-designed performance of mixed cropping caused 30 to 60% yield increase compared with monoculture systems (Kochaki and Soltani, 1998; Kochaki *et al.,* 2004).

An important issue is that increase in performance and yield in intercropping systems will be obtained easily and without the use of costly inputs and perhaps this is one of the most important benefits of intercropping considered on sustainable systems. (Mazaheri, 1998). The legume family species have a special position in fodder production and soil fertility that caused by biological fixation of nitrogen. Alfalfa is one of the most important legumes forage plants. Symbiotic Rhizobium strains cause nitrogen fixation by alfalfa roots during their life cycle (Moynihan *et al*., 1996). Grasses also play an important role in fodder production of pastures and their stability, because they balance the ratio of energy to protein involved in animal nutrition. In addition to the benefits from symbiotic nitrogen fixation, positive effects of mixing grasses and legumes may derived from niche differentiation, such as effects resulting from differences in their seasonal growth pattern or across years (Nyfeler *et al.,* 2009).

The direct use of monocultured alfalfa as pasture for livestock leads to bloating, but intercropping with grasses eliminate the bloating risk and the increase the possibility of greater use of this feed that is rich in protein and provides a balanced and complete feed (Jafari, 2005; Bahrani and Kazemeini, 2008). Various aspects of intercropping of forage plants have been studied in different research projects. Recent results, using two grasses and two forage legumes at 31 sites across Europe that were harvested for three years, have indeed demonstrated strong positive mixing effects (Finn *et al.,* 2012). Yield benefits were generally robust to changes in the relative abundance of the four component species. The results of alfalfa intercropping with five species of perennial grasses showed that the combination of intercropping plants in the experiment due to weather conditions changed over the years. So that in the cool months of April, May, September and October species of grasses and in the warm months of June, July, August and September alfalfa formed greater percentage of the mixture (Heydari Sharifabad *et al.,* 2000; Jafari *et al.,* 2003).

The purpose of this experiment was to determine the most appropriate and best ratio intercropping of alfalfa and three

grass species in order to achieve higher forage production coupled with good quality in rain fed farming conditions of Sisab region in North Khorasan province of Iran.

Materials and Methods

The experiment was established in natural resources research station of Sisab (28°37' latitude, 27°57' longitude and 1500 m altitude) in North Khorasan, Iran, during 2009 to 2011. Minimum, average and maximum precipitation was 170, 250 and 372 mm, respectively. The mean annual, minimum and maximum absolute temperature was 12.2, 40.5 and -18°C, respectively, and it was semi-arid climate based on the Domarten classification method.

The experimental design was a split plot based on randomized complete block design with three replications. The main factors (A) were various seed combinations of *Medicago sativa* (Ms), *Festuca arundinacea* (Fa), *Agropyron desertorum* (Ad) and *Agropyron elongatum* (Ae) in 13 levels (Table 1).

Table 1. The numbers and the levels of main factor treatments

No. of treatments	The levels of main factors treatments
1	Alfalfa 100%
2	Alfalfa 75% +Fa 25%
3	Alfalfa 50% +Fa 50%
4	Alfalfa 25% +Fa 75%
5	Fa 100%
6	Alfalfa 75%+Ad25%
7	Alfalfa 50%+Ad 50%
8	Alfalfa 25%+Ad 75%
9	Ad 100%
10	Alfalfa 75%+Ae 25%
11	Alfalfa 50%+Ae 50%
12	Alfalfa 25%+Ae 75%
13	Ae 100%

The sub-plots (B) were including two mixed intercropping systems: Mixed intercropping and Row intercropping. Plowing and ground preparation were made in the fall. In mixed intercropping system, seeds combination of species were mixed in with ratios of 75-25%, 50-50% and 25-75% and sown in rows, but in row intercropping systems, pure seeds of above ratios were sown in separate rows.

Prior to seed sowing, the germination percentages were determined for *M. sativa*, *F. arundinacea*, *A. elongatum* and *A. desertorum* as 95%, 92%, 72% and 40%, respectively. Seeds of each treatment were calculated based on the purity, viability and germination percentages and were sown (due to the treatments) in the bottom of the furrows at a depth of 5 cm with a row spacing of 25 cm (planting date was November 30, 2009). Dry matter (DM) yield was determined by cutting of one square meter of alfalfa and grasses, [alfalfa in 20% flowering stage and grasses in 20% heading stage based on (Jafari *et al.*, 2010) in mid-July], then forage samples were dried in oven at 75°C for 72 hours and weighted. To determine the relative efficiency of intercropping to monoculture, land equivalent ratio (LER) were calculated for the DM yield at the end of growing seasons and for the two systems used. LER was determined according to the equation (1) as stated by Mead and Willey (1980); Mazaheri *et al.*, (2006).

$$LER = L_A + L_B + \frac{Y_A}{S_A} + \frac{Y_B}{S_B} \qquad \text{(Eq.1)}$$

Where:

L_A and L_B = The LER's for the individual crops (Grass and alfalfa)

Y_A and Y_B = Yields of individual crop in intercropping system

S_A and S_B = Yields of sole crops (monoculture system).

The partial LER's are then summed up to give the total LER for the intercrop. Forage quality traits included crude protein (CP), water soluble carbohydrates (WSC), dry matter digestibility (DMD) and acid detergent fiber (ADF), were measured in the laboratory by near infrared spectroscopy (NIR). Details of the methodology and calibrations of NIR are given by Jafari *et al.* (2003), Arzani *et*

al., (2012) and Arzani *et al.*, (2015). Collected data were analyzed using analysis of variance and then means comparisons were made using Duncan's Multiple Range.

Results and Discussion

Analysis of Variance

Result of analysis of variance showed that DM yield and LER significantly (P<0.01) effected by different ratios of intercropping treatments. However, two cropping systems had no significant effects on DM yield and LER. The interaction of mixed cropping ratios and mixed cropping systems were not significant for DM yield and LER. Results of analysis of variance showed significant effect of different seed ratios for CP, WSC (P<0.01), DMD and ADF (P<0.05). The interaction of mixed cropping ratios and mixed cropping systems was significant for CP (P<0.01), but for other quality traits they were not significant (Table 2).

Table 2. Analysis of variance of DM yield, LER and forage quality traits

Sources of variation	DF	MS					
		DM yield	LER	CP	DMD	WSC	ADF
Replication	2	18466.07	0.060	47.70	535.45	23.22	259.34
Cropping composition	12	9873.09**	0.134**	109.94**	184.10*	55.06**	100.08*
Error (a)	22	1729.15	0.070	3.38	237.13	39.79	113.46
Cropping method	1	24.88^{ns}	0.015^{ns}	8.40^{ns}	117.57*	0.019^{ns}	91.67**
Composition * Method	11	603.38^{ns}	0.015^{ns}	11.76**	20.99^{ns}	6.43^{ns}	12.31^{ns}
Error (b)	24	394.32	0.040	2.43	15.98	5.49	8.55

**, Significant at 1% level, *, significant at 5% level, ns, not significant

DM Yield and LER

The means comparison showed that intercropping composition treatments had significant effects on DM yield. The highest DM yield achieved by intercropping ratio of alfalfa 25% -75% *A. elongatum* (2317 kg.ha^{-1}). The monoculture of *Fescue* produced the lowest DM yield (971 kg ha^{-1}). The means comparison results of interaction between intercropping ratio and intercropping methods showed that the highest values of DM yield was obtained by alfalfa 25%-75% *A. elongatum* intercropping ratio and mixed intercropping method (2438 kg.ha^{-1}), whereas alfalfa 50%-50% *A. desertorum* intercropping ratio and mixed intercropping method produced lower values of DM yield (1358 kg.ha^{-1}) (Table 3).

The experiment results showed that intercropping of alfalfa-grasses had more advantages than monoculture methods for DM yield in Sisab region. The competition generated by plant species sharing the same space is defined as a process through which the crops limit the resource mutually in such a way that it does not satisfy its demand (nutritional, physiological etc.), thus generating a reduction in the survival, growth and yield of the individual plants of the crop or its reproduction.

The advantage reasons for intercropping methods could lead to better use of light, water and soil nutrients in the intercropping methods rather than monoculture. Because in the intercropping systems, competition is interspecific (occur between different species), which has been less severe than intraspecific competition (occur between similar species), (Mazahei., 1998). For example, in the present experiment, *A. elongatum*, a species with high DM yield, produced 2290 kg.ha^{-1} DM yield in monoculture, while in mixed intercropping with alfalfa, its DM yield value was relatively higher 2317 kg.ha^{-1} due to the benefits of intercropping including the use of nitrogen fixation by alfalfa because no fertilizers were used in the experiment.

Table 3. Means comparison of different mixed cropping ratio and monoculture treatment on DM yield, LER and forage quality traits

Treatments	DM yield (Kg h^{-1})	LER	CP (%)	DMD (%)	WSC (%)	ADF (%)
Alfalfa 100%	1775.60 ^{bc}	1.00 ^{b}	19.15 ^{a}	41.28 ^{ab}	27.45 ^{a}	41.15 ^{ab}
Alfalfa 75%+F.a. 25%	1730.53 ^{cd}	1.30 ^{ab}	14.51 ^{b}	38.88 ^{ab}	18.86 ^{b}	45.18 ^{ab}
Alfalfa 50%+F.a. 50%	1695.40 ^{cd}	1.27 ^{ab}	13.91 ^{b}	40.24 ^{ab}	19.97 ^{ab}	43.02 ^{ab}
Alfalfa 25%+F.a. 75%	1809.90 ^{bc}	1.45 ^{a}	14.66 ^{b}	39.34 ^{ab}	19.59 ^{ab}	44.69 ^{ab}
F.a. 100%	971.20 f	1.00 ^{b}	8.77 ^{c}	41.35 ^{ab}	16.65 ^{b}	42.17 ^{ab}
Alfalfa 75%+A.d. 25%	1446.80 ^{def}	1.01 ^{b}	7.48 ^{cd}	34.01 ^{b}	17.99 ^{b}	48.42 ^{a}
Alfalfa 50%+ A.d. 50%	1457.30 ^{def}	1.01 ^{b}	8.26 ^{cd}	32.07 ^{b}	18.53 ^{b}	50.04 ^{a}
Alfalfa 25%+A.d. 75%	1554.50 ^{cde}	1.08 ^{b}	7.16 ^{cd}	50.48 ^{a}	19.45 ^{ab}	38.61 ^{b}
A.d. 100%	1198.00 ^{ef}	1.00 ^{b}	3.53 ^{e}	42.82 ^{ab}	17.77 ^{b}	41.79 ^{ab}
Alfalfa 75%+A.e. 25%	2022.08 ^{abc}	1.05 ^{b}	8.79 ^{c}	46.55 ^{ab}	16.62 ^{b}	38.60 ^{b}
Alfalfa 50%+A.e. 50%	2150.22 ^{ab}	1.14 ^{ab}	9.12 ^{c}	32.58 ^{b}	16.79 ^{b}	49.48 ^{a}
Alfalfa 25%+A.e. 75%	2317.95 ^{a}	1.20 ^{ab}	9.57 ^{c}	38.48 ^{ab}	16.17 ^{b}	45.17 ^{ab}
A.e. 100%	2290.20 ^{a}	1.00 ^{b}	6.06 ^{d}	32.75 ^{b}	15.40 ^{b}	50.23 ^{a}

Means followed with the same letter are not significantly different (P<5%).
*M.s. =*Medicago sativa*, F.a. =*Festuca arundinacea*, A.d. =*Agropyron desertorum*, A. e. =*A. elongatum*

The combination of a legume with a grass is the most common type of intercropping, and the majority of successful intercrops grown worldwide, also consist of cereal-legume intercrops (Francis, 1989). More researches were carried out to demonstrate the advantage of intercropping versus monoculture. Ta and Fari (1987) indicated that results of mixed cropping timothy with alfalfa significantly increased both herbage and nitrogen concentration when compared to timothy grown in a pure stand. Sengul (2003) also realized that legume mixtures with one or two grass species gave higher DM yield than the single crop. Shobeirri *et al.* (2011) experiment showed the benefits of intercropping in DM yield. In an experiment, intercropping of vetch and triticale in irrigation condition showed higher DM yield (8850 kg.ha^{-1}) in the mixed intercropping system (50% Vetch + 50% Triticale) than the monoculture treatments in both years. In their experiment, grass species (triticale) use the benefits of intercropping with legumes (vetch). The results of other experiment on alfalfa DM yield in mixed culture with two species of grasses, including *Bromus inermis* and *A. elongatum* showed a significant difference between monoculture with mixed intercropping systems in different years and especially in the second year. DM yield in intercropping treatments increased compared to monoculture.

Najafi and Mohseni, (2003) in comparisons between two methods of row and mixed intercropping in Sisab, Bojnord, Iran found no significant differences in terms of DM yield. The *A. elongatum* intercropping with alfalfa, (alfalfa 25% and 75% *A. elongatum*) treatment produced the highest value of 1436 kg.ha^{-1} DM yield with compared to other treatments.

In an experiment in Brojerd, Lorstan province, Iran, comparing two systems of row intercropping and mixed intercropping, results showed that the average DM yield were 1794 and 1410 kg.ha^{-1} respectively. The amount of DM yield in Row intercropping system were significantly higher (384 kg.ha^{-1}) than Mixed intercropping system (Saremi, 2011). The difference in results was probably because the experiment carried out in Sisab in both intercropping systems, alfalfa was sown in November, but in the Saremi (2011) experiment species of legume (alfalfa) was sown in the spring.

In other experiment on four forage species included Timothy (*Phleum pratense*), Meadow fescue (*Festuca pratensis*), Red clover (*Trifolium*

pratense) and White clover (*Trifolium repens*) the results showed that DM yield in intercropping was higher and more stable over time compared to monoculture system. Timothy performance in intercropping fell from the second year, but the yield of red clover increased. The share of white clover species in mixed DM yield were low and fluctuate over time, while the meadow fescue performance was more stable (Helgadottir *et al.,* 2013). In the present experiment without the use of chemical fertilizers and in rain fed farming conditions by the proper functioning of intercropping of alfalfa with grass species we have achieved good performance. Other researchers have found similar results. The results of alfalfa-meadow fescue mixed intercropping experiment showed that the DM yield of meadow fescue in intercropping system with no Nitrogen fertilizer application was similar to monoculture with the use of 100 $kg.ha^{-1}$ Nitrogen fertilizers. Alfalfa-grass mixtures yielded similarly to monocultures fertilize. Alfalfa was estimated to replace about 116 kg N ha^{-1} in mixtures. Intercropping leads to better weed control compared to monoculture. Alfalfa in intercropping to stabilize seasonal performance due to better growth in the summer months was critical (Tracy *et al.,* 2013).

In an experiment to determine the most suitable combination of alfalfa with Orchard grass in terms of intercropping compared with either of these two forage crop monoculture, the researchers concluded that the combination of 50% alfalfa with 50% Orchard grass with production of 18100 $Kg.ha^{-1}$ of DM matter yield in irrigation condition was the most suitable combination of the two fodder (Ghaffari *et al,* 1998). The results of an experiment showed that intercropping of alfalfa with ryegrass produced higher forage yield than their monoculture. Early varieties of ryegrass also had more performance and forage yield in intercropping were though the amount of forage crude protein was lower (Sulc and Albrecht, 1996).

The results of mean comparison by Duncan showed that proportion of mixed intercropping treatments on land equivalent ratio (LER) was significant ($P<0.05$). Results showed that the LER values of DM yields for both alfalfa-grasses mixtures substantially exceeded that of their corresponding monoculture. Intercropping of alfalfa and grasses species caused higher LER (1.45) than monoculture method. The lowest LER values of DM yields were obtained in monoculture (1.00). The result obtained were strongly coincided with the definition of land equivalent ratio in that the combination of component species in the mixture were more productive than the same species when grown as monoculture. However, the LERs ratio in almost all cases, were greater (over one) than the sole which interpreted as advantage of mixture over sole. Similarly, Mazaheri and Oveysi (2004) documented that an LER of 1.0 or less indicating that no difference in yield between the intercropping and the collections of monoculture, while any value greater than 1.0 indicates that yield advantage for intercropping. Moreover, Mead and Willy, (1980); Mazaheri *et al.*, (2006) confirmed that LER is taken as a measure of relative yield advantages.

Table 4. Means comparison of mixed cropping methods (mixed intercropping and row intercropping) on DM yield, LER and forage quality traits

Method	DM yield	LER	CP (%)	DMD (%)	WSC (%)	ADF (%)
Mixed seed intercropping	1794.77 [a]	1.19 [a]	10.08 [a]	37.26 [b]	18.15 [a]	46.52 [a]
Row pure seed intercropping	1801.50 [a]	1.15 [a]	11.08 [a]	41.10 [a]	18.29 [a]	43.08 [b]

Means followed with the same letter are not significantly different (P<5%).

Quality Traits

The means comparison results showed that intercropping ratios treatments had significant effects on forage quality traits. The effects of treatments were significant for CP, WSC, DMD and ADF (Table 2). Effects of intercropping method (including mixed intercropping and Row intercropping) systems were also significant for DMD and ADF. The interaction effects of intercropping ratios and intercropping method were significant only for CP ($P<0.01$).

The means comparison results showed that monoculture method caused the highest CP (19.15%) in alfalfa (Table 2), which was significantly different from other treatments. The lower value of CP was obtained in monoculture of *A. desertorum* treatment (3.53%). The highest value of DMD was obtained in alfalfa 25% - *A. desertorum* 75% treatment (50.48%). The highest value of WSC was belonging to alfalfa monoculture (27.45%) which was significantly different from other treatments. The amount of WSC in *A. elongatum* monoculture was ranked the lowest (15.40%). The lower ADF values were obtained in alfalfa 25%+ *A. desertorum* 75% and alfalfa 75%+ *A. elongatum* 25% with average values of 38.61 and 38.60, respectively (Table 3).

The effects of intercropping method (including mixed intercropping and Row intercropping) systems were significant for DMD and ADF. The effects of intercropping method on other forage quality traits were not significant. Results of means comparison for DMD showed that, row intercropping method resulted in a higher value of this attribute (41.10%), similarly the lower values of ADF with average value of 43.08 was obtained in Row intercropping method (Table 4). This finding suggested that pure seeds cultivation in alternative rows resulted in higher forage quality.

Means comparison of interaction effects of intercropping ratios and intercropping methods is presented in Table 5. Result indicated that Alfalfa25%-*Festuca*75% in Mixed intercropping method had the highest CP values (16.28%), whereas, the alfalfa 25%- *A.desertorum* 75% in Mixed intercropping method had the lowest CP value (4.85%). The higher and lower DMD with average value of 51.39% and 30.37% were obtained by Alfalfa25%-*A.desertorum* 75% and Alfalfa75%-*A.desertorum* 25% in mix intercropping method, respectively.

Table 5. Means comparison of mixed cropping ratio and mixed cropping methods interaction on forage DM yield, LER and forage quality traits

Treatments	Method	DM yield	LER	CP (%)	DMD (%)	WSC (%)	ADF (%)
Alfalfa 75%+F.a. 25%	Mix	1589.2 de	1.24 ab	15.25 bc	35.35 cde	19.56 bc	48.71 ab
	Row	1871.8 cd	1.37 ab	13.77 cde	42.42 bcd	18.16 cde	41.65 efg
Alfalfa 50%+F.a. 50%	Mix	1723.0 d	1.34 ab	15.01 bcd	40.14 de	20.63 a	43.09 de
	Row	1667.7 d	1.21 ab	12.82 def	40.34 de	19.30 bc	42.95 de
Alfalfa 25%+F.a. 75%	Mix	1817.8 cd	1.53 a	16.28 a	37.82 ef	19.69 bc	46.48 bcd
	Row	1801.9 cd	1.36 ab	13.03 def	40.85 de	19.48 bc	42.91 def
Alfalfa 75%+A.d 25%	Mix	1508.6 de	1.09 ab	6.11 kl	30.37 g	16.24 cde	51.60 a
	Row	1385.0 e	0.93 b	8.85 hi	37.65 ef	19.75 bc	45.24 cde
Alfalfa 50%+A.d. 50%	Mix	1358.8 e	0.98 b	7.60 ij	30.90 g	20.56 a	51.70 a
	Row	1555.6 de	1.04 ab	8.91 hi	33.24 fg	16.50 cde	48.38 abd
Alfalfa 25%+A.d. 75%	Mix	1582.3 de	1.15 ab	4.84 klm	51.39 a	18.13 cd	39.56 fgh
	Row	1526.6 de	1.01 ab	9.48 ghi	49.59 ab	20.77 a	37.67 gh
Alfalfa 75%+A.e. 25%	Mix	1964.4 c	1.00 ab	6.59 jk	42.19 bcd	16.84 cde	40.19 fgh
	Row	2077.6 bc	1.09 ab	10.98 efg	50.91 a	16.40 cde	37.01 h
Alfalfa 50%+A.e. 50%	Mix	2170.3 ab	1.14 ab	7.97 hij	31.36 g	15.74 def	49.82 ab
	Row	2130.1 ab	1.14 ab	10.28 fgh	33.79 efg	17.83 cde	49.14 ab
Alfalfa 25%+A.e. 75%	Mix	2438.5 a	1.22 ab	7.56 ji	35.83 ef	15.94 def	47.55 abc
	Row	2197.2 ab	1.18 ab	11.57 efg	41.11 de	16.39 de	42.79 de

Means followed with the same letter are not significantly different (P<5%).

*M.s. =*Medicago sativa*, F.a. =*Festuca arundinacea*, A.d. =*Agropyron desertorum*, A. e. =*A. elongatum*

For WSC, the highest values of 20.63 and 20.56 were obtained in alfalfa 50%-*Festuca*50% and alfalfa50%-*A.desertorum*50% in Mixed intercropping method, respectively, whereas, the lowest values of WSC were obtained in alfalfa25%-*A.elongatum75%* and alfalfa 50%+ *A.elongatum50*% with average value of 15.94% and 15.74%, respectively, in Mixed intercropping method (Table 5).

The lower ADF were obtained in alfalfa 25% -*A. desertorum*75% and Alfalfa75%- *A.elongatum25*% with average values of 37.67% and 37.01%, in Row intercropping method, respectively. This result indicated that more CP of alfalfa than *A.elongatum* led to lower ADF and higher forage quality.

Forage quality is affected by many factors such as the species, cutting interval, phase of plant development, soil fertility, fertilizer, disease and climatic conditions. It is usually found that the most important factor affecting protein content in herbage dry matter is phase of plant development. Forage quality will decrease, in term of decreasing CP and increasing levels of cell wall constituents, with advancing maturity. At reproductive stage, the quality of grass will decrease (Kusmiyati *et al.*, 2013).

About the quality of forage experiment results showed that row intercropping systems had a positive effect on the composition of forage and improves the quality of forage that was produced. In this case, the forage quality could be set with the intercropping of different species of grasses and legumes. Because of each species planted in intercropping systems (including legumes and grasses) are of particular genetically forage quality, changing the ratios of any species could be used to manage quality of forage production, as that forage production have balanced ratio of starch and protein.

Baghjari (2011) in assessing of mixed cropping on forage quality showed that alfalfa monoculture produced the highest amount of DMD and CP with average values of 61.3 and 28.2%, respectively. In another study, Saremi, (2011) obtained the higher CP with value of 20.7% in

monoculture of alfalfa followed by mixed cropping of alfalfa 25% + 75% *A. cristatum*, and mixed cropping of all combinations of Fescue-alfalfa with an average of 19 to 20%).

In the present experiment despite the highest amount of CP in alfalfa monoculture treatment, by entering the grasses to composition of mixed cropping, the forage quality could be increased. In similar conclusion Jung *et al.*, (1996) suggested that mixed cropping of legume-grass increases the nutritional value of forage while the problems of monoculture will also be solved.

Conclusion

These results confirm that proper selection of four species (one legume and three grasses) possessing different functional traits has resulted in mixtures which surpassed monocultures, both in total yield and LER over a period of two years. These results demonstrate that species composition in mixtures was highly affected on forage yield and quality. Rangeland management viewpoint, emphasis on intercropping of alfalfa and grasses and can be recommended as it results in well balanced mixtures that show persistent forage yield, Higher LER and should give good quality fodder. It was concluded that mixed intercropping of alfalfa and *Festuca* produced moderate DM yield coupled with higher quality traits. Whereas, mixed intercropping of alfalfa and *A.elongatum* produced highest DM yield but lower forage quality.

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اثرات کشت مخلوط یونجه با سه گونه گرامینه مرتعی بر عملکرد، نسبت برابری زمین و خصوصیات کیفی علوفه در شرایط دیم استان خراسان شمالی

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چکیده. به منظور تعیین مناسب‌ترین ترکیب کشت مخلوط یونجه چندساله (*Medicago sativa*) با سه گونه از گرامینه‌های مناطق معتدله شامل *Agropyron elongatum* و *Agropyron desertorum* و *Festuca arundinacea*، از نظر عملکرد کمی و کیفی علوفه، آزمایشی بصورت طرح کرت‌های خرد شده (Split plot) در قالب طرح بلوک‌های کامل تصادفی در سه تکرار طی سال‌های ۱۳۸۸ الی ۱۳۹۰ در محل ایستگاه تحقیقات منابع طبیعی سیساب واقع در استان خراسان شمالی انجام شد. تیمارهای آزمایش شامل فاکتور اصلی نسبت‌های مختلف کشت مخلوط گونه‌ها در ۱۳ سطح و فاکتور فرعی شامل کشت ردیفی بذر مخلوط (Mixed intercropping) و کشت ردیفی بذر خالص (Row intercropping) در دو سطح بود. در این تحقیق عملکرد علوفه خشک و صفات کیفی علوفه اندازه‌گیری شد. نتایج نشان داد که اثر نسبت‌های مختلف کشت مخلوط یونجه و گراس روی وزن خشک علوفه معنی‌دار بود. بیشترین مقدار تولید علوفه خشک در هکتار مربوط به تیمار نسبت کاشت مخلوط یونجه ۲۵درصد- *Agropyron elongatum*، ۷۵ درصد به میزان ۲۳۱۷ کیلوگرم علوفه خشک در هکتار بود که نسبت به کشت یونجه خالص به میزان ۲۳/۳ درصد افزایش نشان داد. اثر تیمار نسبت کشت مخلوط روی صفات کیفی علوفه معنی‌دار بود. بیشترین میزان پروتئین خام در تیمار کشت یونجه خالص بدست آمد و در مرتبه بعدی میزان پروتئین خام در تیمار یونجه ۷۵درصد + فستوکا ۲۵ درصد به میزان ۱۴/۵۱ درصد بود. بطورکلی کشت مخلوط یونجه با گونه *Festuca arundinacea* مقدار علوفه کمتر با کیفیت بهتری تولید نمود. در حالی که کشت مخلوط یونجه با گونه *Agropyron elongatum* مقدار علوفه بیشتری تولید نمود اما کیفیت علوفه تولیدی از لحاظ میزان پروتئین پایین‌تر بود.

کلمات کلیدی: پروتئین‌خام، کربوهیدراتهای محلول، کیفیت علوفه، ماده خشک قابل هضم، نسبت برابری زمین