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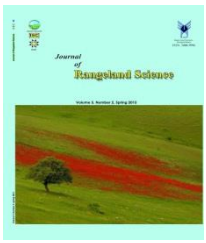

Research and Full Length Article:

Effects of Mix Cropping of Alfalfa and Annual Ryegrass on Forage Production

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Abstract. Mix cropping of alfalfa (*Medicago sativa*) and annual ryegrass (*Lolium rigidum*) may improve forage production in the rangeland and field conditions, especially in spring after the establishment year. In this study, the effects of different sowing rates of alfalfa and annual ryegrass seeds in the replacement and additive series of mix cropping were evaluated on forage yield in first year after the establishment in Shahrekord, Iran. Treatments included 100-0, 80-20, 60-40, 40-60, 20-80, 0-100, 100-25 and 100-50 percent of alfalfa (A) and annual ryegrass (R) seeds, respectively. Results showed that the highest total annual forage Dry Matter (DM) yield was obtained from $A_{80}R_{20}$ with the average value of 13900 kg ha^{-1} that had no significant difference with pure alfalfa. DM yield was reduced when seed rate proportion of ryegrass increased from 60 to 100% in the replacement series and the least DM yield was obtained from pure ryegrass. There were no significant differences between the additive series ($A_{100}R_{25}$ and $A_{100}R_{50}$) and many replacement series treatments ($A_{80}R_{20}$, $A_{60}R_{40}$ and $A_{40}R_{60}$). Number of alfalfa stems as one of the yield components was reduced by increasing the ryegrass seed rate proportion in $A_{80}R_{20}$ to $A_{20}R_{80}$ and $A_{100}R_{50}$. The lowest number of alfalfa stems in cuts 3 and 4 was obtained for $A_{20}R_{80}$. In general, total DM yield and number of alfalfa stems in $A_{80}R_{20}$ and $A_{60}R_{40}$ of the replacement and in $A_{100}R_{25}$ of the additive series were similar as compared with pure alfalfa, particularly in cuts 3 and 4. Since alfalfa and ryegrass are perennial and annual crops respectively, it is reasonable that less ratio of ryegrass may be used in mix cropping for the stability of forage production in subsequent years.

Key words: Mix cropping, Alfalfa, Ryegrass, Forage production

Introduction

Mix cropping is the planting pattern that two or more crops are cultivated in a piece of farm or rangeland at the same time (Lithourgidis *et al.*, 2011). One of the most common benefits of mix cropping is to produce a higher yield on the same land by more efficient use of the available growth resources that can't be utilized by each single crop grown alone (Ghosh, 2004). The growth resources such as light, water, and nutrients are more absorbed and converted to crop biomass in the intercropping systems while improving such characteristics as canopy development rate, final canopy size (width and height), photosynthetic adaptation of canopies to irradiance conditions, and rooting depth (Midmore, 1993; Morris and Garrity, 1993; Tsubo *et al*., 2001). Mixed cropping particularly legumes with grasses can improve both forage quality and yield because legumes and grasses are good sources of protein and carbohydrate, respectively (Moreira 1989; Toniolo *et al*., 1987; and Khandaker 1994). Planting grasses in mixture with legumes enhanced forage palatability and digestibility in the farm and pasture conditions (Chaudhary and Hussain, 1985). Legumes are able to enrich soil by fixing the atmospheric nitrogen and changing it from an inorganic form to the forms that are available for uptake by the plants. Biological fixation of atmospheric nitrogen can replace nitrogen fertilization wholly or in part. When nitrogen fertilizer is limited, biological nitrogen fixation is the major source of nitrogen in legume-cereal mixed cropping systems (Fujita *et al*., 1992). Intercropping of Berseem clover (*Trifolium alexandrinum*) with Italian ryegrass (*Lolium multiflorum*) provided an equivalence of 80 kg N ha^{-1} per year (Caballero *et al*., 1994). Intercropping of Berseem clover with spring cereals grown for silage may improve forage quality and yield potential benefits of intercropping include the increased yield, increased protein and forage quality, N contributions from legumes, greater yield stability, and reduced incidence of pests, weeds, and diseases (Anil *et al*., 1998).

Other legumes such as pigeon pea or cowpea improved the maintaining of maize yield in intercropping in sub-humid zones of Zimbabwe when maize is grown without mineral fertilizer on sandy soils (Waddington *et al*., 2007). Increasing the light interception in the intercrops reducing the water evaporation, and improving the conservation of soil moisture are some aspects of intercropping maize with cowpea as compared with the maize alone (Ghanbari *et al*., 2010).

Soybean with corn in intercropping produced more forage than sole crops (Putnam *et al*., 1986). Moreover, increases in crude protein content by 11-51% were recorded for the various intercrop treatments in comparison with sole corn crop. DM yield, DM percent, crude protein content and water-soluble carbohydrates of intercropped beans with wheat were improved in comparison with sole bean and wheat crops (Ghanbari-Bonjar and Lee, 2002; Lithourgidis and Dordas, 2010). Barley or oat with pea enhanced forage yield and quality (Carr *et al*., 2004). Also, Land Equivalent Ratio (LEA) of barley in intercrops with Austrian winter pea (*Pisum sativum* ssp. *arvense*) resulted in the values from 1.05 to 1.24 on a biomass basis and from 1.05 to 1.26 on a protein basis indicating a production advantage of intercropping (Chen *et al*., 2004).

Intercropping Common vetch with barley or winter wheat produced greater DM yield than sole common vetch and the intercropping of common vetch with barley at a seeding ratio 65:35 gave higher forage quality than the other tested intercrops (Lithourgidis *et al*., 2007). The DM yield, crude protein content and ash

content of maize forage were increased by intercropping with legumes as compared with maize monoculture (Javanmard *et al*., 2009). In addition, intercropping the legumes with maize significantly reduced the neutral detergent fiber and acid detergent fiber content, increasing digestibility of the forage. Salc and Alberscht (1996) state that the intercropping of *Medicago sativa* with *Lolium* had more hay yield than single cropping and more yield was obtained in early variety of *Lolium* in intercropping albeit of lower crude protein contents. The relative proportion of the component crops is an important factor concerning yield, quality and production efficiency of a cereal-legume or grasses-legume in mixture cropping (Willey and Osiru, 1972). In general, two methods are used for the seeding proportion in mix cropping including the replacement and additive ones of second or companion crop. The objective of this study was to determine the effects of different seeding proportions of alfalfa (*Medicago sativa*) and annual ryegrass (*Lolium rigidum*) as companion crop in mix cropping on forage yield in first year after the establishment.

Materials and Methods

The experiment was carried out in Agriculture and Natural Resources Research Center of Shahrekord, Iran in 2004. This station is located in 32° 8" of northern latitude, 50° 56" of eastern longitude and 2100 m altitude. Treatments were consisted of different seed proportions (%) of alfalfa (*Medicago sativa* (local Hamedani cultivar) and annual ryegrass (*Lolium rigidum*) (Table 1). The seeds were provided by Seed and Plant Improvement Institute of Karaj, Iran. Alfalfa and annual ryegrass seed rates were 30 and 35 kg h^{-1} in pure crop treatments, respectively. Seeds were sown in mid September 2003 in 30 cm rows in mix cropping pattern. Each plot included 12 rows with the length of 8m. Soil preparation included: plowing, gridding of clod and leveling. Fertilizer was used based on soil test in 2003. The experiment was arranged in a completely randomized block design with 8 treatments and 3 replications. Irrigation was applied in each 7-9 days. DM yield and stems per m^2 were assessed in each 4 cuts in 2004. DM yield was determined from the samples dried in 80ºC. Total DM yield and stem number per cut were analyzed based on RCBD, and the effect of cutting were analyzed based on split plot in time. Means comparisons were made using Duncan test ($P<0.05$).

Table 1. Seed rates proportions (%) of alfalfa and annual ryegrass in different treatments of mixed cropping

	Treatments	Seed Rate (kg ha^{-1})	
		Alfalfa (A)	Annual Ryegrass (R)
Replacement	$A_{100}R_0$	30	-
	$A_{80}R_{20}$	24	7
	$A_{60}R_{40}$	18	14
	$A_{40}R_{60}$	12	21
	$A_{20}R_{80}$	6	28
	A_0R_{100}	-	35
Additive	$A_{100}R_{25}$*	30	8.75
	$A_{100}R_{50}$*	30	17.5

* $A_{100}R_{25}$ and $A_{100}R_{50}$ included additive series and others treatments were replacement series

Results and Discussion

According to the results, the highest total annual DM yield was obtained from $A_{80}R_{20}$ with the average value of 13900 kg ha^{-1} that it was not significantly different from $A_{100}R_0$, $A_{60}R_{40}$ and $A_{40}R_{60}$ in the replacement series (Table 2). Also,

the lowest forage production was harvested from A_0R_{100} with the average

value of 5030 kg ha^{-1}. DM production trend reduced when seed rate proportion of ryegrass was increased from 60 to 100% in the replacement series. There were no significant differences between the additive series ($A_{100}R_{25}$ and $A_{100}R_{50}$) and many replacement series treatments for DM yield (Table 2). The higher DM yield in the cuts was obtained from $A_{100}R_0$, $A_{80}R_{40}$, $A_{60}R_{40}$ and $A_{40}R_{60}$ that was significantly increased as compared with $A_{20}R_{80}$ and A_0R_{100}. It seems that increasing the seed rate proportion of ryegrass in $A_{20}R_{80}$ and A_0R_{100} was the reason of forage production reduction. Ryegrass is a cool season annual grass that grows in spring; it cannot produce higher yield during hot summer here in Iran that is in accordance with the third and forth cuts of alfalfa. Vasilakoglou and Dhima (2008) showed that the intercropping of Berseem clover with barley at the seeding rate of 750-113 seeds (clover–barley) could be used as an alternative practice of Berseem clover sole crop and the other treatments for high forage and protein production. In their study, barley was cut once while Berseem clover was cut four times. Nielson *et al*. (1981) reported that alfalfa DM yield in the second year was reduced by mix cropping of oats. They also observed that the interference competition existed in some oat and alfalfa combinations in some intercropping systems. Blaser *et al.* (2006) showed that in intercropping, winter cereal species only affected red clover DM in the following spring of the first year. Cereal seeding rates impacted DM within specific harvest periods, but no effects on seasonal totals.

Table 2. Total and average DM yield in 4 cuts of different treatment of alfalfa and ryegrass in mixed cropping

Treatments	DM Yield (kg ha^{-1})					
	Cut 1	Cut 2	Cut 3	Cut 4	Total	Mean
$A_{100}R_0$	2490.6 c	3455.9 b	3605.2 a	3488.3 a	13040 a	3260 ab
$A_{80}R_{20}$	2693.3 bc	4159.1 a	3715.0 a	3330.3 a	13900 a	3475 a
$A_{60}R_{40}$	2866.5 ab	3934.8 a	3798.8 a	3262.2 ab	13860 a	3465 a
$A_{40}R_{60}$	3060.2 a	3862.3 a	3810.2 a	2918.1 c	13650 a	3412 a
$A_{20}R_{80}$	2799.8 b	2928.3 c	3093.8 b	2876.1 c	11700 b	2915 b
A_0R_{100}	2419.3 c	2611.0 d	0*	0*	5030 c	1258 c
$A_{100}R_{25}$	3056.2 a	2991.6 c	3732.1 a	3050.8 bc	12790 ab	3198 ab
$A_{100}R_{50}$	2913.4 a	2723.2 cd	3779.0 a	2579.9 d	12000 b	2999 b
Mean	2787.3	3334.1	3198.8	2687.2	11996.3	2997.8

*Ryegrass wasn't survival in third and forth cuts
Means followed by the same letters in each column are not significantly different (P<0.05)

Stem number is one of the yield components of forage crops. DM yield of alfalfa had a positive correlation with stem number (Jafari *et al.*, 2012). Number of alfalfa stems was reduced with the increase of ryegrass seed proportion in $A_{80}R_{20}$ to $A_{20}R_{80}$, especially in the first and second cuts but number of ryegrass stems increased in the same cuts (Table 3). In $A_{20}R_{80}$, DM yield reduction was due to the declined alfalfa stems, the least number of alfalfa stems in the third and fourth cuts was attributed to $A_{20}R_{80}$ (Table 3). This result is corresponded with the results reorted by Bakhashwain (2010) that the highest number of plants in the mixed cropping of alfalfa and rhodes grass (*Chloris gayana*) was obtained from 100:0 and 75:25 (alfalfa: rhodes grass).

Table 3. Stems number per m^2 in different treatments of alfalfa and ryegrass in mixed cropping in 4 cuts

Treatments	Cut1		Cut2		Cut3		Cut4	
	Alfalfa	Ryegrass	Alfalfa	Ryegrass	Alfalfa	Ryegrass	Alfalfa	Ryegrass
$A_{100}R_0$	1017 a	-	988 a		679 a	-*	662 a	-*
$A_{80}R_{20}$	915 a	339 e	931 a	1185 c	654 ab	-	647 a	-
$A_{60}R_{40}$	686 b	575 d	727 ab	1235 bc	622 ab	-	596 a	-
$A_{40}R_{60}$	437 c	939 c	636 b	1451 ab	503 cd	-	503 b	-
$A_{20}R_{80}$	262 d	1219 b	265 c	1506 ab	432 d	-	402 c	-
A_0R_{100}	-	1657 a	-	1612 a	-	-	-	-
$A_{100}R_{25}$	877 ab	453 de	668 b	622 e	620 ab	-	641 a	-

$A_{100}R_{50}$	613 b	671 d	660 b	845 d	565 bc	-	546 b	-

* Ryegrass wasn't survival in third and forth cuts

Means followed by the same letters in each column are not significantly different (P<0.05)

There were no significant differences in the treatments of 20 and 40% ryegrass with $A_{100}R_0$. This means that $A_{80}R_{20}$ and $A_{60}R_{40}$ can be used for improving the forage yield and quality particularly in the first and second cuts. In the years, alfalfa weevil (*Hypera postica* Gyll.) damaged the alfalfa leaves in the early spring according to first cut growth; therefore, the addition of some seeds of ryegrass (20 to 40% in replacement and 25% in additive series) in mix cropping with alfalfa can improve the forage yield and quality in spring. Jung *et al*. (1991) evaluated yield and quality of alfalfa and ryegrass mixture and harvested the highest DM yield from 60 alfalfa and 40 ryegrass proportion. Amraei *et al*. (2012) reported that the best combination proportion of alfalfa with grass was the ratio of about two-third of alfalfa and one-third of grasses. They also expressed that the intercropping of alfalfa with grass is a good way to increase forage DM yield in the rangelands. Ross *et al.* (2004) also showed that intercropping Berseem clover with the reduced seeding rates of cereals improved first cut forage quality. In USA, mix stands of warm or cool season grasses and legumes can be maintained under grazing or hay production with a substantial shift in seasonal yield distribution that can be very beneficial to beef producers (Jung *et al.*, 1985).

There were differences in forage production and stem number between the replacement and additive series. Although no significant difference was found for forage yield of most treatments but additive series had lower production. Higher seed density of both species in the additive series caused more interspecies competition; as a result, DM yield decreased in $A_{100}R_{50}$. Also, alfalfa stem number of this treatment was lower than $A_{100}R_{25}$ in the third and fourth cuts that can affect the forage production in subsequent years. Generally, results showed that the total forage DM yield and number of alfalfa stems in $A_{80}R_{20}$ and $A_{60}R_{40}$ in the replacement and $A_{100}R_{25}$ in the additive series were similar with $A_{100}R_0$ particularly in the third and forth cuts. Since alfalfa and ryegrass are perennial and annual crops, it is reasonable for the stability of forage production of alfalfa in subsequent years, to use less ratio of ryegrass in mix cropping.

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تأثیر کشت مخلوط یونجه و ری‌گراس بر تولید علوفه

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چکیده. کشت مخلوط یونجه (*Medicago sativa*) و ری‌گراس یکساله (*Lolium rigidum*) می‌تواند تولید علوفه در شرایط مرتع و مزرعه به ویژه در بهار سال بعد از استقرار را افزایش دهد. در این تحقیق تأثیر نسبت‌های مختلف کاشت بذر یونجه و ری‌گراس در سری‌های جایگزینی و افزایشی کشت مخلوط درهم بر تولید علوفه در سال اول بعد از استقرار ارزیابی شدند. تیمارها شامل درصدهای بذر ۱۰۰-۰، ۸۰-۲۰، ۶۰-۴۰، ۴۰-۶۰، ۲۰-۸۰، ۰-۱۰۰، ۱۰۰-۲۵ و ۱۰۰-۵۰ یونجه (A) و ری‌گراس (R) به ترتیب بودند. نتایج نشان داد که بیشترین عملکرد علوفه خشک از تیمار $A_{80}R_{20}$ با ۱۳۹۰۰ کیلوگرم در هکتار بدست آمد که تفاوت معنی‌داری با یونجه خالص $A_{100}R_0$ نداشت. تولید علوفه خشک زمانی‌که نسبت بذر ری‌گراس در سری جایگزینی از ۶۰ به ۱۰۰ درصد افزایش یافت کاهش نشان داد و کمترین تولید علوفه از تیمار گراس خالص AL_0R_{100} حاصل شد. بین تیمارهای سری افزایشی ($AL_{100}R_{25}$ و $AL_{100}R_{50}$) با همدیگر و تعدادی از تیمارهای سری جایگزینی تفاوت معنی‌داری وجود نداشت. تعداد ساقه یونجه به عنوان یک جز عملکرد، با افزایش نسبت بذر ری‌گراس در تیمار $A_{80}R_{20}$ به $A_{20}R_{80}$ و $A_{100}R_{50}$ کاهش نشان داد. کمترین تعداد ساقه یونجه در چین سوم و چهارم از تیمار$A_{20}R_{80}$ اندازه‌گیری شد. بطورکلی مجموع عملکرد علوفه خشک و تعداد ساقه یونجه در تیمار $A_{80}R_{20}$ و $A_{60}R_{40}$ در سری جایگزینی و در تیمار $A_{100}R_{25}$ از سری افزایشی در مقایسه با یونجه خالص $A_{100}R_0$ به ویژه در چین سوم و چهارم تفاوت معنی‌داری را نشان نداد. با توجه به اینکه یونجه و ری‌گراس به ترتیب چند ساله و یک ساله هستند، بنابراین استفاده از مقادیر کمتر بذر ری‌گراس در کشت مخلوط درهم قابل توصیه است این امر بر ثبات تولید علوفه یونجه در سال‌های بعد تأثیر گذار است.

کلمات کلیدی: کشت مخلوط، یونجه، ری‌گراس، تولید علوفه