



## Evaluation of seed yield and competition indices for intercropped barley (*Hordeum vulgare*) and annual medic (*Medicago scutellata*)

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### Abstract

Annual medic is an annual crop which performs well in various forage cropping systems. However availability of medic seeds is a major challenge for livestock producers in Iran. This study was conducted to determine if intercropping annual medic with barley can produce supplement medic seeds while barley grain yield as the main crop is not compromised. Two experiments were carried out at the experimental farm of University of Tehran. In experiment I (2007), a randomized complete block design with eight cropping ratios comprising of 1B:1M (one row of barley: one row of annual medic), 2B:2M, 4B:4M, 6B:6M, 6B:2M, 4B:2M, 2B:4M, and 2B:6M along with sole culture of barley and annual medic was studied. In experiment II (2009 and 2010), four new treatments were added to the intercropping ratios used in experiment I and also weeds were controlled. The overall results as indicated by competition indices including LER, RCC, and MAI revealed that regardless of ratios, the grain yield of barley when intercropped with medic was lowered. The total seed yield of both crops however, was improved in some of the intercropping ratios when compared to the monoculture of either crop. In 2007 where weeds were not controlled, the LER of the cropping ratio of 2B:2M was 1.32 which is an indication of 32 percent yield advantage over the sole cropping of the two crops. When weeds were controlled (2009 and 2010) the intercropping ratio of 6B:2M was the highest and had a LER of 1.29. The yield advantage of intercropping of medic and barley over their monoculture was also confirmed by RCC and MAI indices. The results of this study indicated that although intercropping of annual medic with barley, using 6B:2M replacement series yielded 259 kg ha<sup>-1</sup> less grain compared to barley sole cropping but it produced a 365 kg ha<sup>-1</sup> annual medic seed which has significantly higher market value than barley.

**Keywords:** Annual medic; Barley; Intercropping; Land equivalent ratio; Monetary advantage index; Relative crowding coefficient.

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**Abbreviations:** A, aggressivity; CR, cropping ratio; LER, land equivalent ratio; MAI, monetary advantage index; RCC, relative crowding coefficient.

## Introduction

Efficient use of natural and biological cycles such as nitrogen fixation by legumes may stimulate yield of the non-legume crops in an intercropped system (Hauggaard-Nielsen et al., 2001). It is generally understood that combinations of legumes with cereals would benefit farmers in resource-limited conditions, specifically in arid and semi-arid environments (Gosh et al., 2009). Intercropping of two or more crop species not only improves yield (Li et al., 2001) but also enhances biological diversity, and suppresses pests and diseases (Trenbath, 1993; Smith and Mcorley, 2000).

Annual medic, a high nutritional annual legume, performs well in a low-input intercropping system with cereals for forage production. While annual medic is able to tolerate shading and provides nitrogen, the companion cereal crops such as barley can grow fast, suppress weed pressure and therefore improve seed production (Simmons et al., 1995; Moynihan et al., 1996; Corre-Hallou and Crozat, 2004). The availability of annual medic seeds remains a major challenge and hampers the widespread use of this valuable crop.

The advantage of intercropping of two or more crops to improve final yield depends on spatial arrangements (intercropping pattern) of participated crops (Herbert et al., 1984; Putnam et al., 1986; De costa and Perera, 1998; Hauggaard-Nielsen et al., 2001; Biabani et al., 2008). The conventional intercropping system is 1:1 row arrangement however, MBILI (Managing Beneficial Interactions in Legume Intercrops) which basically is known as two-by-two staggered arrangement (Tungani et al., 2002; Mucheru-Muna et al., 2010) has been suggested. There are limited reports on effect of various spatial arrangements on productivity of intercropped barley and annual medic. These reports indicated that the yield of barley and/or annual medic in an intercropped system can potentially be enhanced (Simmons et al., 1995; Moynihan et al., 1996; Eshghizadeh et al., 2007).

Various indices such as land equivalent ratio (LER), relative crowding coefficient (K), competitive ratio (CR), aggressivity (A), and monetary advantage (MA), have been developed to describe the competition and possible economic advantage in intercropping (Banik et al., 2000; Ghosh, 2004; Midya et al., 2005; Lithouragidis et al., 2011). Mathematical indices can help researchers summarize, interpret, and display the results from plant competition trials (Weigelt and Jolliffe, 2003). Indices can express various attributes of competition in plant communities, including competition intensity, competitive effects, and the outcome of competition. They help in the interpretation of complex data and allow comparison of results from different studies with the use of the same index. Among indices being used for assessing competition between intercrops, land equivalent ratio is the most commonly used for intercrop versus sole crop comparisons (Agegnehu et al., 2006a).

In current study we used a wide range of cropping pattern to a) determine if intercropping annual medic with barley in a low-input condition can produce a supplement medic seed while the yield of barley as the main crop is not compromised and b) examine the competitive relationships of barley and annual medic in intercrop systems.

## Material and Methods

This study was conducted at the experimental farm of University of Tehran, Iran (35° 48' N, 50° 57' W, 1312.5 m elevation) on a clay-loam soil and a semi-arid environment with 38-year average annual precipitation of 251 mm and annual average temperature of 13.5 °C.

Seed production of an Iranian native cultivar of barley (*Hordeum vulgare* CV. Karoon × Kavir) and annual medic (*Medicago scutellata* CV. Robinson), a native of Australia, were evaluated in an intercropping system in 2007 (Experiment I), 2009 and 2010 (Experiment II). In both experiments, samples of soil in the top 30 cm were taken from experimental plots before seeding the plants. Selected chemical properties of the soil and mean monthly rainfall data which was recorded near the experimental area are presented in Table 1 and Table 2, respectively.

Table 1. Selected properties of the top (0-30 cm) of soil at the experimental site.

Year	pH	Organic Matter (g kg <sup>-1</sup> )	N %	P (mg kg <sup>-1</sup> )	K (mg kg <sup>-1</sup> )	Ca (meq lit <sup>-1</sup> )	Fe (mg kg <sup>-1</sup> )	Mn (mg kg <sup>-1</sup> )	Zn (mg kg <sup>-1</sup> )	Soil texture	Sand %	Silt %	Clay %
2007	7.5	1.20	0.12	122	169	2.3	7.0	16.6	1.2	C.L*	30	38	32
2009	7.8	0.94	0.10	142	151	10.0	8.2	16.0	1.4	L**	38	38	24
2010	8.0	1.40	0.14	210	109	10.4	7.2	18.6	0.7	L	31	49	20

\* C.L: Clay-Loam, and \*\* L: Loamy.

Table 2. Total monthly rainfall during growing seasons in 2007, 2009 and, 2010.

Month	rainfall (mm)			
	2007	2009	2010	30-Yr Average
March	62.9	12.6	46.7	47.7
April	66.0	4.5	43.2	34.7
May	10.2	3.1	10.3	20.8
June	8.3	0.0	0.0	2.3
July	1.3	0.3	0.0	3.1
Total	148.7	20.5	100.2	108.6

### Experiment I

The effect of different cropping patterns employing replacement design on grain yield of barley and annual medic was evaluated. Arrangement consisted of 1B:1M (one row of barley: one row of annual medic), 2B:2M, 4B:4M, 6B:6M, 6B:2M, 4B:2M, 2B:4M and 2B:6M along with sole culture of both crops. The previous crop was wheat which was harvested in July 2006. Before seeding, the experimental site was plowed by moldboard plow, harrowed and divided into four blocks, each contained ten plots. Plots consisted of various row numbers depending on intercropping ratios. Planting rows were 0.25 m wide and 5 m long. Within-row spacings were 5 cm and 3 cm for barley and annual medic, respectively. Plots were seeded on March 13<sup>th</sup> by hand and two extra rows on the border of each cropping pattern were considered as guard rows. One row of barley or annual medic were planted next to each side of a treatment plot (barley border was planted next to annual medic and annual medic bordered to barley). The plots were irrigated during the period between March and July when necessary. It was thought that intercropping of the crops will suppress the weeds therefore no weed control practice was applied in this experiment. Excluding guard rows, four meters of all rows within each plot were hand harvested on 10<sup>th</sup> of July. Seed yields of both crops were individually determined and adjusted for the planting pattern (number of rows per plot). Intercropping advantage and competition between barley and annual medic in intercrops were calculated according to Willey and Osiru (1972), Mead and Willey (1980), and Willey and Rao (1980). Land equivalent ratio (LER) was used to quantify the efficiency of the intercropping treatments.

$$LER = (Y_{ab} / Y_{aa}) + (Y_{ba} / Y_{bb})$$

Where  $Y_{aa}$  and  $Y_{bb}$  are yields as sole crops and  $Y_{ab}$  and  $Y_{ba}$  are yields in intercrops. LER values greater than 1 indicate advantage of intercropping over monoculture. LER was also used to calculate monetary analysis. Relative crowding coefficient (RCC) is a measure of relative dominance of one component crop over the other in an intercropping system. For crop 'a' in association with 'b':

$$K_{ab} = Y_{ab} X_{ba} / (Y_{aa} - Y_{ab}) X_{ab}$$

Where  $X_{ab}$  is the sown proportion of 'a' in mixture of 'b' and  $X_{ba}$  the sown proportion of 'b' in mixture of 'a'. If the product of the two coefficients; i.e.  $K = (K_{ab} K_{ba})$  is greater than 1, there is a yield advantage whereas if  $K$  obtained in the system equals to 1, there is no yield advantage, and if  $K$  in the system is less than 1, there is a yield disadvantage (Gosh, 2004). Aggressivity is another index which represents a simple evaluation of the relative yield increase in 'a' crop over 'b' crop in an intercropping system and was calculated as:

$$A_{ab} = (Y_{ab} / Y_{aa} X_{ab}) - (Y_{ba} / Y_{bb} X_{ba})$$

If  $A_{ab}=0$ , both crops are equally competitive, if  $A_{ab}$  is positive, 'a' is dominant, whereas if  $A_{ab}$  is negative, 'b' is the dominant crop. Willey and Rao (1980) suggested competition ratio (CR) instead of "aggressivity" to indicate the degree that one species competes with the other in an intercrop system. The CR represents the ratio of individual LERs of the two intercropped components and takes into account the proportion of the crops in which they are initially planted. The CR was calculated as:

$$CR_a = (LER_a / LER_b) (X_{ba} / X_{ab})$$

When CR is below 1 there is a positive benefit and the species can be grown in a mixture.

The monetary advantage index (MAI) was calculated as described by Gosh (2004).

$$MAI = \text{value of combined intercrops} \times (LER-1) / LER.$$

The higher the index value, the more profitable is the cropping system (Dhima et al., 2007).

### Experiment II

In this experiment four intercropping ratios of 100B:20M (100% seeding rate of barley as monoculture plus 20 percent of annual medic), 100B:40M, 40B:100M and 20B:100M were added to the eight ratios explained in experiment I. Since weeds were not suppressed satisfactorily in 2007, in this experiment we controlled the weeds twice each year manually early in growing seasons. Seeds were planted on March 13<sup>th</sup> in 2009 and March 17<sup>th</sup> in 2010. All other cultural practices were similar to the experiment I. Plants were harvested on July 10<sup>th</sup> and 15<sup>th</sup> in 2009 and 2010, respectively. Evaluation methods of Yield were similar to the experiment I.

### *Statistical Analysis*

Data analyses were conducted separately for 2007 and a combined analysis was performed for 2009 and 2010 using the MIXED procedure of SAS (SAS, 2001). Effects were considered significant for P-values  $\leq 0.05$  by the F-test. Duncan multiple range test was conducted for mean comparisons.

## **Results and Discussion**

### *Experiment (I)*

#### *Barley*

Cropping ratio had a significant effect on barley grain yield (Table 3). As expected, the higher ratio of barley in the intercropping, the higher barley grain was produced. Maximum barley grain yield was obtained from its sole culture in amount of  $1416 \text{ kg ha}^{-1}$  (Table 4). The relatively low yield of barley in this experiment was primarily due to high weed pressure. It was conceivable that when some planting rows of barley were replaced with annual medic the barley yield be reduced compared to its sole cropping. However, we hypothesized that barley grain yield per unit area may improve due to reduction in competition and therefore the total yield of harvested crops (barley grain plus annual medic seeds) may increase. Other reports indicated that barley grain yield per area unit grown with the association of various legumes improved due to the complementary effect of companion legume crops (Willey, 1979; Chatterjee and Bhattacharya, 1986; Ofori and Stern, 1987; Banik and Bagchi, 1993). Intercropping of barley and annual medic creates a wavy canopy which is more efficient in light interception compared to the monoculture of companion crops. Biabani et al. (2008) reported that intercropping of two soybean cultivars which were varied in height created wavy canopy architecture and therefore improved final yield by 11 percent. Our study confirmed this because barley produced higher grain yield in alternate planting pattern of 1B:1M compared to the other 50:50 barley-medic patterns (Table 4). However, some reports have shown that no yield improvement of cereal crops was obtained when intercropped with legumes (Thorsted et al., 2006; Pridham and Entz, 2008).

#### *Annual medic*

Annual medic seed yield was significantly influenced by cropping ratios (Table 3). As stated for barley, the higher percentage of annual medic rows in the intercrops the higher medic seeds were harvested (Table 4). The highest medic seed yield ( $422 \text{ kg ha}^{-1}$ ) was harvested from 6M:2B probably due to the lower inter-specific competition between the two crops. In contrast, the lowest seed yield of annual medic was obtained from 2M:6B ratio in which annual medic was intensively suppressed by barley plants as the dominant component. The results of this study confirmed other reports (Ross et al., 2004; Jensen et al., 2006) that indicated legumes are not benefiting as much as non-legumes from wavy architecture canopies.

Table 3. Significance levels for grain and seed yield data of barley and annual medic sole cultures and their combinations in 2007 (experiment I) and 2009 and 2010 (experiment II).

SOV	Experiment I		Experiment II	
	BGY	MSY	BGY	MSY
Y	-	-	NS	**
CR	**	**	**	**
Y × CR	-	-	NS	**

\*\*Significant at  $P < 0.01$ ; NS= not significant.

Table 4. Grain yield of barley and seed yield of annual medic as affected by intercropping systems (data in experiments I and II are means of two years except for annual medic in the experiment II).

CR	Experiment I		Experiment II		
	Barley	Medic	Barley	Medic 2009	Medic 2010
1B:1M	1040 <sup>bc</sup>	292 <sup>cd</sup>	1101 <sup>cd</sup>	435 <sup>ghijk</sup>	500 <sup>fg</sup>
2B:2M	916 <sup>cd</sup>	352 <sup>bc</sup>	1041 <sup>cde</sup>	487 <sup>fgh</sup>	545 <sup>ef</sup>
4B:4M	825 <sup>de</sup>	249 <sup>de</sup>	938 <sup>de</sup>	409 <sup>hijk</sup>	477 <sup>ghij</sup>
6B:6M	805 <sup>de</sup>	255 <sup>de</sup>	836 <sup>c</sup>	400 <sup>ijk</sup>	469 <sup>fghi</sup>
Sole Barley	1416 <sup>a</sup>	-	1907 <sup>a</sup>	-	-
100B:20M	-	-	1822 <sup>ab</sup>	114 <sup>m</sup>	129 <sup>m</sup>
100B:40M	-	-	1660 <sup>b</sup>	255 <sup>l</sup>	272 <sup>l</sup>
6B:2M	1100 <sup>b</sup>	192 <sup>c</sup>	1648 <sup>b</sup>	352 <sup>k</sup>	377 <sup>jk</sup>
4B:2M	1023 <sup>bc</sup>	216 <sup>de</sup>	1223 <sup>c</sup>	364 <sup>jk</sup>	401 <sup>ijk</sup>
2B:4M	703 <sup>c</sup>	302 <sup>cd</sup>	918 <sup>de</sup>	502 <sup>fg</sup>	641 <sup>bcd</sup>
2B:6M	398 <sup>f</sup>	422 <sup>b</sup>	877 <sup>e</sup>	595 <sup>de</sup>	656 <sup>bcd</sup>
40B:100M	-	-	468 <sup>f</sup>	622 <sup>cde</sup>	681 <sup>bc</sup>
20B:100M	-	-	227 <sup>g</sup>	637 <sup>bcd</sup>	709 <sup>b</sup>
Sole Medic	-	514 <sup>a</sup>	-	826 <sup>a</sup>	877 <sup>a</sup>
CV	17.07	10.28	6.10	8.29	8.29

Means in each column with the same letter are not significantly different at  $P < 0.05$ .

### Experiment (II)

#### Barley

The effect of year and the interaction of year by cropping ratio on grain yield of barley was not significant (Table 3), therefore, average of the two growing seasons was used for mean comparison (Table 4). A significant difference was found for barley grain yield in various cropping ratios. Barley grain yield decreased from 1907 kg ha<sup>-1</sup> in monoculture to 1648, 1223 and 979 kg ha<sup>-1</sup> as barley ratio declined to 75, 67 and 50 percent, respectively (Table 4). Among planting patterns, the highest grain yield (1822 kg ha<sup>-1</sup>) was obtained from 100B:20M. We expected that when we added some annual medic to 100% barley we get an improvement in barley grain yield due to the N fixation ability of the legume. However, that was not the case and no yield improvement was obtained from addition of 20% annual medic to pure stand of barley. This could be due to insufficient N contribution from annual medic to barley plants while a degree of interspecific competition between the two crops was occurred. Agegnehu et al. (2006) reported that mixed cropping of barley and fava bean reduced barley grain yield when seeding rate of fava bean exceeded 25% of its pure stand. In another study, Agegnehu et al. (2008) reported that increasing the fava bean seed rate from 12.5% to 62.5% decreased wheat grain yield from 3601 kg ha<sup>-1</sup> to 3039 kg ha<sup>-1</sup> while fava bean yield was

increased from 141 kg ha<sup>-1</sup> to 667 kg ha<sup>-1</sup>. Therefore, a cost-benefit study can be beneficial to determine if the farmers will benefit from intercropping of cereal crops with legumes which traditionally have much higher market values.

#### *Annual medic*

Annual medic seed yield was significantly influenced by year and interaction of year × cropping ratio ( $P < 0.001$ ). Therefore, medic seed yields for 2009 and 2010 are presented separately in Table 4. Seed yield of annual medic was 11% greater in 2010 than 2009. The yield difference could partly be attributed to the soil characteristics of the two years but more likely due to significant difference in total rainfall in 2009 compared to 2010 (Table 2). A severe drought condition was occurred in 2009 and plants received only 20.5 mm precipitation compared to 100.6 mm which is the norm for this location.

Cropping ratios also had a significant influence on medic seed yield (Table 3). As expected, sole cropping of medic produced the highest yield compared to the other cropping ratios. Adding barley as companion crop to annual medic reduced its yield compared to medic sole cropping. For example the ratio of 20B:100M produced 659 kg ha<sup>-1</sup> annual medic seeds which was 22 percent less than the yield obtained from its sole cropping. This result indicated that annual medic is more susceptible to crowding stress than barley which had only 5% reduction in yield. The highest annual medic seed yield (877 kg ha<sup>-1</sup>) was obtained from its sole culture in 2010 and the yield reduced as barley population increased in the cropping system (Table 4). Among intercropping ratios, 20B:100M in 2010 was out yielded other cropping ratios. Similarly other reports indicated that in intercropping systems, legumes are often dominated by non-legumes (Banik et al., 2006; Jensen et al., 2006).

#### *Competition Indices*

##### *Land equivalent ratio and relative crowding coefficient*

The land equivalent ratio (Table 5) exceeded unity in most intercropping systems in the experiments I and II indicating an advantage of intercropping compared to the sole cropping. Exceptions were 6B:6M and 100M:20B in Exp II where LERs were below 1.00. The highest LER value (1.32) was obtained from 2B:2M in the experiment I while the highest LER value for experiment II (1.29) was found in 6B:2M. The advantage of intercropping, expressed by  $LER > 1$  was related to the improved barley grain yields in intercropping while a minor reduction in annual medic seed yield occurred. The overall results indicated that economic efficiency can be improved through intercropping system.

The results from calculated RCC are presented in Table 5. When a species has a RCC greater than one it indicates that the species has produced more yield than is expected (Willey, 1979). In experiment I, due to lack of weed control, barley produced higher yield only in three of the eight intercropping ratios. However, total RCC in experiment I was higher than unity in all intercropping patterns indicating that intercropping improved the total yield of barley and annual medic which had been already expressed by LER (Table 5).

Similar reports on yield enhancement from intercropping of legume-nonlegume crops have been reported (Banik et al., 2006; Ghosh et al., 2006; Agegnehu et al., 2008; Vasilakoglu and Dhima, 2008). In experiment II intercropping of the two crops generally improved the final yield (Table 5) as expressed by RCC. The exceptions included the 20B:100M where annual medic yield improvement did not compensate the overall yield and 6B:6M which was quite unexpected and the authors have no explanation for it. Agegnehu et al. (2006) and Oseni (2010) suggested that cereals may not always be the dominant crops in intercropping with legumes.

Table 5. LER and RCC of barley and annual medic in different cropping ratios for experiment I (2007) and II (2009 and 2010).

Intercrop	Land Equivalent Ratio		Relative Crowding Coefficient					
	Experiment I	Experiment II	Experiment I			Experiment II		
			K <sub>b</sub>	K <sub>m</sub>	K	K <sub>b</sub>	K <sub>m</sub>	K
1B:1M	1.21	1.12	2.76	0.94	2.60	1.36	1.21	1.64
2B:2M	1.32	1.14	1.83	2.17	3.97	1.20	1.53	1.83
4B:4M	1.07	1.01	1.39	0.98	1.37	0.96	1.08	1.03
6B:6M	1.14	0.94	1.31	1.31	1.72	0.77	1.04	0.80
100B:20M	-	1.09	-	-	-	22.0	0.16	3.52
100B:40M	-	1.17	-	-	-	6.80	0.64	4.35
6B:2M	1.14	1.29	1.16	1.80	2.08	2.13	1.31	2.79
4B:2M	1.14	1.08	1.30	1.45	1.88	0.89	1.58	1.40
2B:4M	1.08	1.14	1.97	0.70	1.37	1.86	1.06	1.97
2B:6M	1.10	1.20	1.17	1.52	1.77	2.53	0.97	2.26
40B:100M	-	1.01	-	-	-	0.32	3.20	1.02
20B:100M	-	0.90	-	-	-	0.14	3.70	0.51

#### *Aggressivity, competition ratio, and monetary advantage index*

The aggressivity parameter and competition ratio (Table 6) confirmed the tendency of barley as the dominant crop in majority of cropping ratios used in the experiment I. However, in experiment II, annual medic showed positive aggressivity in most cropping ratios. This could be largely due to difference in weed pressure in 2007 which was more severe compared to 2009 and 2010. Annual medic is susceptible to weed competition therefore, in experiment I where no weeding was practiced; the crop became less dominant whereas in the experiment II, annual medic was dominant crop in almost all intercropping systems. In 2007 we observed that the highest weed pressure occurred in monoculture of annual medic and thus as the ratio of annual medic ratio increased in the cropping system plots were more infested (data not shown). Similarly, Agegnehu et al. (2006 a, b) reported that teff and barley were dominated in their respective mixtures with fava bean.

In this study the positive monetary advantage values (Table 6) obtained from different cropping systems indicating a definite gain from intercropping over pure stands except for 6B:6M and 20B:100M in the experiment II. In particular, the highest MAI values were obtained from 2B:2M (\$1037.2) and 6B:2M (\$1266.5) in experiments I and II, respectively. These findings are in line with the results for LER (Table 5). Gosh (2004) and Dhima et al. (2007) reported that higher LER is closely related to higher MAI values which emphasize the economic benefits from intercropping.



Table 6. Aggressivity, competition ratio, and monetary advantage index of barley and annual medic intercropping for experiment I (2007) and experiment II (2009 and 2010).

Intercrop	Aggressivity		Competition Ratio				MAI	
	Experiment I	Experiment II	Experiment I		Experiment II		Experiment I	Experiment II
			barley	medic	barley	medic		
1B:1M	0.49	0.06	1.52	0.66	1.05	0.95	699.6	587.14
2B:2M	-0.07	-0.12	0.94	1.06	0.99	1.12	1037.2	706.50
4B:4M	0.17	-0.06	1.18	0.84	0.95	1.06	217.9	50.20
6B:6M	0.00	-0.09	1.00	1.00	0.87	1.14	410.5	-304.20
100B:20M	-	0.26	-	-	1.39	0.72	-	335.47
100B:40M	-	0.10	-	-	1.15	0.87	-	708.33
6B:2M	-0.47	-0.58	0.69	1.44	0.66	1.51	413.3	1266.55
4B:2M	-0.18	-0.47	0.85	1.18	0.73	1.37	419.7	373.00
2B:4M	0.62	0.43	1.66	0.60	1.42	0.71	261.3	732.42
2B:6M	0.03	0.44	1.02	0.98	1.85	0.54	356.8	1051.33
40B:100M	-	-0.15	-	-	0.89	1.26	-	57.47
20B:100M	-	-0.19	-	-	0.73	1.37	-	-617.60

## Conclusion

The results of this study showed that the total yield of barley and annual medic can be improved by adopting certain intercropping patterns. The calculated LER exceeded unity in most cropping systems, indicating that intercropping was advantageous due to higher exploitation of the limited environmental resources. When barley and annual medic were intercropped with 6B:2M ratio, the overall yield was improved by 29 percent. Monetary advantage index revealed that highest benefits were obtained from 6B:2M and 2B:2M with \$1266.5 and \$1037.2, respectively.

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