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Effect of different intercropping patterns on yield and yield components of sorghum (*Sorghum bicolor* L.) and mungbean (*Vigna radiate* L.)

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Abstract

Intercropping is considered for increasing and stability of yield per average unit. In order to evaluate the effect of planting patterns on yield and yield components of sorghum and mungbean, an experiment conducted in 2013 at the Research Farm, Faculty of Agriculture, University of Tabriz, Tabriz, Iran, as randomized complete block design with seven treatments and three replications. The treatments were included pure stands for both species, row intercropping and four levels strip intercropping 2:1, 3:1, 1:2 and 1:3 for sorghum and mungbean number of rows per strip, respectively. The results showed that the maximum LAI for sorghum and mungbean obtained in (2:1) and (sole cropping of mungbean) treatments, respectively. The effect of different intercropping on number of grains per pod was not significant. The grain yield and number of grains per panicle of sorghum were significantly affected by different patterns of culture. Also, the highest (33.93%) Harvest index (HI) of sorghum was obtained in (2:1) treatment.

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Introduction

Stable agriculture is ascribed to the authentic management of agricultural resources, which in addition to fulfilling the ever-changing needs of humans, maintains the health of environment and capacity of water and soil resources (Reijntjesetal, 1992). Intercropping is one of the most common practices used in sustainable agricultural systems which has an important role in increasing the productivity and stability of yield in order to improve resource utilization and environmental factors (Alizadeh *et al.,* 2010). Benefits of intercropping may be briefed as: better use of resources, improvement of soil fertility by legume components of the system, soil preservation through covering the bare land between the rows, reduction of biotic and abiotic risks by increasing diversity, suppression of weeds infestation, etc (Emam, 2003).

Yield advantage in intercropping occurs because component crops differ in their use of growth resources in such a way that when they are grown in combination, they are able to complement each other and so make better overall use of resources than when grown separately (Willey, 1979). Cereal-legume intercropping is a more productive and profitable cropping system in comparison with solitary cropping (Evans *et al.*, 2001). If a legume is grown in association with another crop, commonly a cereal, the N nutrition of the associated crop may be improved by direct N transfer from the legume to the cereal. Therefore, productivity, normally, is potentially enhanced by the inclusion of a legume in the cropping system (Maingi *et al.,* 2001). Sorghum (*Sorghum bicolor* L.) is the fifth most important cereal in the world followed by wheat, rice, maize and barley (El Naim *et al.,* 2012). Sorghum is used not only for human food, but also for fodder and feed for animals, building material, or for brooms (Doggett, 1988). Mungbean (*Vigna radiate* L.) seeds are primarily used for food purposes. They are a rich source of lysine and proteins, and thus can supplement cereal-based human diet (Singh, 2000). So this experiment was conducted to investigate different ratios of sorghum and mungbean intercropping to achieve maximum yield and introduce the most suitable intercrop pattern for two species.

Materials and methods

Site description

The field experiments was conducted in 2013 at the Research Farm of the Faculty of Agriculture, Tabriz University, Iran (latitude 38.05° N, longitude 46.17° E, Altitude 1360 m above sea level). The climate is characterized by mean annual precipitation of 245.75 mm, mean annual temperature of 10°C, mean annual maximum temperature of 16.6 °C and mean annual minimum temperature of 4.2°C and a sandy- loam soil texture.

Experimental design

The experimental design was a randomized complete block with seven treatments and three replicates. The treatments were included pure stands for both species, row intercropping and four levels strip intercropping 2:1, 3:1, 1:2 and 1:3 for sorghum and mungbean number of rows per strip, respectively. The method used was the substitution method according to constant densities and changing ratios. Each plot consisted of eight rows of 4 meters long with row spacing 50 cm which were away 50 cm from the adjacent plot. The row spacing for sorghum seed was considered 25 cm and 10 cm for the mungbean. Seeding densities of sorghum and mungbean were 8 and 20 seeds m^{-2}, respectively. All plots were irrigated immediately following planting, but the subsequent watering was made according to climatic conditions of the experiment site. Hand weeding of the experimental area was performed as required.

Data collection

For measuring the yield and yield components of the two species, in each plot five plants of sorghum and mungbean accidently were selected after removing marginal effects and traits were measured. Leaf area index (LAI) was calculated for the two crops. Also, Harvest index (HI) was calculated by the following equation.

$$HI = \frac{Economical\ yield}{Biological\ yield}$$

Data analysis

Statistical analysis of the data was performed with SPSS software. The significance of difference between treatments was determined using the Duncan multiple range test at the 5% probability level.

Results and discussion

Leaf area index (LAI)

At the beginning of mungbean plants growth period, no difference was observed between different planting patterns in Leaf area index trait. As the days after emergence passed, mungbean leaf area index increased. Although this increasing trend reached its zenith 100 days after emergence, it took a downward turn which continued until the end of the growth period, especially in intercropping treatments. Leaf area index of mungbean in monoculture treatment was higher than all intercropping treatments (Fig 1). An increase of a certain extent in Leaf area index resulted in increased photosynthesis and more absorption of light, which ultimately led to production of more dry matter. Pandita *et al.* (2000) reported that in intercropping maize with mungbean, mungbean LAI amount in monoculture was more than intercropping.

Table 1. Analysis of variance for yield and yield components of mungbean mixed with sorghum.

		Mean squares					
Source of Variation	df	Number of grains per pod	Number of Pod plant^{-1}	1000 seed weight	Grain yield	Biological yield	Harvest index
Replication	2	0.308^{ns}	23.167*	0.568^{ns}	3169.91^{ns}	4349.31^{ns}	0.038^{ns}
Treatments	5	1.619^{ns}	32.484**	11.981**	844971.58**	4577625.3**	19.33**
Error	10	0.766	3.167	0.182	2441.32	7511.3	2.252
CV (%)		11.07	6.05	0.75	3.68	4.14	2.38

*, ** Significant at the 0.05 and 0.01 probability levels, respectively, ns, non-significant.

T2 (mungbean monoculture), T3 (1:1), T4 (2:1), T5 (3:1), T6 (1:2) and T7 (1:3).

Effect of different sorghum and mungbean sowing patterns on sorghum leaf area index is shown in Figure 2. Leaf area index of sorghum exhibited an increasing trend which was slow until 70 days after emergence. As the temperature increased, the leaves began to expand rapidly and leaf area index reached its maximum. After this stage, increased shading and reduced light penetration into the canopy caused the photosynthetic activity to decline, and leaf area index exhibited a decreasing trend due to the loss of lower leaves of the canopy. The maximum sorghum leaf area index was observed in treatment (2:1). Kayhan *et al.* (1999) reported that in intercropping maize with soybean, leaf area index amount in intercropping was more than monoculture. similar results were also reported by Walker and Ogindo (2003).

Yield and yield components of mungbean

T1 (sorghum monoculture), T3 (1:1), T4 (2:1), T5 (3:1), T6 (1:2) and T7 (1:3).

Number of grains per pod

Effect of different patterns of culture was not significant on mungbean number of grains per pod (Table 1). However, (1:3) treatment was with a mean of 8.95 of the highest number of grains per pod than other treatments (Table 2). It seems that intraspecific competition is less affected in reducing of mungbean number of grains per pod compared to interspecific competition. Pandita *et al.* (2000) revealed that number of grains per pod of mungbean was reduced considerably in intercropping system as compared to sole crop.

Number of pods plant

The results of variance analysis table showed that the effect of patterns of culture on mungbean number of pods plant^{-1} was significant at 1% level (Table 1). Number of pods plant^{-1} was higher in case of sole cropping of mungbean (33.6) as compared to all the intercropping patterns (Table 2). Possible reason for higher number of pods plant^{-1} in sole mungbean plots might be attributed to no inter specific competition and better utilization of nitrogen being applied as a starter dose and fixed by root nodule. Similar results are reported by Asim *et al.* (2006) who observed that number of pods plant^{-1} of mungbean were higher in monoculture as compared to their corresponding intercropped.

1000- seed weight

The results of variance analysis showed that the effect of patterns of culture on the weight of 1000- seed was significant at 1% level (Table1). The maximum mungbean 1000- seed weight was obtained from its treatment (3:1) in amount of 58.64 gr (Table 2). The reason of this result was due to the greater number of pods plant^{-1} and the number of grains per pod in monoculture compared to intercropping patterns, plants available in monoculture should be saved themselves assimilate in more reservoirs and this leads to reduced seed weight in monoculture than other treatments. Son and Chung (1969) reported increase in 1000-grain weight of sorghum in sorghum and soybean intercropping system.

Table 2. Mean comparison for yield and yield components of mungbean mixed with sorghum.

Treatments	Number of grains per pod	Number of pod plant-1	1000 seed weight (g)	Grain yield (kg.ha-1)	Biological Yield (kg.ha-1)	Harvest Index (%)
Sorghum (sole)	-		- -	-	-	-
Mungbean (sole)	8.79a	33.6a	53.12e	2012.2a	5185.4a	38.92a
1Sorghum +1Mung bean	7.69a	28.4bc	57.18cd	1282.4d	3550.3d	36.22a
2Sorghum +1Mung bean	7.26a	25.9c	58.22ab	700.6e	2158.2e	32.81b
3Sorghum +1Mung bean	7.31a	25.6c	58.64a	750.8e	2246.4e	33.46b
1Sorghum +2Mung bean	7.75a	31ab	57.79bc	1601.8c	4250.5c	37.86a
1Sorghum +3Mung bean	8.95a	31.9a	56.68d	1698.6b	4490.5b	37.95a

Means with at least one similar letter, are not significant different (P<= 0.05) based on Dunkan test.

Grain and biological yields

Mungbean grain yield was significantly affected by different patterns of culture (Table 1). The maximum grain yield was achieved in sole cropping of mungbean treatment (Table 2). It seems that the lower grain yield in intercropped plots may be due to shading effect of sorghum on mungbean due to variation in plant architecture. Subramanian and Rao (1988) in a field experiment consisting intercropping of sorghum with pigeonpea and mungbean reported that both component crops of sorghum and pigeonpea recorded less grain yield as compared to sole crop yields of sorghum and pigeonpea. In the sorghum + mungbean system, grain yield of sorghum was not significantly reduced but the yield of mungbean was reduced by 80 percent as compared to respect its sole crop yield.

Table 3. Analysis of variance for yield and yield components of sorghum mixed with mungbean.

		Mean squares				
Source Variation	of df	Number of grains per panicle	1000 seed weight	Grain yield	Biological yield	Harvest index
Replication	2	4967.61^{ns}	0.147^{ns}	7934.78^{ns}	68398.35^{ns}	0.079^{ns}
Treatments	5	119608.34**	1.006^{ns}	1806613.74**	16948983.86**	11.33**
Error	10	6158.06	0.624	7831.08	16695.05	0.075
CV (%)		7.27	2.97	4.21	1.91	0.87

*, ** Significant at the 0.05 and 0.01 probability levels, respectively, ns, non-significant.

As can be seen from table (1) the effect patterns of culture were significant on biological yield. Sorghum-mungbean intercropping decreased mungbean biological yield as compared to sole cropping of mungbean. It might be due to less photosynthetic activities by mungbean crop due to less exposure to sunlight and canopy covered by sorghum leaves.

Table 4. Mean comparison for yield and yield components of sorghum mixed with mungbean.

Treatments	Number of grains per panicle	1000 seed weight (g)	Grain yield (kg.ha-1)	Biological Yield (kg.ha-1)	Harvest Index (%)
Sorghum (sole)	1125.6b	27.21a	3011.2a	10012a	30.25d
Mungbean (sole)	-	-	-	-	-
1Sorghum +1Mung bean	920.3cd	26.34a	2160c	6464.4c	33.43b
2Sorghum +1Mung bean	1324.2a	27.08a	2692.8b	7941.4b	33.93a
3Sorghum +1Mung bean	1285.6a	26.93a	2605b	8050b	32.47c
1Sorghum +2Mung bean	987.5bc	25.88a	1234.4d	4152.8d	29.72e
1Sorghum +3Mung bean	832.4d	25.98a	1186d	3980d	29.60e

Means with at least one similar letter, are not significant different (P<= 0.05) based on Dunkan test.

Harvest index (HI)

Harvest index of mungbean was significantly (P<0.01) affected by different sowing patterns (Table 1). The HI was highest in sole cropping of mungbean treatment averaging 38.92 (Table 2). Jahani *et al.* (2008) reported the highest harvest index of lentils in monoculture treatment of this plant. In experiments conducted by Tavasoli *et al.* (2010) to investigate intercropping millet (*Panecummiliaceum*) and beans, also the highest harvest index of beans was obtained in the monoculture of beans.

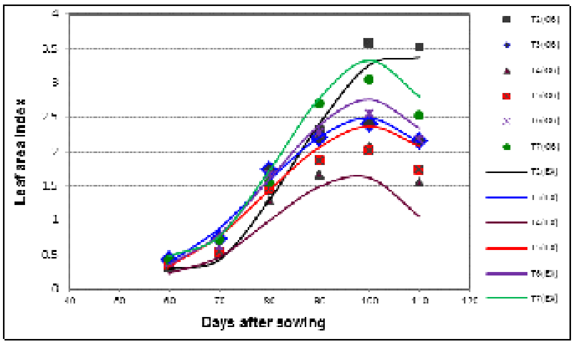

Fig. 1. Effect of different sorghum and mungbean sowing patterns on mungbean leaf area index.

Yield and yield components of sorghum

Number of grains per panicle

The results of analysis of variance for c sorghum traits as RCB design are referred to in Table 3. The effect of planting patterns was significant on number of grains per panicle of sorghum. Among different planting ratios, (2 sorghum + 1 mungbean) had the highest number of grains per panicle (Table 4). Similar results were also reported by Himayatullah (1991).

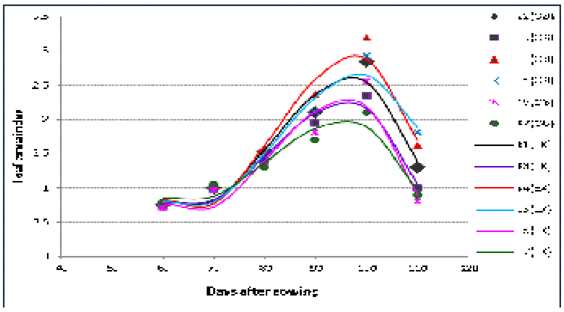

Fig. 2. Effect of different sorghum and mungbean sowing patterns on sorghum leaf area index.

1000- seed weight

Effect of different patterns of culture were not significant on sorghum 1000-seed weight (Table 3). However, sole cropping of sorghum treatment was with a mean of 27.21 gr of the highest seed weight than all the intercropping patterns (Table 4). Gary and Francies (1999) reported that in intercropping maize, soybean and sorghum, soybean seed weight was not significant. Manjith Kumar *et al.* (2009) stated that different ratios of intercropping did not significant effect on chickpea seed weight.

Grain and biological yields

The effect of planting patterns was significant on grain yield of sorghum (Table 3). Among different planting ratios, sole cropping of sorghum had the highest grain yield (Table 4). Possible reason for yield loses might be due to interspecific competition between sorghum and mungbean for below and above ground growth factors i.e. soil moisture, nutrient, space and solar radiation. Raghuwanshi *et al.* (1993) reported that maximum grain yield of sorghum was obtained from sole crop of sorghum as compared to intercropping with soybean. Also, sorghum biological yield was significantly affected by different patterns of culture (Table 3).

Harvest index (HI)

Harvest index of sorghum was significantly ($P<0.01$) affected by different sowing patterns (Table 3). The highest (33.93%) and the lowest (29.60%) harvest index of sorghum was achieved in (2 sorghum + 1 mungbean) and (1 sorghum + 3 mungbean), respectively (Table 4). According to Singh and Stoskopt (1971) harvest index positively correlated with grain yield but negatively correlated with vegetative growth.

Conclusions

In general, the results showed that the yield and yield components of sorghum and mungbean were significantly affected by the treatments. In the present study, mungbean has beneficially effect on yield and yield component of sorghum. The maximum Harvest index for sorghum obtained in (2:1) treatment. Therefore according to the results of this experiment, intercropping of sorghum and mungbean was superior to monoculture and recommended for similar conditions.

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