Sowing date and mixing rate could improve crops yield Case study: intercropping of maize and lentil

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Abstract: A field experiment was conducted to study the effect of sowing date and mixing rate on yield of maize and lentil in intercropping systems in Tabriz, Iran, during 2012. Treatments were sowing date of lentil related to maize (20, 10 days earlier than maize and simultaneously with maize) and sowing rate of lentil (100% maize, 12.5%:100%, 25%:100%, 37.5%:100% and 50%:100% of lentil-maize, respectively, included 100% of recommended seeding rate for lentil as control). Lentil biomass per unit area in monoculture experienced a significant increase up to 255 g per square meter as compared to intercropped treatments. Lentil produced a higher grain yield (26.8 g m^{-2}), when it was sown 10 days earlier than maize with 100% density. Increasing of mixing rate of lentil led to reduction in maize biomass. When lentil was sown 10 days earlier, the maize produced higher grain yield in 100% maize+12.5% lentil treatment. Sowing of lentil 20 days earlier in 50% optimum density along with maize was more profitable because of higher LER of 2.2. While, LER in sowing treatment of lentil 10 days earlier was lower than unit (0.9) in 12.5% optimum density along with maize. With a view to relative value total (RVT) index, the lentil sowing of 20 days earlier in 12.5% optimum density along with maize (RVT=1.42) was better than sowing of 20 days earlier in 37.5% optimum density with RVT of 1.31. Intercropping of lentil 20 days earlier was recommended in 12.5% optimum density along with maize full density.

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1. Introduction

Maize (Zea mays L.) is the most widely grown grain and forage crop with annually 1730×10^6 Mg production throughout the Iran. Lentil (Lens culinaris L.) is a poor competitive plant with weeds and its ability to compete with weeds in Iran relies largely on the application of herbicides (Majnoun Hosseini, 2008). There is need to develop the best cropping pattern to increase crop production and decrease weeds interference. Intercropping is an agricultural practice of cultivating two or more crops in the same farm during the same cropping season (Andrews and Kassam, 1976). When two or more crops are grown together, each must have adequate space to maximize cooperation and minimize competition between the crops. Spatial arrangement, plant density, maturity dates of the crops and plant architecture must be considered to accomplish this (Silva et al., 2009). It has been shown that intercropping helps in increasing farm income (Kalra and Gangwar, 1980), while Mandal et al. (1985) reported that intercropping of wheat, mustard and chickpea decreased number of fruiting branches per plant, number of pods per plant as well as 1000 seeds weight. In an experiment conducted by Najari Sadeghi et al. (2013) hundred seeds weight of bean was ranging from 37 g in earlier sowing of bean than marigold, in row intercropped pattern up to 46.4 g in bean sole-cropping. When bean delayed cropping marigold in strip pattern, produced seeds with 100 seeds weight same as single cropping. In Onuh et al. (2011) study on mung bean/melon/maize intercrop, mung bean mono-cropping resulted in higher leaves number and finally grain yield. The intercropping maximum and minimum land equivalent ratios (LER) of 1.066 and 0.974 were attained by 50%SC704:50%SC604 and 25%SC704:75%SC604 combinations in an experiment on maize cultivars, respectively. Also, 50%SC704:50%SC604 combination showed the yield advantage of (LER>1) as compared with monoculture in equal land area (Mazaheri et al., 2003). Laster (2006) reported that soybean and bean intercropping in 1:1 ratio gave the highest monetary return and LER of 2 and the yield advantage was more in intercropping than all sole cropping systems. Mazaheri and Oveysi (2004) reported that SC604 and SC704 intercropping in 1:1 ratio gave 15.3% and 7.8% greater grain yield as compared to 1SC704:3SC604 and 3SC604:1SC704 combinations, respectively. The aim of the present study was to evaluate effect of sowing date and mixing rate on yield of maize and lentil in intercropping systems.

2. Material and Methods

The field experiment was conducted on a sandy loam soil at the Agricultural Research Station of Islamic Azad University of Tabriz, Iran, during 2012 growing season. Tabriz is located in the north-west of Iran; the climate is semi-arid and cold and average annual precipitation is 270 mm. The experimental field had been in a bean-barley rotation cycle for the last two years. The experimental area was ploughed in the fall and manured with 10 t ha^{-1}. The Fields were cultivated, disked, furrowed and then plotted in spring before sowing the seeds there. Fertilizers used, in spring and before sowing, included 150, 100 and 75 kg ha^{-1} of ammonium phosphate, potassium sulfate and urea, respectively. The studied treatments were sowing date of lentil related to maize (D_1=20 days earlier, D_2=10 days earlier than maize and D_3= simultaneously with maize), sowing rate of lentil (I_1=100% maize, I_2=12.5%:100%, I_3=25%:100%, I_4=37.5%:100% and I_5=50%:100% of lentil-maize, respectively, included I_6=100% of recommended seeding rate for lentil as control). The studied variables were biomass and grain yield in lentil, biologic and grain yield in maize; LER and RVT (relative value total) as intercropping indexes. The land equivalent ratio (LER) is the most basic tool that agricultural scientist generally employ to evaluate polyculture (Mead and Rilley, 1980). It is calculated as equation 1:

$$\mathbf{LER = (P_1/M_1) + (P2/M_2)}$$

Where, P_1 and P_2 are the yields of maize and lentil crops in polycultures and M_1 and M_2 are the yields of those of these crops in monocultures. Any result over 1, would signify a polyculture advantage; any result below one signifies a monoculture advantage. The problem with LER is that such calculation does not account for the value of the crops that are being sown (Moseley, 1974). The solution to this problem is provided in calculating relative value total (RVT) of the crop mixtures. Such calculation is relevant for the farmer that has monetary value as his farming goal (Vandermeer, 2004). RVT is given in equation 2:

$$\mathbf{RVT = aP_1 + bP_2/aM_i}$$

Where P_1, P_2 and Mi are as defined in equation 1, a and b are the market prices of maize and lentil respectively. All data were statistically analyzed based on randomized complete block design, using MSTAT-C software. The means of the treatments were compared using the least significant difference test at * $P < 0.05$.

3. Results and Discussion

3.1. Analysis of variance

Interaction of sowing date and mixing rate of lentil related to maize on its biomass and grain yield per unit area were significant at 1% and 5% probability levels, respectively. Effect of mixing rate on maize biologic yield was significant at 5%; and interaction of sowing date and mixing rate on its grain yield was significant at 5% probability levels. Interaction of the factors studied on LER and RVT were significant at 1% and 5% probability levels, respectively (Table 1).

Table 1: Mean squares of studied variables in intercropping of maize and lentil

SV	df	Lentil biomass	Lentil grain yield	Maize biological yield	Maize grain yield	LER	RVT
Replicate	2	12.999	10.010	458.658	125.101	10.013	12.012
Sowing date (D)	2	190.008**	30.032**	12.210	85949.475**	0.919**	0.330**
Mixing rate (I)	5	35.665	4.458*	89798.554*	4253150.598**	0.201**	0.080**
D×I	10	285.300**	5.498*	546.489	28521.249*	0.089*	0.029*
Error	34	19.224	1.767	28099.380	7612.267	0.029	0.008
CV (%)	-	11.00	11.58	8.59	22.88	11.58	9.11

*, ** mean significant at 5% and 1% probability levels, respectively.

3.2. Mean comparisons of data

Based on means comparison of data obtained from the lentil biomass study per unit area in monoculture experienced significant increase up to 255 g per square meter as compared with intercropped treatments (Table 2). Sowing date influences stem height, time to ripening, seed size and finally the yield (Khanal et al., 2004). In an experiment conducted by Ghosh et al. (2006), the biological yield of soybean (Glycine max) as intercropped with sorghum (Sorghum bicolor), was reduced nearly by 30% related to sole-cropping one. Above-ground biomass in crop plants in polyculture systems could be increased due to improvement of intercropped components capacity for greater resources absorption (Jahansooz et al., 2007). In intercropping of faba bean (Vicia faba) and barley, bean biomass decreased significantly as compared to multiple cropping (Ketachew et al., 2007). Based on Jahani et al. (2009) reports, when lentil strip-intercropped with cumin (Cuminum cyminum), its biomass decreased up to 2100 kg per hectare. Totally, the lentil grain yield in monoculture was greater than polyculture treatments. The highest yield (26.8 g m^{-2}) was obtained, when lentil sown 10 days earlier than maize with 100% density, and the lowest from treatments of 10 days earlier than maize×50% mixing rate (4.5 g m^{-2}), 20 days earlier than maize×37.5% mixing rate (3.8 g m^{-2}) and simultaneously with maize×50% mixing rate (3.5 g m^{-2}) (Table 2). Shayegan et al. (2009) emphasized on effect of mixing rate on seed yield. These researchers stated that the grain yield of millet was reduced when maize+foxtail millet (Setaria italica) intercropped by 100% + 12.5%.

Table 2: Mean comparisons of sowing date and mixing rate on some of studied variables in maize+lentil intercropping

Treatments	Lentil biomass (g m-^{2})	Lentil grain yield (g m-^{2})	Maize grain yield (g m-^{2})
D1I1	-	-	365.7 e
D1I2	25.0 g	7.8 de	487.4 c
D1I3	46.7 e	8.8 d	405.0 d
D1I4	61.5 d	3.8 e	372.7 e
D1I5	93.4 c	24.4 a	370.4 e
D1I6	255.0 a	22.6 a	-
D2I1	-	-	442.7 c
D2I2	25.3 g	4.5 e	647.7 a
D2I3	37.1 f	14.0 c	452.7 c
D2I4	52.8 d	16.9 bc	357.7 e
D2I5	65.9 d	18.1 b	480.0 c
D2I6	123.4 b	26.8 a	-
D3I1	-	-	527.7 b
D3I2	9.9 h	3.2 e	437.7 c
D3I3	24.7 g	12.1 cd	523.7 b
D3I4	42.7 ef	8.8 d	548.0 b
D3I5	40.0 ef	3.5 e	450.4 c
D3I6	45.0 e	17.3 bc	-

Means in each column with the same letter have not significant difference at 5% probability level.
D and I mean sowing date and mixing rate of lentil, respectively.

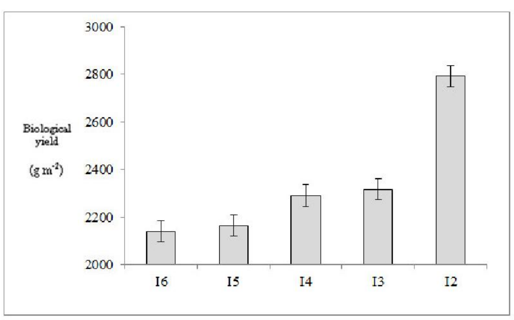

Figure 1: Maize biological yield as affected by lentil mixing rate

Increasing of mixing rate of lentil leads/led to reduction in maize biomass. Crop biomass in control was 2793 g m^{-2}, while nearly 2165 and 2140 from 37.5% and 50% of recommended density rate of lentil (Figure 3). Accumulation of biomass in above-ground parts of crop plants in maize+bean intercropping system was significantly affected by cropping pattern due to light interception by canopy (Rostami et al., 2012). These results are in good agreement with those reported by Rezaei Chianeh et al. (2011) on maize+faba bean.

When lentil was sown 10 days earlier, maize produced higher grain yield in 100% maize+12.5% lentil treatment (Table 2). Xu (2007) indicated that in intercropping of maize+faba, the bean seed yield of corn improved by 26%-43%. Xu (2007) suggested that these increasing values could be due to organic acidic materials releasing from faba bean root system and nitrogen fixation.

The sowing of lentil 20 days earlier in 50% optimum density along with maize was more profitable because of higher LER of 2.2. While, LER in sowing treatment of lentil 10 days earlier in 12.5% optimum density along with maize was lower than unit (0.9) (Figure 2). LER were more than unit when bean intercropped simultaneously or 10 days after marigold varieties (Najari Sadeghi et al., 2013). Evaluation of biological yield in intercropping systems by sharifi et al. (2006) revealed that higher land equivalent ratio was obtained from 25% bean+75% sorghum treatment. Darbaghshahi et al. (2009) reported that LER in saffron-chamomile intercropping was improved due to higher water and nutrient extrapolation.

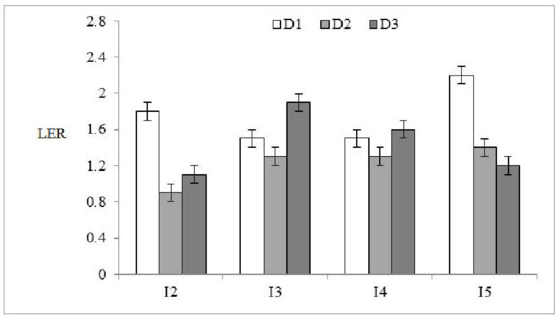

Figure 2: LER as affected by lentil sowing date and mixing rate as intercropped with maize

With a look to relative value total (RVT) index, lentil sowing of 20 days earlier in 12.5% optimum density along with maize (RVT=1.42) was better than sowing of 20 days earlier in 37.5% optimum density with RVT of 1.31 (Figure 3). Rezaei Chianeh et al. (2011) have reported a RVT of 1.16 for maize+faba bean intercropping in their study. Fotuhi Chianeh et al. (2013) reported RVT>1 for all intercropping treatments of maize+red bean.

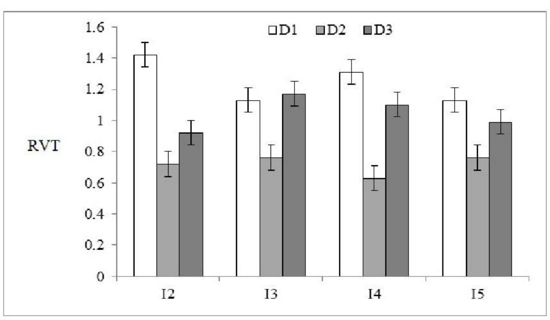

Figure 3: RVT as affected by lentil sowing date and mixing rate as intercropped with maize

4. Conclusion

Based on our results obtained from the study conducted, the sowing of 20 days earlier was recommended for intercropping of lentil in 12.5% optimum density along with maize in 100% density.

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