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Different Intercrop Arrangements with Lentil and Barley under Dryland Condition

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Abstract: This study was carried out to evaluate the performance of different intercrop arrangements with lentil and barley crops under dryland condition. This experiment was conducted in field conditions in Van, eastern of Turkey (38°-55'N, 42°-05'E, 1725 m above sea level) in 2004-2005 in winter growing seasons. In this study, all intercrop arrangements affected on yield and yield components of barley and lentil significantly. Intercrop arrangements reduces all yield components except plant height of lentil. In barley, all intercrop arrangements increased plant height. Separately, mixing intercrop arrangement reduced number of seed per spike and seed weight per spike of barley compared to sole barley. Row cropping arrangement increased number of seed per spike and seed weight per spike of barley. The highest land equivalent ratio for straw was determined by 100% barley + 60% lentil and 100% barley + 40% lentil mixtures with 1.34 and 1.29, respectively. The highest LER for seed was obtained 100% barley + 20% lentil mixtures as 1.20 LER.

Key words: Broadcast, mixing cropping, barley, lentil, LER

INTRODUCTION

Intercropping system is the growing of two or more crop species or cultivars simultaneously in the same field during a growing season (Ofori and Stern, 1987). Grossman and Quarles (1993) reported that four basic spatial arrangements such as row intercropping, strip intercropping, mixed intercropping, relay intercropping were used in intercropping system.

Intercropping has many advantages, such as nutrient recycling in the soil, better control of weeds, pests and diseases (Rämert *et al*., 2002; Szumigalski and Rene, 2005) and an increased biodiversity and greater stability of yield in case of on the whole a pure culture (Vandermeer, 1989). In many years, cereals and legumes, both for forage and for grain, are the most common intercrops. The main advantage of the legume cereal intercrop is the input of nitrogen to the system by the fixation of atmospheric nitrogen by the legume, which results in improved use of renewable nitrogen sources (Hiebsch and McCollum, 1987). High N use efficiency in legume-based cropping systems can be achieved by managing the cereal-lentil intercrops to enhance the symbiotic N_2 fixation without reducing the soil N uptake efficiency (Schmidtke *et al*., 2004). Moreover, some advantages of legumes include opportunity to grow crops simultaneously without sacrificing land (Kang *et al*., 1990) and improved soil physical conditions and higher water infiltration because of their root activity (Rao *et al*., 1998). Willey (1979) reported that intercropping exhibited biological advantages over sole cropping when inter-specific competition for growth resources was less than intra-specific competition.

Some researchers report that the advantages of various intercropping such as wheat±peas (Edje, 1983; Subedi, 1997), wheat±lentils (Rahman, 1984; Akter *et al*., 2004; Çiftçi and Ülker, 2005), wheat±chickpeas (Sharma *et al*., 1987), barley±lentil (Çiftçi and Ülker, 2005), barley±peas (Poggio, 2005; Hauggaard-Nielsen *et al*., 2006). In contrary, Islam *et al*. (1991) reported that the highest grain was obtained from sole cropping for barley and lentil.

In generally, cereals straw is used as a feed for animals in Turkey. However, cereals constitute forages relatively low in protein (Robinson, 1969) and animals usually require some form of relatively costly protein concentrate supplementation (Anil *et al*., 1998). Lentil straw has high protein ratio (Engin, 1989). As these situations grain cereal legume intercropping has the potential to provide higher straw protein, compared to sole barley straw. Caballero *et al*. (1995) reported that advantages of cereal legume forage intercropping increased yield and protein content of mixed diets.

The objectives of the study are to assess the potential of lentil and barley with different intercrops arrangements when compared with sole crops.

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MATERIALS AND METHODS

This experiment was conducted in field conditions in Van, eastern of Turkey (38°-55'N, 42°-05'E, 1725 m above sea level) in 2004-2005 in winter growing seasons. Tokak 157/37 barley cultivar and Kayi lentil cultivar was selected as the test plant because of the current concern for high yielding.

The plots were ploughed in Spring. Second ploughing was done in opposite directions before planting on October. The experimental design was a randomized complete blocks with 3 replications with a total number of 48 plots. Area of each plot was 6.4 m^2 (1. 60×4 m each one). Monocrops were established by sowing 250 germinable lentil seeds per square meter and 450 germinable barley seeds per square meter. Lentil seed were inoculated by adding a peat of *Rhizobium leguminosarum* (mixed strain, Institute of Research Soil and Water, Ankara, Turkey). In this experiment, following treatments was used:

T1 : Lentil 100% + 0% Barley (Broadcast)
T2 : Lentil 100% + 20% Barley (Mixed crop)
T3 : Lentil 100% + 40% Barley (Mixed crop)
T4 : Lentil 100% + 60% Barley (Mixed crop)
T5 : Barley 100% +0% Lentil (Broadcast)
T6 : Barley 100% + 20% Lentil (Mixed crop)
T7 : Barley 100% + 40% Lentil (Mixed crop)
T8 : Barley 100% + 60% Lentil (Mixed crop)
T9 : Lentil 50% + 50 % Barley (Mixed crop)
T10 : 1:1 row system of L : B (Intercrop)
T11 : 2:1 row system of L : B (Intercrop)
T12 : 3:1 row system of L : B (Intercrop)
T13 : 1:2 row system of L : B (Intercrop)
T14 : 1:3 row system of L : B (Intercrop)
T15 : Line sown sole Lentil
T16 : Line sown sole Barley

All plots fertilized with phosphorus and nitrogen. At planting fertilizer for sole barley such as DAP was used and rest of half of nitrogen was applied as top dressing before ear emergence as source of nitrogen AS. At planting fertilizer for sole lentil and intercrop such as DAP was used. Phosphorus source was di ammonium phosphates (N 18-P 46%) and nitrogen source was ammonium sulphates (N 21%) in this experiment. Fertilizers were applied with a hand and mixed into the top 1-5 cm of soil at planting time. Lentil and barley were sowed on 28 October 2004. During this experiment, all plots were weeded two times by hand. Insects and pests and disease infestation were not observed in experimental crops. Irrigation was not supplied on plots. The experiment was conducted under rainfeed condition.

The sample unit consisted of 10 plants harvested from three randomly selected samples from the two middle rows of each plot, at grain maturity. All plant samples were collected from the central part of each plot to avoid edge effects. Some important plant characters in lentil such as plant height (cm), number of pod per plant, number of seed per plant, seed weight per plant (g), straw yield (kg ha^{-1}) and seed yield (kg ha^{-1}) and one of the yield characters number of plant per square meter were investigated in this experiment. Spikes m^{-2}, plant height (cm), number of seed/spike, seed weight/spike, seed yield (kg ha^{-1}) and straw yield (kg ha^{-1}) were researched in barley crops. At physiological maturity, seed and straw yields were obtained by removing all plants in each plot at harvest excluding the border rows. Lentil and barley plants were separated at harvest.

The seed yield of lentil and the seed yield of barley cultivars were used to calculate the land equivalent ratios (LER), defined as the relative land area required for sole crops to produce the yield achieved in intercropping (Mead and Willey, 1980; Vandermeer, 1989). The LER is defined as:

LER = Intercrop yield of lentil/Sole crop yield of lentil+
Intercrop yield of barley/Sole crop yield of barley

The soil samples were taken from the surface horizon of experiment area. The physical and chemical characteristics of the soil are shown in Table 1. The soil has sandy-clay loam texture and low organic matter and nitrogen, rich lime content medium phosphorus and is low alkaline (Kacar, 1995).

Table 1: Selected physical and chemical properties of the soil

Depth	0-20	20-40
Texture	Sandy-clay- loam	Sandy-clay- loam
pH	7.80	7.70
Total salt (%)	0.021	0.019
Lime (%)	17.90	13.20
Organic matter (%)	1.85	1.81
Total N (%)	0.092	0.086
Available P (mg kg^{-1})	6.71	4.22

Table 2: Climatic data of Van province in 2004-2005 years and long term periods (LTP)

	Temp. (^{0}C)		Rainfall (mm)		Relativehumidity (%)	
Months	04-05	LTP	04-05	LTP	04-05	LTP
September	18.0	16.3	-	15.4	48.7	55.2
October	12.0	10.3	48.1	49.6	64.1	63.2
November	4.6	4.3	102.4	47.5	75.1	67.0
December	-3.7	-1.1	41.0	32.1	73.8	69.0
January	-3.3	-3.6	34.4	41.9	77.1	69.0
February	-4.0	-3.5	27.2	35.4	73.7	64.0
March	2.5	0.5	59.1	46.2	70.9	57.0
April	8.9	7.0	55.9	57.5	64.1	50.0
May	13.3	13.0	35.8	40.5	62.5	44.0
June	18.7	17.8	13.0	16.8	55.4	41.0
July	24.1	22.0	0.3	5.5	51.3	43.0
Total			417.2	323.4		

The climatic data of the region are represented in Table 2. Temperate climatic condition is ruled in the region. During the course of experiment, from November to July in 2004-2005 years, rainfall was high during the autumn and winter months, which is important for recharging soil water. Amount of the rainfall was quite different over long term period. For instance, the 2004-2005 winter growing season had higher rainfall as long term period. Temperatures were obtained as same as long term periods (Anonymous, 2005).

Statistical analysis: The data obtained for the one years were analyzed statistically (analysis of variance) for significant differences. These analyses were performed by the procedure of COSTAT statistical package. Means were grouped in Duncan Multiple Comparison Test (Duzgunes *et al*., 1997).

RESULTS AND DISCUSSION

Lentil yield and yield components: In this study, all treatments affected on yield and yield components of lentil significantly ($p<0.01$). Plant m^{-2} was different number in all treatment and the highest plant number was obtained at T15 which was fallowed by T12. Number of plant in line sown sole lentil treatment was higher compared to broadcast treatment. Low plant number was determined in broadcast sown, because of sowing depth may not uniform in broadcast. Broadcast sown system was not favorable practice in lentil growing system compared to line sown system in this experiment. This situation effected seed yield directly in this present experiment. Seed ratio was higher in mixing cropping with broadcast compared to row sown lentil. However plant number was higher in row cropping system (Table 3).

Plant height was different at all treatments significantly ($p<0.01$). The highest plant height was determined from T7 and the lowest one obtained from T1, T2 and T11. Plant height was higher in mixing and row intercropping treatments. This may be the competing of two different crops (Table 3).

Number of pod per plant was higher in line sown sole lentil and lentil in broadcast. Pod number was decreased in mixing and row cropping system (Table 3). Lentil was less competitive in intercropped with barley (Gangasaran and Giri, 1985).

Number of seed per plant was higher in line sown sole lentil and lentil in broadcast. Similar results were taken at seed weight per plant (Table 3).

All treatments effected seed yield significantly. The highest seed was obtained with treatment of line sown sole lentil with 1190.0 kg ha^{-1} and similar higher seed yield was determined from broadcast sole crop and row cropping compared to mixing cropping lentil with barley (Table 3). Straw yield was obtained similarly with seed yield. Lentil yields were reduced significantly when intercropped with barley. Both lentil and barley yields were significantly ($p<0.01$) reduced by intercropping, showing that both species were in active competition. Especially reduction in yield was higher in lentil. This may be lentil is less competitive crops in intercrop with barley (Gangasaran and Giri, 1985).

Barley yield and yield components: Barley yield and yield components was significantly different in all treatments ($p<0.01$). Spikes m^{-2} was different in all treatments and the highest plant number was obtained at treatment of T16. This was followed by T14 and T5. Number of plant in line sown sole barley treatment was higher compared to broadcast treatment (Table 4).

Table 3: Effects of different intercrop arrangements on yield and yield components of lentil

Treatments	Plant m^{-2}	Plant height (cm)	Pod/plant	Seed/plant	Seed weight/plant	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T1	137.6b	27.0f	8.40b	9.46a	0.59bc	702.6c	1148.6c
T2	104.6d	27.0f	8.23b	9.50a	0.52d-f	531.0e	989.3e
T3	99.0e	28.2c-e	7.13de	8.06cd	0.36jk	365.0g	789.0f
T4	97.0e	29.5ab	6.36ab	7.53de	0.32k	315.0hi	683.0g
T5	-	-	-	-	-	-	-
T6	47.0i	29.6ab	5.16i	6.66e-g	0.44hi	201.0k	340.6i
T7	68.3g	30.0a	4.93i	6.70e-g	0.41ij	304.6i	480.6j
T8	78.0f	29.2ab	4.46j	6.10g	0.45g-i	333.3h	600.6h
T9	83.3f	28.0c-f	7.00ef	7.36c-e	0.47f-h	370.0fg	626.6h
T10	105.0d	27.7d-f	7.46d	8.10bc	0.60b	666.6d	1036.6d
T11	130.0c	27.2f	6.73fg	7.63cd	0.54c-e	699.0c	1170.0c
T12	142.0b	28.6b-e	7.86c	8.60b	0.56b-d	805.0b	1383.3b
T13	69.6g	28.9bc	6.46g	7.10d-f	0.54c-e	389.0f	791.0f
T14	54.2h	29.4ab	6.06h	6.53 fg	0.50e-g	280.0j	600.0k
T15	206.0a	27.7ef	10.0a	10.16a	0.70a	1190.0a	1720.0a
T16	-	-	-	-	-	-	

*Difference indicated with same letter(s) are non-significant (Duncan, 0.01)

Table 4: Effects of different intercrop arrangements on yield and yield components of barley

Treatments	Spikes m^{-2}	Plant height (cm)	No. of seed Seed/spike	Weight/spike	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T1	-	-	-	-	-	-
T2	70.0k	58.7j	19.00c	0.92d	660.0n	843.3n
T3	130.0i	60.66hi	18.00d	0.87ef	1030.0l	1446.0l
T4	180.0g	61.33hi	17.53ef	0.83f	1210.0j	1803.0j
T5	278.0b	65.00ab	16.16g	0.79g	1910.1d	2860.1d
T6	267.0c	63.83cd	17.00f	0.69h	1760.1f	2750.1e
T7	253.0d	63.00de	16.00g	0.63i	1430.5 h	2483.3f
T8	229.0e	62.50ef	15.00h	0.61i	1311.2I	2356.6g
T9	130.0i	60.33j	17.83de	0.88de	1003.3m	1223.3m
T10	199.0f	62.16e-g	19.00c	0.87ef	1770.1e	2130.0h
T11	139.0h	62.00e-g	19.33c	1.16a	1550.2g	1966.0i
T12	90.0j	61.66f-h	20.00b	1.18a	1190.1k	1466.0k
T13	249.0d	64.33bc	21.00a	1.11b	2480.6c	2906.6c
T14	283.0b	65.66a	19.33c	1.03c	2850.6b	3503.3b
T15	-	-	-	-	-	-
T16	357.0a	65.33ab	20.00b	0.89de	3090.3a	3806.6a

*Difference indicated with same letter(s) are non-significant (Duncan, 0.01)

Table 5: LER analysis results

	Straw partial LER			Seed partial LER		
Treatments	Lentil	Barley	Total LER	Lentil	Barley	Total LER
T1	1.00	-	1.00	1.00	-	1.00
T2	0.86	0.29	1.15	0.75	0.34	1.09
T3	0.68	0.50	1.18	0.51	0.53	1.04
T4	0.59	0.63	1.22	0.44	0.63	1.07
T5	-	1.00	1.00	-	1.00	1.00
T6	0.30	0.96	1.26	0.28	0.92	1.20
T7	0.41	0.86	1.29	0.43	0.74	1.17
T8	0.52	0.82	1.34	0.47	0.68	1.15
T9	0.54	0.42	0.96	0.52	0.52	1.04
T10	0.60	0.55	1.15	0.56	0.57	1.13
T11	0.68	0.51	1.19	0.58	0.50	1.08
T12	0.80	0.38	1.18	0.67	0.38	1.05
T13	0.45	0.76	1.21	0.32	0.80	1.12
T14	0.34	0.92	1.26	0.23	0.92	1.15
T15	1.00	-	1.00	1.00	-	1.00
T16	-	1.00	1.00	-	1.00	1.00

Broadcast sown system was bad practice in barley growing system compared to line sown system. This situation effected seed yield directly in this experiment. Seed ratio was higher in mixing cropping with broadcast compared to row sown barley. However plant number was higher in row cropping.

Plant height was different at all treatments significantly ($p<0.01$). The highest plant height was determined from T14 and the lowest one obtained from T2 and T9. Number of seed per spike was higher in T13 (Table 4)

Seed per spike per was decreased in mixing cropping. This reduction was depended on percentage of barley and lentil. Higher percentage of barley in the intercrops reduced seeds per spike (Table 4). Moreover, barley was higher competitive in intercropped with lentil in this study.

Seed weight per spike was significantly different and higher in row cropping system (Table 4). Intercrop competition reduced seed weight per spike in barley in this study.

All treatments effected seed yield significantly in barley. The highest seed yield was obtained with treatment of line sown sole barley with 3090.3 kg ha^{-1} and similar higher seed yield was determined from broadcast sole crop and row cropping compared to mixing cropping barley with lentil (Table 4). Straw yield of barley was obtained similarly with seed yield. Barley were generally a much more dominant component of intercrop yields.

Seed and straw LER: LER is used frequently as index of biological advantage, which places the component crops on a relative and directly comparable basis (Willey, 1979). It is defined as the relative land area that would be required for sole crops to produce the yields achieved in intercropping. A value of LER higher than 1.0 indicates an advantage in favor of intercropping, whereas values <1.0 indicate a disadvantage of intercrops. Alternative methods such as the relative yield total are potentially even less effective for comparing the agricultural advantage of intercropping (Finney, 1990). The land equivalent ratio is a measure often used to combine the yields of two or more unlike crops into one index for comparison with sole culture or among intercrop systems.

In this study the highest land equivalent ratio for straw was determined by 100% barley + 60% lentil and 100% barley + 40% lentil mixtures with 1.34 and 1.29 respectively. This result was higher compared to 100% lentil + 60% barley and 100% lentil + 40% barley mixtures results. Barley vegetative growth was higher than lentil's and resulted that barley was higher competitive than lentil.

The highest LER for seed was obtained 100% barley + 20% lentil mixtures as 1.20 LER was low as higher seed

ratio used in mixing cropping compared to row intercropping (Table 5). Similar LER was obtained in row intercropping with mixing cropping, although low seed input was used in the row intercropping. The high intra and inter crop competition between barley and lentil in mixing cropping resulted high straw yield. High percentage of barley in intercropping gave higher straw LER and seed LER. Similar results were reported by Akter *et al*. (2004), Çiftçi and Ülker (2005).

As results of this experiment, the best advisable intercrop treatment for straw yield under dryland condition of Van province is B 100% + 60% L mixing cropping treatment. This treatment gave higher straw yield compared to sole cereal and pulse crops straw yield. Moreover, the best advisable intercrop treatment for seed yield is B 100% + 20% L treatment and in addition both of these treatment 1:1 L:B (Intercrop) 1:3 L:B (Intercrop) were advisable treatment due to low seed input.

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