



## Productivity, economics and competitive indices of lentil (*Lens Culinaris*)–based intercropping systems in Kashmir valley

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### ABSTRACT

A field experiment was conducted during winter seasons of 2005-06 and 2006-07 at Shalimar, Srinagar to study the productivity and profitability of lentil (*Lens Culinaris* Medik)–based intercropping systems. Eleven lentil based cropping systems viz., lentil sole, brown sarson (*Brassica campestris* L. var. brown sarson) sole, oats (*Avena sativa* L.) sole, lentil+brown sarson 1:1, lentil+brown sarson 2:1, lentil+brown sarson 4:1, lentil+brown sarson 6:1, lentil+oats 1:1, lentil+oats 2:1, lentil+oats 4:1 and lentil+oats 6:1, were tested in randomized block design with three replications. Number of pods/ plant of lentil were significantly higher in sole crop followed by 6:1 and 4:1 row ratio of lentil + brown sarson and lentil + oats systems, respectively. Significantly higher siliquae/ plant was recorded in intercropping systems compared to sole brown sarson. Seed yield of lentil (1.46 t/ha) and brown sarson (1.37 t/ha) was highest in sole stand. Based on lentil seed equivalent yields (1.47 t/ha), net returns (Rs 25,750) and B:C ratio (3.32), lentil + oats in 2:1 was found the best. It was closely followed by sole lentil.

**Key words:** Aggressivity, Economics, Intercropping, LER, Lentil, Relative crowding coefficient

Intercropping has been in vogue for centuries to sustain yield, minimize risk, utilize the lag phase and improve productivity. Selection of an appropriate and compatible component crops for intercropping system helps in reducing inter- and intra-plant competition for resources, thereby enhancing the productivity with optimal use of available and applied resources. Scientific approach of intercropping increases the productivity/unit area/unit time under a situation where two crops are grown in intercropping at a certain proportion and row ratio (Ali, 1988). Lentil, brown sarson and fodder oats are mainly grown as sole crops in Kashmir valley. During 2004, pulses were grown in 0.309 m ha with the production of 0.152 m tonne (t) and 9 productivity 0.492 t/ha, whereas, oilseeds were grown in 0.063 m ha producing 0.366 m t having a productivity of 0.58 t/ha in the state (Anonymous, 2007). It is possible to grow these crops as intercrops due to their diverse morphology; growth rhythm and similar climatic requirements. Intercropping increases the cropping intensity, productivity and profitability through optimum utilization of soil, water, nutrient and sunlight in time and space. Singh and Rana (2006) observed that Indian mus-

tard paired row (30/90 cm) + lentil (2 rows) intercropping system proved more productive without impairing the yield of individual crops. In view of this, an experiment was under taken to find out the possibility of increasing economical production of pulses, oilseeds and fodders through intercropping by adopting appropriate spatial arrangement of component crops.

### MATERIALS AND METHODS

The field experiment was conducted during winter season of 2005-06 and 2006-07 at the Agronomy Research Field, Division of Agronomy, SKUAST-K, Shalimar, Srinagar located at 34°08' N, 74°52' E at a height of 1,611 m above mean sea level. The soil was silty clay loam having pH 7.1 and high in organic carbon (1.0%). The available soil N, P and K were 403, 15.8 and 127.4 kg/ha, respectively. The mean temperature during the experimental period ranged from -7.8 to 33.2 °C in 2005-06 and -5.6 to 31.6 °C during 2006-07. The precipitation received during the cropping season was 406.7 mm and 583.5 mm in 2005-06 and 2006-07, respectively. There was heavy snowfall from 12 to 22 March, 2007. The experiment comprised of 11 treatments viz., sole lentil, sole brown sarson, sole oats, lentil + brown sarson (1:1), lentil + brown sarson (2:1), lentil + brown sarson (4:1), lentil + brown sarson (6:1), lentil + oats (1:1), lentil + oats (2:1),

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lentil + oats (4:1) and lentil + oats (6:1), replicated thrice in a randomized block design. The crops were sown on 21 and 4 October during 2005 and 2006, respectively. Fertilizer was applied @ 40-26.4-20; 60-13.2-20 ; 80-17.6-20 kg N-P-K/ha in sole crops of lentil, brown sarson and oats, respectively, whereas a dose of 40-26.4-20 kg N-P-K/ha, was applied to all the intercropping combinations. Row-to-row spacing of 20, 30 and 23 cm was followed for sowing of sole crops of lentil, brown sarson and oats, respectively whereas, a spacing of 20 cm was followed for the intercrop combinations. The varieties sown were 'Precose', 'KS-101' and 'Sabzar' for lentil, brown sarson and oats, respectively. Lentil and brown sarson were harvested on 30 and 26 May during 2006 and 2007, respectively, but oats was harvested as fodder in two cuttings on 1 April and 1 May, 2006 and 2007. Land equivalent ratio (LER), aggressivity (A), relative crowding coefficient (RCC), competitive ratio (CR), net return and B: C ratio was computed as per standard methods. Lentil equivalent yield and economics were worked out on the basis of existing market price. The costs of inputs were Rs 50, 45, 25/kg seed of lentil brown sarson and oats, respectively, Rs 5.44, 10.44 and 5.35/kg of urea, diammonum phosphate and muriate of potash, respectively. The output sold @ Rs 25, 15.5 and 1/kg of seed of lentil and brown sarson and oats fodder, respectively.

## RESULTS AND DISCUSSION

### Growth and yield attributes

Plant height, number of seeds/pod and 1,000-seed weight of lentil did not show significant differences between sole and different intercropping systems (Table 1). Number of pods/ plant in sole crop remained at par with the 6:1 and 4:1 lentil + brown sarson and lentil + oats fodder systems. The higher number of pods/plant in lentil

under the sole lentil crop and wider row ratios viz., 6:1 and 4:1 with brown sarson and oats might be due to lower competition and reduced shading effect of brown sarson and oats over lentil crop. In brown sarson, plant height, length of siliqua, number of seeds/siliqua and 1,000-seed weight remained unaffected due to various intercrop ratios. Significantly higher number of siliquae/plant were recorded in all row ratios of intercropping compared to sole crop. Plant height and number of tillers, meter row length of oats did not vary significantly due to intercropping treatments. (Table 2). All the intercrop combinations remained statistically at par in respect to number of siliquae/plant. Similar findings were reported earlier by Kumar *et al.* (2006).

### Yield

Seed yield of lentil was significantly higher in sole crop (1.46 t/ha) followed by intercropping in lentil + brown sarson and lentil + oats (6:1), Table 1. Lentil is the poor competitive crop due to very slow growth and low plant height compared with brown sarson and oats which resulted into low yields under intercropping with these crops. Ahlawat *et al.* (2005) and Tripathi *et al.* (2005) recorded reduction in yield of chickpea due to intercropping with Indian mustard. Singh and Rana (2006) also reported the similar response of lentil when intercropped with Indian mustard.

Sole crop of brown sarson produced significantly higher yield (1.37 t/ha) than all combinations of intercropping (Table 2). Yield of brown sarson decreased due to reduced number of plants in intercropping systems. Oat fodder yield recorded was significantly higher under sole oats than in all intercrop combinations. The same trend was found under both first and second cuts. Singh *et al.* (2008) also reported higher tonnage of oat fodder under

**Table 1.** Plant height and yield attributes and yield of lentil as influenced by different row ratios in intercropping with brown sarson and oats

Treatment	Plant height (cm)		Pods/ plant		Seeds/ pod		1,000-seed weight (g)		Lentil seed yield (t/ha)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Lentil sole	40.9	37.4	55.27	33.80	1.44	1.53	41.47	36.95	1.50	1.42
Lentil + Brown sarson (1:1)	44.2	41.1	30.70	27.67	1.24	1.40	38.93	36.84	0.45	0.47
Lentil + Brown sarson (2:1)	45.2	34.7	41.10	20.00	1.30	1.40	42.53	38.54	0.76	0.58
Lentil + Brown sarson (4:1)	46.1	34.6	41.43	22.80	1.19	1.60	37.46	38.12	0.98	0.74
Lentil + Brown sarson (6:1)	45.4	39.7	50.47	23.27	1.19	1.53	42.57	39.51	1.16	0.88
Lentil + Oats (1:1)	42.2	40.6	36.07	18.00	1.19	1.40	41.43	37.81	0.65	0.41
Lentil + Oats (2:1)	39.9	36.8	43.46	23.83	1.21	1.43	43.37	36.84	0.87	0.70
Lentil + Oats (4:1)	46.4	39.9	45.00	23.06	1.29	1.43	41.57	38.00	0.93	0.83
Lentil + Oats (6:1)	41.7	39.7	48.00	24.20	1.23	1.47	41.90	38.32	1.17	0.92
SEM ±	1.8	2.3	3.27	1.23	0.58	0.06	2.00	1.60	0.10	0.07
CD (P=0.05)	NS	NS	9.79	3.70	NS	NS	NS	NS	0.29	0.22

**Table 2.** Plant height, yield attributes and yield of brown sarson, and oat fodder as influenced by different row ratios in intercropping with lentil

Crops	Plant height (cm)*		Siliquae/ plant or No. of tillers /m row length*		Siliqua length (cm)		Seeds/ siliqua		1000-seed weight (g)		First and second cut oat fodder yield (t/ha)**		Brown sarson seed yield / oats fodder yield (t/ha)*	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
	Brown <i>sarson</i>	124.1	124.8	216.7	197.4	5.10	5.13	16.20	19.47	2.15	2.95			1.48
Oats	121.0	125.3	177.7	185.0							16.04 (10.55)	18.21 (11.10)	26.59	29.31
Lentil+Brown <i>sarson</i> (1:1)	116.4	125.2	285.2	236.7	5.53	5.00	17.47	20.87	2.01	2.91			1.05	0.87
Lentil+Brown <i>sarson</i> (2:1)	115.8	125.6	296.0	240.5	5.87	5.17	18.33	22.67	2.11	2.81			0.85	0.62
Lentil+Brown <i>sarson</i> (4:1)	117.3	115.7	311.8	255.2	5.69	4.63	19.70	19.37	2.18	2.83			0.58	0.55
Lentil+Brown <i>sarson</i> (6:1)	113.5	123.7	318.7	257.0	6.03	5.20	19.97	23.60	2.10	2.98			0.43	0.37
Lentil+Oats (1:1)	124.7	130.0	180.3	190.0							12.59 (8.65)	14.78 (9.09)	21.24	23.87
Lentil+Oats (2:1)	126.7	129.7	182.7	188.3							10.57 (5.99)	11.36 (6.63)	16.57	17.99
Lentil+Oats (4:1)	124.3	128.0	174.3	194.7							6.77 (3.71)	8.48 (5.28)	10.48	13.76
Lentil+Oats (6:1)	127.7	126.7	187.0	189.3							3.89 (2.51)	3.87 (2.13)	6.40	6.00
SEm ±	5.7 (4.4)	3.3 (4.4)	14.0 (5.5)	10.0 (9.2)	0.45	0.39	1.08	1.28	0.06	0.51	0.91 (0.62)	0.64 (0.28)	0.075 (1.54)	0.047 (0.87)
CD (P=0.05)	NS (NS)	NS (NS)	45.6 (NS)	32.4 (NS)	NS	NS	NS	NS	NS	NS	2.99 (1.88)	2.09 (0.92)	0.25 (5.01)	0.15 (2.83)

\*Figures in parenthesis refer to oats; \*\*Figures in parenthesis refers to oats second cut fodder yield

**Table 3.** Equivalent yield of different intercrops and economics (x 10<sup>3</sup>Rs/ha) as influenced by lentil-based intercropping systems

Treatments	Lentil seed equivalent yield (t/ha)		Cost of cultivation (mean of 2 years)	Net return		B:C ratio	
	2005-06	2006-07		2005-06	2006-07	2005-06	2006-07
	Lentil	1.49		1.42	11.31	26.06	24.23
Brown <i>sarson</i>	0.92	0.79	10.16	14.33	9.57	2.41	1.94
Oats	1.06	1.17	13.12	13.47	16.19	2.02	1.23
Lentil + Brown <i>sarson</i> (1:1)	1.10	1.01	10.49	17.06	14.81	2.63	2.41
Lentil + Brown <i>sarson</i> (2:1)	1.29	0.96	10.76	21.44	13.33	2.99	2.24
Lentil + Brown <i>sarson</i> (4:1)	1.34	1.08	10.98	22.53	15.96	3.05	2.45
Lentil + Brown <i>sarson</i> (6:1)	1.43	1.11	11.07	24.65	16.70	3.23	2.51
Lentil + Oats (1:1)	1.55	1.37	11.98	25.53	22.21	3.13	2.86
Lentil + Oats (2:1)	1.53	1.42	11.12	27.23	24.27	3.45	3.18
Lentil + Oats (4:1)	1.35	1.38	10.50	23.13	23.95	3.20	3.29
Lentil + Oats (6:1)	1.43	1.16	10.26	25.47	18.86	3.48	2.84
SEm ±	0.11	0.06					
CD (P=0.05)	0.32	0.18					

sole oats than combinations of intercrop.

Lentil equivalent yield (LEY) remained consistently higher wherever lentil crop was combined with oats rather than brown *sarson*. The highest lentil seed equivalent yield was recorded under the treatment lentil + oats (2:1) which remained at par with sole lentil and all the row ratios of lentil + oats. The higher output price of lentil grain and higher output of oats fodder resulted into higher LEY when compared with the sole brown *sarson* and combination of brown *sarson* with lentil. In the present study, lentil with oats seems to be more compatible than lentil + brown *sarson*. Kumar *et al.* (2006) reported higher seed yield of component crops in an intercropping system (chickpea + Indian mustard) which showed complimentary relationship and resulted in higher chickpea equivalent yield.

#### Yield advantage and competitive functions

Land equivalent ratio (LER) was >1.0 in all lentil + oats combinations in both the years with the exception that 6:1 ratio intercropping had LER<1.0 (Table 4). Kumar and Singh (2006) had earlier reported similar results while working with a chickpea + mustard intercropping. In the present study, the aggressivity of lentil on brown *sarson* and oats remained very low as indicated by the negative values of aggressivity and lower RCCa (<1.0). These findings are in conformity with those of Ahlawat *et al.* (2005) who reported negative aggressivity for chickpea in all intercropping systems with barley and linseed. Other intercrops of this investigation were quite aggressive, the maximum being lentil + oats in 4:1 combination (1.42). A RCCb value of 4.18 for lentil + oats (1:1) further substantiated the aggressivity of brown *sarson*/oats over lentil. The higher values of competitive ratio was observed un-

der 1:1 lentil + oats and 6:1 lentil + oats for lentil crop during 2005-06 and 2006-07, respectively, whereas, as intercrop under 4:1 lentil + brown *sarson* and 4:1 lentil + oats both. Ahlawat *et al.* (2005) have also reported similar findings wherein mustard was highly competitive. As such, lentil worked out to be a poor competitor as this study indicates.

#### Economics

Significantly higher net return was accrued in 2:1 lentil + oats fodder combination followed by its 4:1 intercropping and sole lentil (Table 3). Higher out put prices of lentil and higher oats fodder yield has turned into higher net return and B:C ratio. Kumar *et al.* (2006) also recorded higher returns in an intercropping system involving chickpea + Indian mustard.

Thus it can be concluded from the results that sowing of lentil with oats in 2:1 row ratio is a productive and profitable intercropping combination for temperate Kashmir.

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**Table 4.** Land equivalent ratio, aggressivity, relative crowding coefficient(RCC) and competitive ratio (CR) as influenced by different intercrops and row ratios

Treatment	Land equivalent ratio		Aggressivity of lentil		Aggressivity of brown sarson and oats		RCCa (Lentil)		RCCb (Intercrop)		Lentil		Intercrops		CR
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	
	Lentil	1.00	1.00												
Brown sarson	1.00	1.00													
Oats	1.00	1.00													
Lentil + Brown sarson (1:1)	1.01	1.01	-0.81	-0.69	0.81	0.69	0.43	0.50	2.44	2.13	0.43	0.49	2.35	1.84	
Lentil + Brown sarson (2:1)	1.08	0.89	-0.97	-0.84	0.97	0.84	0.52	0.35	2.72	1.88	0.44	0.42	2.27	2.14	
Lentil + Brown sarson (4:1)	1.04	0.95	-1.15	-1.52	1.15	1.52	0.47	0.27	2.60	3.07	0.42	0.30	2.41	3.04	
Lentil + Brown sarson (6:1)	1.07	0.91	-1.12	-1.30	1.12	1.30	0.58	0.27	2.45	2.45	0.45	0.36	2.24	2.53	
Lentil + Oats (1:1)	1.23	1.11	-0.73	-1.05	0.73	1.05	0.77	0.41	3.97	4.39	0.55	0.36	1.83	3.25	
Lentil + Oats (2:1)	1.21	1.10	-1.00	-1.11	1.00	1.11	0.70	0.48	3.30	3.18	0.47	0.40	2.14	2.91	
Lentil + Oats (4:1)	1.01	1.05	-1.19	-1.62	1.19	1.62	0.41	0.35	2.60	3.54	0.39	0.31	2.54	3.74	
Lentil + Oats (6:1)	1.02	0.86	-0.77	-0.67	0.77	0.67	0.61	0.31	1.90	1.54	0.54	0.53	1.84	2.19	

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