

Effect of *Brassica* spp. and their sowing proportions on productivity, competition and economics of wheat (*Triticum aestivum*) + *Brassica* mixed cropping system under rainfed conditions of Himachal Pradesh

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ABSTRACT

An experiment was conducted during winter (*rabi*) season of 2003 and 2004 to identify the suitable *Brassica* spp. and their optimum sowing proportion for wheat (*Triticum aestivum* L. emend. Fiori & Paol.) + *Brassica* mixed cropping system. Brown sarson (Local) was more competitive than mustard ('RCC 4') in all the mixed cropping patterns, decreasing the total productivity by 4.9 and 6.1% respectively. Mixed cropping of wheat + mustard ('RCC 4') in 100% + 10% and 100% + 20% seeding proportion gave significantly higher wheat yield, total productivity and net returns compared with sole wheat and farmer's practice of wheat + brown sarson (100% + 50%), followed by wheat + brown sarson (Local) in 100% + 20% seeding proportion. These treatments gave 4.4–9.9% and 15.0–21.1% higher productivity over sole wheat and farmer's mixed cropping practice. The competitive ratio, aggressivity and LER of the main crop wheat were maximum when the mixed cropping of wheat + mustard or wheat + brown sarson was followed in 100% + 20% seeding proportion, followed by that of wheat + mustard (100% + 10%). In all other sowing patterns the wheat crop was dominant.

Key words : Mixed cropping, Wheat, *Brassica*, Productivity, Economics

In hilly areas where farmers have marginal or small land holdings and agriculture is primarily rainfed, the practice of intercropping or mixed cropping may be a feasible and viable agronomic practice to increase the production with assurance against biotic and abiotic environmental stresses and meet the requirements from unit land area. Mixed cropping of wheat (*Triticum aestivum* L. emend. Fiori & Paol.) and sarson (*Brassica*) is a common practice during winter (*rabi*) season under rainfed areas of Himachal Pradesh. The farmers, either due to ignorance or with desire to get more from same land, are using the recommended seed rate of wheat and 50–60% seed rate of brown sarson (*Brassica*), that too of a local variety with height and feeding zone similar to that of wheat crop, resulting in severe competition. In intercropping or mixed cropping, spatial arrangement or seeding proportion and selection of crop varieties are very important so that crops in the mixture are complementary or at least have no adverse effect on overall production. The hill farmers do not want to spend more time and resources on intercropping or scientific farming. In this situation when farmer has preference for mixed cropping, their present practice can be improved by two options, viz. using optimum seeding proportion of crops in the mixture and se-

lection of *Brassica* spp. that gives least competition to the main crop of wheat. Hence this experiment was undertaken to identify the suitable *Brassica* spp. and their optimum sowing proportion for wheat + *Brassica* mixed cropping.

MATERIALS AND METHODS

The experiment was conducted at Shivalik Agricultural Research and Extension Centre, Kangra during winter (*rabi*) season of 2003 and 2004. The soil was silty clay loam, having pH 6.0; and the available nitrogen, phosphorus and potassium 254, 22.5 and 128.2 kg/ha respectively. The study comprised 16 treatments, viz. sole wheat ('Chandrika'); *Brassica* spp, mustard ('RCC 4') and brown sarson (Local); farmer's practice of wheat + local sarson at 100%+50% seed rate; and combinations of wheat + *Brassica* in 5, 10 and 20% of additive and replacement series. The randomized block design was followed with three replications. The crops were sown in second and last weeks of November during 2003 and 2004 respectively. The *rabi* rainfall during 2003 and 2004 was 381.6 and 194.6 mm respectively. Wheat + *Brassica* were sown in the desired proportion by sowing wheat after second ploughing and levelling, and then broadcast-

ing *Brassica* seed at desired rate uniformly. All sole crops were supplied with recommended fertilizer, and in wheat+*Brassica* mixed cropping treatments, only the recommended rate of fertilizer was used for wheat, i.e. 120 kg N, 60 kg P₂O₅ and 40 kg K₂O/ha in replacement series, but the fertilizer rate was enhanced based on seed of *Brassica* in additive series. The recommended fertilizer rate for rapeseed (*Brassica*) mustard was kept the same as that for wheat. Harvesting was done crop wise at maturity, with local sarson maturing in the last week of March, mustard in the second week of April and wheat in the last week of April. Pooled data were computed for different biological indices and the economics was calculated on the basis of market prices.

RESULTS AND DISCUSSION

Effect of mixed cropping

Wheat

The yield attributes and yield showed significant variations due to adoption of different sowing patterns (Table 1). Mixed cropping of wheat+mustard in additive series of 100%+10% and 100%+20% and of wheat+brown sarson in 100%+20% gave effective tillers/m² and grains/spike statistically on a par with those of sole wheat cropping.

In all other sowing patterns the yield attributes decreased significantly. The 1,000-grain weight significantly decreased in 80% + 20% sowing proportion, and this reduction was more in wheat + brown sarson mixed cropping. This may be ascribed to the fact that local sarson

with same plant height, shallow root system and early maturity competed for resources severely compared with tall and deep-rooted mustard.

The influence of various sowing patterns on wheat attributes was also reflected on wheat yield. Mixed cropping in wheat with mustard ('RCC 4') gave slightly higher wheat grain yield compared with brown sarson (local) mixed cropping. The increase was 2.38 and 5.65% in replacement and additive series respectively. Replacement of wheat seed rate by 5 to 20% with mustard and local sarson decreased the wheat yield by 17.3 and 19.9%, whereas their addition by 10 to 20% (additive series) in wheat increased the yield by 12.1 and 8.5% respectively. The decrease in yield with replacement series and increase with additive series can be ascribed to direct effect of the population of main crop wheat towards yield and advantage to *Brassica* crop in replacement series. Except in mixed cropping of wheat + mustard in additive series of 100% + 10% and 100% + 20% and of wheat + brown sarson in 100% + 20%, where wheat grain yield was statistically on a par with that of sole wheat cropping in all other mixed cropping patterns, the wheat yield decreased significantly in comparison with that of sole cropping. Decrease in wheat grain yield in intercropping with rapeseed and mustard has been reported by other workers too (Dwivedi and Namdeo, 1992; Singh and Yadav, 1990).

Brassica spp.

The yield-attributing parameters in *Brassica* spp. dif-

Table 1. Yield-attributing characters and yield of wheat and sarson in mixed cropping

Treatment	Effective tillers/m ²	Grains/spike	1,000-grain weight (g)	Wheat-grain yield (q/ha)	No. of branches/plant	No. of siliquae/plant	1,000-grain weight (g)	Sarson-seed yield (q/ha)	Wheat-equivalent yield (q/ha)
Wheat + 'RCC 4' (95% + 5%)	310.7	41.7	47.9	38.57	9.00	76.3	3.216	0.91	41.61
Wheat + 'RCC 4' (90% + 10%)	275.3	38.7	47.5	35.91	8.33	75.7	3.211	1.29	40.36
Wheat + 'RCC 4' (80% + 20%)	235.7	35.5	44.3	31.36	9.33	76.3	3.245	1.96	37.87
Wheat + 'RCC 4' (100% + 5%)	312.0	40.7	45.0	38.62	5.67	60.7	3.138	0.53	40.78
Wheat + 'RCC 4' (100% + 10%)	361.7	46.3	48.9	42.58	6.67	70.0	3.139	0.96	45.84
Wheat + 'RCC 4' (100% + 20%)	370.7	47.3	49.1	43.28	6.33	74.7	3.201	0.96	46.63
Wheat + Local sarson (95% + 5%)	314.7	42.3	47.9	38.36	8.33	69.7	2.383	0.80	40.72
Wheat + Local sarson (90% + 10%)	268.7	40.0	48.6	34.28	8.00	62.0	2.436	1.10	37.76
Wheat + Local sarson (80% + 20%)	220.7	34.0	41.0	30.74	8.67	64.7	2.572	1.53	35.54
Wheat + Local sarson (100% + 5%)	306.7	42.7	46.7	37.93	6.33	50.0	2.379	0.48	39.35
Wheat + Local sarson (100% + 10%)	316.7	44.7	48.5	38.74	7.33	60.0	2.402	0.96	41.41
Wheat + Local sarson (100% + 20%)	350.8	47.3	48.7	41.41	8.00	64.0	2.382	1.00	44.30
Farmer's practice									
Wheat + Local sarson (100% + 50%)	208.0	30.0	40.3	29.99	9.33	79.3	2.535	2.83	38.52
Sole wheat	364.0	47.3	49.4	42.44					30.47
Sole 'RCC 4'					16.00	134.7	2.945	10.39	23.08
Sole Local sarson					12.67	116.7	2.473	8.19	42.44
CD (P=0.05)	13.8	4.3	3.9	2.46	1.52	7.4	0.303	0.75	2.83

Values in parentheses are proportions of seed rate used

ferred significantly and were also influenced by different mixed cropping patterns followed. Although the number of branches/plant both in musard ('RCC 4') and brown sarson (Local) were statistically at par, the number of siliquae/plant and 1,000-grain weight were more in the former than in the latter in both replacement and additive series. However, in farmer's practice of wheat + brown sarson in 100% + 50% sowing proportion, the yield attributes of local variety were on a par with those of 'RCC 4', which could be due to its increased competitiveness at this high seed rate in mixed cropping. The seed yield of both the *Brassica* varieties decreased significantly in mixed cropping. The highest seed yield (2.83 q/ha) was obtained in wheat + brown sarson in 100%+50% seeding proportion. The increase in seed rate from 5 to 20% in replacement and additive series increased the seed yield of mustard ('RCC 4') by 115 and 81% respectively, compared with the increase of 91 and 108% in brown sarson (Local) respectively.

Total productivity

The mixed cropping pattern followed influenced significantly the total productivity. Mixed cropping in wheat with mustard ('RCC 4') either in replacement series or additive series gave 2.4 and 5.7% more total productivity than mixed cropping with brown sarson (Local). Replacement of wheat in mixed cropping by 5-20% with mustard and brown sarson decreased the productivity by 8.9 and 12.7%, whereas taking these in additive series increased the yield by 14.3 and 12.6% respectively. Mixed cropping

of wheat + musard in 100% + 10% and 100% + 20% sowing resulted in significantly higher total productivity over sole wheat cropping and farmer's practice. Thakur and Kumar (1998) also reported higher total productivity in wheat + musard intercropping in 8:2 or 10:1 ratio, which is the same sowing proportion as observed in our study. However, wheat + brown sarson in 100% + 50% sowing proportion, giving yield of 44.30 q/ha, was statistically on a par with the above-mentioned two best sowing patterns. The increase over sole and farmer's practice was 4.4–9.9 and 15.0–21.1 per cent respectively.

Biological feasibility

Intercropping advantage in terms of land-equivalent ratio (LER) and area time-equivalent ratio (ATER) showed that wheat + mustard ('RCC 4') and wheat + brown sarson (Local) were superior when taken in 100% + 10% or 100% + 20% seeding proportion. The farmer's practice of wheat + brown sarson (100% + 50%) seeding proportion was also found superior with higher LER and ATER values to sole cropping. This may be the reason that farmers are not ready to give up the wheat+*Brassica* mixed cropping.

Except in wheat + mustard in 100% + 10% or 100% + 20% and wheat + brown sarson in 100% + 20% sowing proportions, where wheat was found more competitive with positive aggressivity value in all other mixed cropping patterns, *Brassica* species were found more competitive and dominant in mixed cropping. Among different *Brassica* spp., brown sarson (Local) was more competitive

Table 2. Production efficiency and returns in wheat + *Brassica* mixed cropping

Treatment	ATER	LER	Competitive ratio		Aggressivity index of wheat	Relative crowding coefficient			Net returns (Rs/ha)	B:C ratio
			Wheat	Sarson		Wheat	Sarson	K		
Wheat + 'RCC 4' (95% + 5%)	1.00	0.99	0.55	1.82	-0.791	0.52	1.82	0.95	23,288	2.24
Wheat + 'RCC 4' (90% + 10%)	0.99	0.97	0.76	1.32	-0.304	0.61	1.28	0.78	22,006	2.13
Wheat + 'RCC 4' (80% + 20%)	0.98	0.93	0.98	1.02	-0.021	0.71	0.93	0.66	19,614	1.91
Wheat + 'RCC 4' (100% + 5%)	1.05	0.96	0.89	1.12	-0.103	0.51	1.08	0.55	22,727	2.17
Wheat + 'RCC 4' (100% + 10%)	1.09	1.10	1.09	0.92	0.081	3.04	1.02	3.10	26,677	2.55
Wheat + 'RCC 4' (100% + 20%)	1.18	1.11	2.22	0.45	0.559	10.3	0.51	5.25	27,282	2.60
Wheat + Local sarson (95% + 5%)	0.99	1.00	0.49	2.04	-0.993	0.49	2.06	0.24	22,702	2.18
Wheat + Local sarson (90% + 10%)	0.98	0.94	0.67	1.50	-0.449	0.42	1.40	0.59	20,069	1.94
Wheat + Local sarson (80% + 20%)	0.97	0.91	0.97	1.03	-0.031	0.66	0.92	0.61	18,054	1.76
Wheat + Local sarson (100% + 5%)	1.04	0.95	0.77	1.30	-0.277	0.42	1.25	0.53	21,712	2.08
Wheat + Local sarson (100% + 10%)	1.08	1.03	0.78	1.28	-0.257	1.05	1.33	1.40	23,146	2.21
Wheat + Local sarson (100% + 20%)	1.16	1.09	1.59	0.63	0.358	6.33	0.70	4.43	25,404	2.42
Farmer's practice										
Wheat + Local sarson (100% + 50%)	1.40	1.05	1.03	0.98	0.017	1.20	1.06	1.27	19,465	1.85
Sole wheat									25,066	2.52
Sole 'RCC 4'									9,655	1.06
Sole Local sarson									5,111	0.56

Values in parentheses are proportions of seed rate used

than mustard ('RCC 4'), which was also reflected in lower wheat yield in wheat+brown sarson mixed cropping. Wheat crop competitiveness was higher in additive series than in replacement series. The competition ratio and aggressivity value of wheat crop were higher when wheat + mustard and wheat+brown sarson mixed cropping was followed in 100% + 20% seeding proportion (Table 2).

Economic viability

The economic feasibility in terms of net return showed that except wheat + mustard mixed cropping in 100% + 10% or 100% + 20% seeding proportion, all other sowing patterns recorded net returns and benefit : cost ratio values lower than sole cropping of wheat. However, wheat + *Brassica* mixed cropping was found more remunerative than mustard or brown sarson sole cropping. Taking

wheat + mustard mixed cropping in 100% + 10% and 100% + 20% seeding proportions increased the net return by Rs 1,611 and Rs 2,216 over sole wheat cropping and Rs 7,212 and Rs 7,817 over farmer's practice of wheat + brown sarson (100%+50%) mixed cropping.

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