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RESEARCH PAPER

Production potential and monetary efficiency of Indian mustard (*Brassica juncea*) in intercropping system under rainfed conditions of North-West Himalayas

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Abstract : A field experiment was conducted during winter (*Rabi*) season of 2011-12 and 2012-13 at actual line of control between India and Pakistan occupied Kashmir (ALC); in Teethwal block of district Kupwara (Jammu and Kashmir) to evaluate the production potential, biological feasibility and economic viability of intercropping of brown sarson (*Brassica campestris*) with wheat (*Triticum aestivum* L.), lentil (*Lens culinaris* Medikus), pea (*Pisum sativum* L.), potato (*Solanum tuberosum* L.), oats (*Avena sativa* L.) and also as sole crop. Brown sarson yield decreased in sole/monocropping and yield of mustard was inversely proportional due to intercropping with nonleguminous crops, whereas yield of mustard was in the order 11.26 and 11.85 q ha^{-1} during 2011-12 and 2012-13 seasons, respectively. yield components, *viz.*, primary branches/plant, secondary branches/plant, pod/plant, seeds/pod and 1000-seed weight (g) of main crop of brown sarson also increased in the intercropping systems where component crops are legumes. Brown sarson with lentil or pea was most remunerative in respect of benefit : cost ratio. These intercropping systems showed higher brown sarson-equivalent yield, biological efficiency and monetary advantage among other intercropping systems.

Key Words : Brown sarson, Production, Monetary advantage, Intercropping

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INTRODUCTION

Brown sarson (*Brassica campestris*) is a major winter (*Rabi*) season oilseed crop in India because it account for 21 per cent of the total oilseeds in area and 23 per cent of the total oilseeds production in the country (GOI, 2007-08). Brown sarson (*Brassica campestris*) constitute an important source of edible oil next to groundnut in India and it is a predominant crop among the oilseed *Brassicas*. Brown sarson (*Brassica campestris*)- wheat (*Triticum aestivum* L.) is the principal cropping system in Jammu and Kashmir covering 40 per cent of the area. Since both the crops are exhaustive often results low yields. Under such situations, intecropping with legumes seems to be a viable agronomic strategy to provide production stability and insure mechanism against adverse environmental conditions. Since India mustard is a widely spaced crop, legume intercropping offers enough opportunities to realize higher system productivity, improves soil health, conserves soil moisture and increases total yield (Singh *et al.*,2008). Legumes has emerged as potential replacement for wheat due to wider adaptability and suitability to exploit the rainy (*Kharif*) residual moisture. Increase in productivity of mustard – based cropping systm with integration of legumes has been widely reported (Kumpawat, 2004 and Jamwal, 2005). Inclusion of legumes in cropping system significantly contributes to nitrogen economy and reduces energy inputs. The legumes can be included as intercrops for studying the residual effect on fertility. Yield advantage in the intercropping system may vary depending on the level of competition between component crops and their respective planting pattern (Sarkar and Pal, 2004). Information on legumes intercropping in brown sarson–based cropping system is very inadequate. Keeping these in view, the present investigation was undertaken to explore the viability of increasing total crop productivity by intercropping legumes and non-legumes with brown sarson under sub-montanous agro-climatic zone of Karnah sector (Jammu and Kashmir).

MATERIAL AND METHODS

The experiment was conducted under rainfed conditions at demonstration plot of Dringla, adopted under National Agricultural Innovation Project-3 SRLS at actual line of control between India and Pakistan Occupied Kashmir (ALC); in Teethwal block of Karnah sector (34.5^{0}N latitude and 74.5^{0}E longitude 2658 m above msl) of district Kupwara, Jammu and Kashmir, during *Rabi* season 2011-12 and 2012-13. The soil of experimental site was silty clay loam, having pH 6.1, soil status was medium in organic carbon (0.90), available N (265.7 kg/ha), available P (15.6 kg/ha) and available K (159.2 kg/ha). Five intercropping systems, *viz.,* pure Indian mustard, mustard + wheat, mustard + lentil, mustard + peas, mustard + potato and mustard + oats in all possible combinations with recommended dose of fertilizers during *Rabi* season were arranged in Randomized Block Design with 3 replications. Brown sarson "Shalimar Brown Sarson-1" was sown in rows 30 cm apart with plant-to-plant spacing of 10 cm during first to second week of October. The legume and non-legume intercrops were sown in between the 2 brown sarson rows with recommended fertilizer on area basis wheat (120 kg N + 60 kg P + 30 kg K and 20 kg $ZnSO_4$/ha), lentil (30 kg N + 60 kg P + 30 kg K/ha), pea (30 kg N + 60 kg P + 30 kg K/ha), potato (150 kg N + 100 kg P + 100 kg K/ha) and oats (80 kg N + 17.2 kg P + 16.6 kg K/ha). In the *Rabi* season the plots were divided into 6 parts, *i.e.* control and recommended 80 kg N + 50 kg P + 40 kg K +30 kg gypsum + 1 kg borex/ha as treatment in brown sarson. Sulfosulfuron in wheat, pendimethalin in lentil and pea, isoproturon in brown sarson and alchalor in potato with one hand weeding were followed to control weeds. The FYM (0.5: 0.20: 0.41% N: P: K) of 30% moisture content was applied on air dry weight basis at sowing by thorough mixing with soil. In all the crops dose of fertilizers was applied as per the recommended package of practices. In brown sarson, nitrogen as per treatment was applied in splits, half of the nitrogen and full dose of phosphorus, potash, gypsum and borex was applied as basal dose at the time of sowing by placement method, the remaining half of the nitrogen was applied at the time of first irrigation. Total rain fall of 1374.6 mm, 1225.7 mm was received during *Kharif* and 405. 6 mm, 108.7 mm during *Rabi* in respective years of cultivation. The seed and straw samples were analyzed for N, P and P using standard analytical procedures and uptake was calculated. Soil samples at harvest of last cycle was analyzed for available NPK. Nutrient balance in soil was calculated as v-(X-a)-N, where v is the nutrient removed by crops in the initial soil status of the nutrient element; a is the final soil status of the nutrient element and N is the nutrient added through fertilizer (Raghuvanshi *et al.*,1991). The economic analysis was made considering the prevailing market costs of inputs and prices of output.

RESULTS AND DISCUSSION

The experimental findings obtained from the intercropping of brown sarson with legume and non-legume crops as well as sole crop of brown sarson have been discussed here with suitable reasons establishing cause and effect relationship in the light of available evidence.

Effect on yield components:

All the yield attributes of brown sarson *viz.,* primary branches/plant, secondary branches/plant, pod/plant and seeds/pod were beneficially influenced by intercropping the brown sarson with lentil and pea as compared to non-leguminous crops (potato, wheat, oats) and sole brown sarson. Intercropping with leguminous crops (lentil and pea) helped to achieve better growth as reflected by marked increase in; primary branches/plant, secondary branches/plant, pod/plant and seeds/pod (Table 1). However, the primary branches/plant were at par by intercropping the brown sarson with potato crop. This might be accredited to balance competition, temporal complementarity and better utilization of resources by the component crops having differential rooting pattern, canopy distribution and nutritional requirements. Padhi and Panigrahi (2006) and Rana *et al.* (2006) also reported beneficial effects of intercropping ensuing higher total productivity and profitability may be due to additional advantage of intercrop yield and higher economic value of intercrop.The lowest yield attributes in terms of primary branches/plant, secondary branches/plant, pod/plant, and seeds/pod were observed with sole brown sarson and brown sarson + wheat and brown sarson + oats.

Effect on yield-attributing characters:

Intercropping of brown sarson with lentil or pea proved superior in terms of yield attributes than sole crop of brown sarson or intercropping with wheat or oats. Yield attributes showed variation and decreasing trends in the intercropping systems in which non-leguminous crops (wheat or oats) are components crops (Table 2). The reduction in yield components might be due to shading and competition consequence of non-leguminous crops on associated brown sarson under different intercropping systems. These results corroborate the findings of Rana (2006). 1000-grain weight decreased significantly in intercropping system in which wheat or oats are component crops. Brown sarson in association with lentil or pea recorded significantly more 1,000-grain weight owing to differential growth habits and addition of nitrogen as well as organic matter by the leguminous crops compared with other cropping systems. Maximum reduction in yield attributes was recorded in brown sarson intercropped with wheat due to greater competition effect of the intercrop on brown sarson. This corroborates the findings of Singh *et al.* (2008).

Effect on yield:

Yield is the final test to evaluate and justify the contribution of various treatments and their manipulation in the field of crop production. The intercropping which is one of the most important agronomic practice, was found to induce striking variations in the yield behaviour in the present study. Intercropping of brown sarson with

Table 1 : Yield components of brown sarson as influenced by intercropping

Treatments	Primary branches/plant		Secondary branches/plant		Pods/plant		Seeds/pod	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Mustard pure	3.70	3.65	3.26	3.61	121.18	131.45	10.69	10.45
Mustard + wheat	3.08	3.14	2.87	2.83	113.96	120.56	9.75	10.12
Mustard + kentil	4.99	4.90	4.32	4.78	129.21	146.76	11.30	11.47
Mustard + peas	4.36	4.25	3.80	4.17	122.35	146.38	10.88	10.84
Mustard + potato	4.31	4.19	3.68	3.85	121.81	139.76	10.71	10.77
Mustard + oats	3.07	3.25	2.97	3.22	120.18	129.25	10.18	10.43
S.E.±	0.34	0.23	0.18	0.15	0.33	1.39	0.25	0.24
C.D.(P=0.05)	0.99	0.67	0.51	0.43	0.95	4.12	NS	NS

NS= Non-significant

Table 2 : Yield of brown sarson as influenced by intercropping system

Treatments	1000-seed weight (g)		Seed yield (q/ha)		Straw yield (q/ha)		Biological yield (q/ha)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Mustard pure	2.39	2.33	10.18	10.76	22.53	20.92	32.71	31.68
Mustard + wheat	2.33	2.32	9.19	10.02	18.59	19.20	27.78	29.22
Mustard + lentil	2.52	2.50	11.26	11.85	26.43	25.77	37.69	37.62
Mustard + peas	2.47	2.41	11.15	11.13	24.09	23.56	35.24	34.69
Mustard + potato	2.43	2.39	11.09	11.06	22.58	22.14	33.23	33.20
Mustard + oats	2.39	2.31	10.10	10.42	20.99	21.65	31.75	32.07
S.E.±	0.03	0.03	0.12	0.14	0.33	0.39	0.45	0.66
C.D.(P=0.05)	0.11	0.09	0.35	0.39	0.93	1.12	1.32	1.92

lentil significantly recorded higher seed yield of 11.26 and 11.85 q ha^{-1} during 2011-12 and 2012-13 seasons, respectively, compared to intercropping with wheat with yields of 09.19 and 10.02 q ha^{-1}, oats with yields of 10.10 and 10.42 q ha^{-1}, or sole crop with yields of 10.18 and 10.76 q ha^{-1} during the respective years. All the intercropping combinations with leguminous crops resulted in greater yield advantage (Table 2). The nutrients from different layers of the soil were evenly used. A brown sarson-legume mixture was beneficial because of an efficient fixation of atmospheric nitrogen into the soil. Leaf shedding and their subsequent decomposition reduces the chances of micro-nutrient deficiency in brown sarson as the legumes absorb such nutrients from lower layer and return them to the surface soil through shedding of leaves and decomposition and ultimately yield was significantly increased. Similar findings were also reported by Jat and Ahlawat (2004).

Effect on oil content and oil yield:

The oil content of seed which is one of the most important quality characters of oil seed crop that exercises direct influence upon the oil yield was observed to be influenced by intercropping during both the years. It was observed that intercropping the brown srason with lentil and pea, the seed oil content improved sifnificantly from 35.8 per cent to 37.8 per cent and 36.0 per cent to 37.5 per cent during first and second season, respectively (Table 3). The increase in oil content in seed could be attributed to increase in protein content of seed by addition of N due to leguminous crops (Chauhan *et al.*,1995). The oil value in terms of quantity and quality becomes higher when a brown sarson was intercropped with legume *viz.*, lentil or pea as these crops efficiently fixed atmospheric nitrogen into the soil. These results confirms the findings of Patel and Bhargava (1987) and Saran and Giri (1990) who also observed a significant improvement in oil content by applying nitrogen.

Effect on nutrient uptake:

Significantly highest N, P and K uptake *i.e.* 29.76 and 27.74 kg N, 6.40 and 6.48 kg P and 18.65 and 19.19 kg K during first and second season, respectively (Table 4) was observed in brown sarson + lentil cropping system. This was followed by brown sarson + pea and brown sarson + potato system. The nutrient uptake was statistically at par with all the above cropping systems. Intercropping the brown sarson with leguminous crops

Table 3 : Oil content and oil yield of brown sarson as affected by intercropping system

Treatments	Seed oil percentage (%)		Seed oil yield (kg/ha)		Harvest index (%)		B: C ratio	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Mustard pure	35.8	36.0	379.12	391.77	31.07	33.19	2.25	2.12
Mustard + wheat	34.9	35.2	363.87	373.44	29.28	31.49	2.11	1.66
Mustard + lentil	37.4	37.5	409.86	433.71	35.20	34.29	2.74	3.04
Mustard + peas	36.6	36.8	394.54	414.36	33.63	33.31	2.64	2.57
Mustard + potato	36.4	36.6	381.10	398.75	32.04	33.24	2.45	2.46
Mustard + oats	35.5	35.6	375.52	390.16	29.87	32.08	2.15	2.09
S.E.±	0.25	0.23	1.65	1.63	1.31	1.26		
C.D. (P=0.05)	0.74	0.67	4.92	4.87	4.58	4.53		

Table 4: Nutrient uptake by brown sarson (kg/ha) in intercropping system

Treatments	Nitrogen uptake (kg/ha)		Phosphorus uptake (kg/ha)		Potassium uptake (kg/ha)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Mustard pure	25.83	25.89	5.46	5.64	15.81	16.43
Mustard + wheat	22.29	22.87	4.21	4.39	14.03	14.57
Mustard + lentil	29.76	27.74	6.40	6.48	18.65	19.19
Mustard + peas	27.87	27.46	6.27	6.38	17.07	17.17
Mustard + potato	26.12	26.59	6.15	6.41	15.90	16.71
Mustard + oats	24.45	24.35	4.59	4.64	15.42	15.22
S.E.±	0.70	0.65	0.41	0.37	0.80	0.51
C.D.(P=0.05)	1.95	1.92	1.22	1.10	2.35	1.45

significantly increased the nutrient uptake. It was attributed to higher biomass production under brown sarson + lentil or brown sarson + pea intercropping system. Further, the N, P and K uptake by brown sarson in brown sarson + potato intercropping was markedly superior, being 26.12 and 26.59 kg N, 6.15 and 6.41 kg P and 15.90 and 16.71 kg K during first and second season, respectively. This could be due to more plant population, yield attributes and yield of brown sarson in brown sarson + potato intercropping system. Compared to sole crop or intercropping with wheat and oats higher N, P and K uptake was observed during both the years.

Total N, P and K uptake of the system was significantly higher in brown sarson + lentil and brown sarson + pea intercropping system than in sole brown sarson, brown sarson + oats and brown sarson + wheat. This could be attributed to the higher total biomass production under legume brown sarson intercropping systems and hence higher total uptake of N, P and K over sole cropping. These results confirm those of Singh and Rana (2006).

Effect on available nutrients (NPK):

Soil available N, P and K content as compared to initial soil N, P and K status did not differe much when sole brown sarson, brown sarson + oats and brown sarson + wheat cropping system was followed (Table 5), where as in brown sarson + lentil, brown sarson + pea and brown sarson + potato intercropping there was positive N, P and K balance with highest in brown sarson + lentil (273.96 and 274.30 kg N, 16.00 and 16.15 kg P and 162.70 and 162.85 kg K during first and second season, respectively), that was at par with brown sarson + pea (273.90 and 274.30 kg N, 16.00 and 16.10 kg P and 162.63 and 162.74 kg K during first and second season, respectively) followed by brown sarson + potato (273.78 and 274.10 kg N, 15.60 and 15.78 kg P and 162.61 and 162.69 kg K during first and second season, respectively) intercropping. This showed that nutrients removed by these cropping systems were less than the applied one and the leaf biomass as litter added by lentil and pea added to the nutrient pool of soil. Beneficial effect on sustainable balance for maize based cropping system has been reported by Pathak *et al.* (2005) and Jamwal (2005).

Effect on economics:

The monetary efficiency of an intercropping is finally decided in terms of the economics (benefit: cost ratio) of the cropping system. The present investigation indicated superior economic viability of brown sarson + lentil intercropping with 2.74 and 3.04 B: C ratio during first and second season, respectively, followed by brown sarson + pea intercropping (2.64 and 2.57 B:C ratio during first and second year, respectively) and brown sarson + potato (2.45 and 2.46 B: C ratio during first and second year, respectively) intercropping (Table 3) mainly owing to higher economic production in these systems.

Conclusion:

On the basis of two years experimentation, the conclusion was drawn in view of the objectives of the project where it was ascertained that intercropping of brown sarson with leguminous crops like lentil and pea brought on positive improvement in yield components and yield of brown sarson. The agronomic efficiency of the crop was also encouraging reflected through oil content and oil yield. Subsequently, the concentration and uptake of nutrients improved as per change in component crops. The highest benefit cost ratio (3.04) was realized when brown sarson was intercropped with lentil. This higher

Table 5 : Available nutrients (NPK) in soil after harvest of brown sarson (kg/ha) in intercropping system

Treatments	Available nitrogen (kg/ha)		Available phosphorus (kg/ha)		Available potassium (kg/ha)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Mustard pure	273.70	274.10	15.60	15.60	162.55	162.68
Mustard + wheat	273.30	273.60	15.80	15.45	162.45	162.55
Mustard + lentil	273.96	274.30	16.00	16.15	162.70	162.85
Mustard + peas	273.90	274.30	16.00	16.10	162.63	162.74
Mustard + potato	273.78	274.10	15.60	15.78	162.61	162.69
Mustard + oats	273.48	273.90	15.60	15.60	162.51	162.65
S.E.±	0.08	0.11	0.10	0.13	0.07	0.10
C.D.(P=0.05)	0.23	0.31	0.29	0.28	NS	0.28

NS= Non-significant

B:C ratio was due to; more nutrient uptake, best employment and utilization of labour, machine and power throughout the year. Total bio-mass production per unit area per period of time was increased because of fullest use of land as the inter-row space was utilized which otherwise would have been used for weed growth. Thus, the profit per unit area becomes high.

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