RESEARCH ARTICLE

PRODUCTIVITY AND COMPATIBILITY OF WHEAT (*TRITICUM AESTIVUM* L.) AND INDIAN MUSTARD (*BRASSICA JUNCEA* L.) INTERCROPPING AS INFLUENCED BY FARMYARD MANURE AND FERTILIZER LEVELS

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Received-10.05.2017, Revised-24.05.2017

Abstract: A field experiment was conducted during winter (*rabi*) seasons of 2010-11 and 2011-12 at Institute of Agricultural Sciences, Banaras Hindu University, Varanasi to evaluate the productivity, compatibility and economics of wheat and Indian mustard intercropping as influenced by row proportions, farmyard manure (FYM) and fertilizer levels under irrigated conditions. Among row proportions, 8:1 row proportion of wheat and Indian mustard intercropping recorded significantly the highest yield attributing characters *viz.*, grain spike^{-1}, spikelet length and yield in case of wheat, and number of siliqua plant^{-1} and number of seed siliqua^{-1} in case of Indian mustard. The seed yield and stover yield of mustard were higher in 6:2 row proportion which was remained at par with 8:2 and 10:2 row proportions. There was also recorded significantly higher land equivalent ratio, aggressivity index with 8:1 row proportion of wheat + Indian mustard intercropping over 10:2, 8:2 and 6:2 row proportions. Conversely, the highest net return as well as B: C ratio was recorded in 10:2 row proportion which was at par with 8:1 row proportion. To achieve higher yield advantage and efficient resource utilization in wheat + mustard intercropping, the application of 100% RDF along with 30 kg N through FYM observed significantly higher yield attributes, yield, competitive indices and economics of wheat and Indian mustard, but it was remained at par with 100% RDF plus 15 kg N through FYM.

Keywords: Farmyard manure, Fertilizer level, Intercropping, Mustard, Row proportion, Wheat

INTRODUCTION

Intercropping is an advanced agro-technique and is considered to be an effective and potential mean of increasing crop production per unit area and time, particularly for farmers having marginal and small holdings. It provides an efficient utilization of environmental resources, decreases the cost of production, provides higher financial stability for farmers, decreases the pest damage, inhibits weeds growth more than monocultures, and improves soil fertility through fertilizers increasing to the system and increase yield and quality (Francis *et al*., 1976; Willey, 1979). Substantial increase in total production over space and time not by means of costly inputs but by simple expedient of growing crops together are the unique advantage associated with intercropping, mainly micro-climatic manipulation is shown to be appreciably more limited in sole cropping than in intercropping (Stigter and Baldy, 1995).

In India, wheat (*Triticum aestivum* L.) with Indian mustard (*Brassica juncea* L.) intercropping is an old and important cropping system under both irrigated and rainfed conditions. Growing cereals with pulses and oilseeds endowed with varying rooting depth and growth pattern help better extraction of soil moisture and nutrients from different soil profile. Further, it is also known to intercept more solar energy and give comparatively higher stability and insurance of yield during aberrant weather conditions than sole crops (Willey, 1979a; Sinha *et. al*., 1985 and Mandal and Mahapatra, 1990). Intercropping of wheat with mustard is ecologically suitable, economically viable, operationally feasible and socially acceptable cropping system during winter season in India (Ghoniskar and Shinde, 1994). The country still is presently surplus in the production of wheat but in spite of quantum jump in oilseed production during the last two decades, its production is not sufficient to meet country's growing edible oil demands. This is attributed to improvement in standard of living with better purchasing power of people due to better economic growth as well as the high growth rate of Indian population. Its scarcity has necessitated the import of 51 per cent of our requirements at a huge cost of Rs. 56910 crores 2013-14 (Hedge and Sudhakara Babu, 2014). Mixed cropping of mustard with wheat is very common in eastern Uttar Pradesh which is one of the major causes of low productivity of mustard in the region. The reason might be use of improper proportion of the component crops. Accordingly, their compatible combination for the maximum utilization of natural resources based on complementarily is essential.

In intercropping system, the competition between main and subsidiary crops depend on the maturity periods, rooting pattern, canopy spread and plant habit etc. of the component crops (Singh and Gupta, 1994). It has been proved beyond doubt that in wheat + mustard intercropping, the competition offered by mustard is much higher than wheat. However, it can be altered to some extent by modification of row

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proportion and higher yield advantages as well as monetary return can be achieved by proper nutrient management (Verma *et al.*, 1997 and Srivastava and Bohra, 2006). Realising the importance of these facts, the present investigation is therefore, proposed to assess the productivity, compatibility and economics of wheat and Indian mustard intercropping system as influenced by row proportions, farmyard manure and fertilizer levels under irrigated conditions.

MATERIAL AND METHOD

The experiment was carried out during two consecutive winter (*rabi*) seasons of 2010-2011 and 2011-2012 at the Agricultural Research Farm of Banaras Hindu University, Varanasi in Northern Gangetic Alluvial Plain of India (83°03′0″ E longitude; 25°18′0″ N latitude and an altitude of 128.9 metre above sea level). The experimental soil was Gangetic alluvial with *p*H 7.41. It was moderately fertile-being low in available organic carbon (0.48%) as well as available nitrogen (190.50 kg ha^{-1}) and medium in available phosphorus (19.85 kg ha^{-1}) as well as available potassium (213.44 kg ha^{-1}). The experiment was laid out in split-plot design comprising four row proportions of wheat + mustard intercropping, *i.e*., 8:1, 6:2, 8:2 and 10:2 in main plot and two different levels of farmyard manure (15 and 30 kg N through farmyard manure) and two fertilizer levels (75 and 100% RDF) in sub-plots. The two extra plots of sole wheat 'HUW-234' and sole Indian mustard 'Vardan' were taken for the estimation of yield, competitive indices and monetary advantage. Thus, all the total sixteen {(4 main plots x 4 sub plots) + 2 additional plots} treatment combinations were replicated thrice. The experimental plot of 22.95 m^2 (7.65 m x 3.00 m) was separated by 1 m plot-border. Seed bed preparation including ploughing, disk harrowing and planking was done as per the requirement of main crop. Well decomposed farmyard manure was applied as per treatments. In replacement series of wheat and mustard intercropping, normally fertilizer is applied on the basis of wheat fertilizer requirement. So, a common recommended dose of fertilizer (RDF) i.e. 120 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1} was applied to the crops in wheat + mustard intercropping. Similarly, the sole wheat and mustard recommended nutrient dose of 120 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1} and 90 kg N, 40 kg P_2O_5 and 40 kg K_2O ha^{-1}, respectively were applied. Half dose of N and full doses of P_2O_5, and K_2O were applied as basal before sowing. Remaining half dose of N to wheat was top dressed in two equal splits at tillering and spike emergence stages whereas to mustard, it was applied at one month stage of crop. Fertilizers used were urea, single super phosphate and muriate of potash. In sole as well as in intercropping system, wheat crop was sown at a row spacing of 22.5 cm and plant to plant distance was maintained as per seed rate. However in sole mustard, thick sowing was done at a row spacing of 45 cm. The plant to plant distance of mustard was maintained at 12 cm by two thinning at an interval of 14 and 21 days after sowing. Weather data of average temperature (^{0}C), average rainfall (mm) and evapo-transpiration (mm) were recorded daily at the experimental site with using meteorological observatory and are reported as mean weekly data for both the years. Grain or seed yield index was calculated according to Singh and Gupta (1994) where sole stand of wheat or Indian mustard was taken as 100.

Grain or Seed yield index (%)

$$= \frac{\text{Intercropping yield (kg ha}^{-1})}{\text{Sole cropping yields (kg ha}^{-1})} \times 100$$

The cost of cultivation, gross return and net return under different treatments were worked out on the basis of prevailing cost of different enterprises. Net return (Rs. ha^{-1}) and benefit: cost ratio was calculated with the help of the following formula:

Net return (Rs. ha^{-1}) = Gross return (Rs. ha^{-1}) - Cost of cultivation (Rs. ha^{-1})

Benefit: cost ratio = Net return (Rs. ha^{-1})/ Cost of cultivation (Rs. ha^{-1})

Competitive indices for assessing the yield advantage and competition in intercropping systems are given below:

Land Equivalent Ratio (LER)

Land equivalent ratio (LER) indicates the efficiency of intercropping in using the resources of the environment compared with sole cropping (Mead and Willey 1980). This is a widely used index to assess any yield advantage in intercropping and measures the efficiency of an inter/mixed crop. Moreover, LER indicates the total land area required by sole crops to achieve the same yield as the intercrops (Willey 1985). When the LER is > 1, intercropping favours growth and yield of species. By contrast, when LER is < 1, intercropping negatively affects growth and yield of plants grown in mixtures (Caballero *et al.*, 1995). LER was calculated based on formula given by Singh and Bohra (2012):

$$\text{LER} = \text{LERa} + \text{LERb}$$

$$\text{LERa} = \frac{\text{Yab}}{\text{Yaa}}$$

$$\text{LERb} = \frac{\text{Yba}}{\text{Ybb}}$$

Where, LERa and LERb are the partial LER of crops 'a' and 'b', respectively. Yab and Yba are the yields of two component crops; Yaa and Ybb are the yields per unit area when 'a' and 'b' are grown as sole crops under those conditions with which comparison are to be made.

Aggressivity index

A indices, which has been attempted to measure the inter crop competition, by relative yield changes of both the component crops is the aggressivity proposed by Mc Gilchrist (1965) originally for replacement situations. Moreover it gives a simple measure of how much the relative yield increase in crop ‘a’ is greater than that for crop ‘b’ and *vice-versa* in an intercropping system and can be expressed as ‘A’.

Aggressivity index of crop ‘a’ with ‘b’ is given as according to Singh and Bohra (2012):

$$\mathrm{Aab} = \frac{\mathrm{Yab}}{\mathrm{Zaa} \times \mathrm{Zab}} - \frac{\mathrm{Yba}}{\mathrm{Ybb} \times \mathrm{Zba}}$$

Similarly, aggressivity index of crop ‘b’ with ‘a’ is given as

$$\mathrm{Aba} = \frac{\mathrm{Yba}}{\mathrm{Zbb} \times \mathrm{Zba}} - \frac{\mathrm{Yab}}{\mathrm{Yaa} \times \mathrm{Zab}}$$

Where,

Yaa = pure stand yield of crop ‘a’, Ybb = pure stand yield of crop ‘b’, Yab = mixture yield of crop ‘a’ in combination with ‘b’ Yba = mixture yield of crop ‘b’ in combination with ‘a’, Zab = sown proportion of crop ‘a’ in mixture with ‘b’ and Zba = sown proportion of crop ‘b’ in mixture with ‘a’

An aggressivity value of zero indicates that the component crops are equally competitive. For any situation, both components will have the same numerical value but the sign for the dominant component will be positive and that for the dominated crop will be negative. The greater the numerical value, the larger the difference in competitive abilities.

Statistical analysis

The data pertaining to each of the characters of the experimental crops were tabulated and finally analyzed statistically by applying the standard technique to draw a valid conclusion. Analysis of variance for split plot design was worked out as per the standard procedure given by Cochran and Cox (1957) and the significance was tested by ‘F’ test. Treatment mean differences were separated and tested by Fisher’s protected least significant difference (LSD) at a significance level of $p \leq 0.05$.

RESULT AND DISCUSSION

Yield attributes and yield

The yield attributing characters *viz.*, grain spike^{-1}, spikelets spike^{-1} and 1000-grain weight of wheat in wheat + mustard intercropping recorded significantly lower as compared to sole stand of wheat (Table 1). Among row proportions of wheat + mustard intercropping, the significantly higher wheat grain spike^{-1}, spikelets spike^{-1} and 1000-grain weight, grain yield and straw yield and mustard siliqua plant^{-1}, seed siliqua^{-1}, 1000-seed weight in wheat and mustard intercropping was recorded in 8:1 row proportion which was followed by 10:2, 8:2 and 6:2 row proportions except mustard seed yield and stover yield which was maximum in 6:2 row proportion remained at par with 8:2 row proportion. This could be ascribed to the inter-generic competition between the component crops for possible under and above ground resources *viz.*, space, nutrients, moisture. These results find supported from the works of Sharma *et al*. (1986), Singh *et al*. (1995) and Srivastava *et al.* (2007).

Farmyard manure and fertilizer levels from 75% RDF + 15 kg N through FYM to 100% RDF + 30 kg N through FYM applied to wheat and mustard correspondingly increased wheat, *viz.*, grain spike^{-1}, spikelets spike^{-1} and 1000-grain weight, grain yield and straw yield and mustard, *viz.*, siliquae plant^{-1}, seed siliqua^{-1}, 1000-seed weight, seed yield and stover yield of wheat and mustard intercropping. Among the farmyard manure and fertilizer levels, wheat *viz.*, grain spike^{-1}, spikelets spike^{-1} and 1000-grain weight, grain yield and straw yield, and mustard *viz.*, siliqae plant^{-1}, seed siliqua^{-1}, 1000-seed weight, seed yield and stover yield significantly the highest at 100% RDF + 30 kg N through FYM which was remained at par with 100% RDF + 15 kg N through FYM over rest of the treatments.

A close examination of the data indicated the adverse effect of mustard on wheat under different row proportions of wheat + mustard intercropping. Grain yield index increased with increasing wheat proportion. On the contrary, the lowest grain yield index was recorded at highest mustard proportion on area basis when two row of mustard was sown after every six rows of wheat. In wheat + mustard intercropping, the area under wheat reduced 25, 20, 18 and 16%, respectively in 6:2, 10:2, 8:2 and 8:1 row proportions respectively, with corresponding yield reduction in wheat yield on percent wheat grain yield index basis was noted 92.85, 85.37, 76.91 and 70.40% during first year and 94.71, 85.54, 77.31 and 70.94 (8:1, 10:2, 8:2 and 6:2) per cent during second year, respectively in comparison to sole stand. In mustard crop, seed yield index of mustard decreased with every increase in proportion of wheat rows. Accordingly, the seed yield index was recorded maximum with six rows of mustard alternated with two rows of mustard. Mustard replaced 11.12, 16.67, 20 and 25% area of wheat in 8:1, 10:2, 8:2, and 6:2 row proportions respectively, with corresponding seed yield of 35.73, 42.55, 46.33and 51.22% during first year and 37.16, 43.49, 45.12 and 50.38% during second year, respectively in comparison to sole stand. It shows that the seed yield of mustard was proportionately higher as compared to area replaced. Application of fertility doses from 75% RDF + 15 kg N through FYM to 100% RDF + 30 kg N through FYM applied to wheat correspondingly increased grain yield index of wheat during both the years of experimentation. The farmyard manure and fertilizer level, grain yield index significantly highest at 100% RDF + 30 kg N through FYM, which was at par with 100% RDF + 15 kg N through FYM during both the years. However, the lowest grain yield index was observed in 75% RDF + 15 kg N through FYM and 75% RDF + 30 kg N through FYM. Similar resulted was corroborated by Srivastava *et al*. (2007).

Yield advantage and competitive indices

In wheat + Indian mustard intercropping, 8:1 and 10:2 row proportions were found comparable, but both were recorded significantly higher yield advantage and greater biological efficiency over 8:2 and 6:2 row proportions. Yield advantage of 25% and 25% first year 28% and 29% in second year was registered in 8:1 and 10:2 row proportion, which indicates similar yield to that of the pure stand of both the crops even with 29 % and 32% reduced land, justifying their desirability over monoculture of wheat or Indian mustard. This result corroborates the findings of Singh and Gupta (1994) and Srivastava *et al*. (2007). The aggressive nature of Indian mustard, made it more competitive than wheat. The aggressivity of Indian mustard was the maximum at 8:1 row proportion of wheat + mustard intercropping, followed by 10:2, 8:2 and 6:2 row proportions.

Aggressivity index of Indian mustard in wheat + Indian mustard intercropping enhanced markedly with increasing levels of fertility to Indian mustard causing corresponding decline in these indices for wheat because mustard uptake quickly in compression to wheat. The maximum total LER was observed at the highest farmyard manure and fertilizer level 100% RDF + 30 kg N through FYM followed by 100% RDF + 15 kg N through FYM. These results are in agreement with the findings of Srivastava *et al*. (2007).

Protein and oil contents and their yields

Variation in the row proportions of Indian mustard with wheat pertaining to intercropping system produced lucid impact on the oil production of mustard during both the years. Maximum protein content, protein yield, oil content and oil yield was recorded under 6:2 row proportion remained at par with 8:2 row proportion. The farmyard manure and fertilizer level doses maximum seed protein content was recorded in highest farmyard manure and fertilizer level. However, the reverse trend was noticed in seed oil content. In spite of that protein yield and oil yield was recorded in 100% RDF + 30 kg N through FYM, which was at par with 100% RDF + 15 kg N through FYM. This could be attributed to the highest seed yield obtained under the highest farmyard manure and fertilizer level, which decreased markedly with every curtailment in farmyard manure and fertilizer level (Table 4). Singh (1983) and Tomer *et al*. (1996) also obtained higher oil yield with increasing levels of fertility.

Economics

As evident from data on Table 4, in general, intercropping of wheat and mustard in 10:2 and 8:1 row proportions was found more remunerative than growing either of the component crops in pure stand as well as wheat + mustard in 6:2 row proportion. Among four row proportions in wheat + mustard intercropping,10:2 row proportion recorded highest gross return and net return benefit: cost which was at par with 8:1 row proportion and both proved remunerative over 8:2 and 6:2 row proportion during both the years of experimentation. Nevertheless, the lower yield remained associated with 6:2 row proportion followed by 8:2 and 8:1 row proportions. Increase in farmyard manure and fertilizer levels from lower to higher level markedly increased the gross return and net return (Rs.ha^{-1}), but decreased the benefit: cost ratio due to increased cost of cultivation. Accordingly, application of 100% RDF + 30 kg N through FYM significantly higher gross return, net return and also increase cost of cultivation, which was at par with 100% RDF + 15 kg N through FYM . While, B: C ratio was highest in the application of 100% RDF + 15 kg N through FYM.

Thus, to achieve higher yield advantage and efficient resources utilization in wheat + Indian mustard intercropping, ten rows of wheat be taken after every 2 rows of Indian mustard and the component crops can be fertilized with 100% RDF + 15 kg N through FYM.

Table 1. Effect of row proportion, farmyard manure and fertilizer level on yield attributes and yields of wheat in wheat + Indian mustard intercropping

Treatment	Grain spike^{-1}		Spikelets spike^{-1}		1000-grain weight (g)		Grain yield (kg ha^{-1})		Straw yield (kg ha^{-1})		Grain yield index (%)	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Wheat + Mustard intercropping (Row proportion)												
8:1	43.78	46.41	16.64	16.69	42.11	43.12	4174	4358	5227	5627	90.83	92.69
6:2	34.91	35.95	14.08	14.11	36.77	37.50	3165	3265	4105	4405	68.86	69.43
8:2	37.43	38.93	14.91	14.94	38.51	39.32	3457	3557	4334	4634	75.24	75.66
10:2	39.80	41.79	15.73	15.77	39.93	40.85	3838	4004	5125	5491	83.52	85.13
SEm±	0.63	0.70	0.23	0.24	0.39	0.40	106	116	111	120	-	-
CD (P=0.05)	2.18	2.42	0.81	0.82	1.36	1.39	367	402	383	416	-	-
Farmyard manure and fertilizer level												
75% RDF + 15% N through FYM	36.79	38.48	14.06	14.10	35.94	36.74	3338	3482	4382	4723	72.65	74.04
100% RDF* + 15% N through FYM	40.26	42.11	16.50	16.53	42.14	43.06	3841	3964	4852	5193	83.58	84.31
75% RDF + 30% N through FYM	37.79	39.53	14.14	14.17	36.24	37.04	3471	3607	4513	4863	75.54	76.72

100% RDF + 30% N through FYM	41.07	42.96	16.66	16.70	43.00	43.95	3983	4131	5045	5378	86.67	87.85
SEm±	0.56	0.59	0.16	0.16	0.38	0.39	72	89	88	91	-	-
CD (P=0.05)	1.63	1.71	0.47	0.48	1.12	1.14	209	259	258	265	-	-
Sole vs. Intercrop												
Sole (Control)	49.07	52.50	26.60	26.68	41.23	42.22	4495	4702	5601	5971	100.00	100.00
Intercrop	38.98	40.77	15.34	15.38	39.33	40.20	3658	3796	4698	4981	79.61	80.73
SEm±	1.15	1.23	0.61	0.62	1.86	1.90	155	184	185	192	-	-
CD (P=0.05)	3.32	3.54	1.77	1.78	5.35	5.47	445	530	532	552	-	-

*RDF: Recommended dose of 120 N, 60 P_2O_5, 60 K_2O kg ha^{-1}

Table 2. Effect of row proportion, farmyard manure and fertilizer level on yield attributes and yields of mustard in wheat + Indian mustard intercropping

Treatment	Siliquae plant^{-1}		Seed siliqua^{-1}		1000-seed weight (g)		Seed yield (kg ha^{-1})		Stover yield (kg ha^{-1})		Seed yield Index (%)	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Wheat + Mustard intercropping (Row proportion)												
8:1	389.91	413.31	12.18	12.79	3.85	4.00	647	702	2374	2552	34.00	35.60
6:2	347.46	361.36	10.44	10.65	3.29	3.36	945	978	3120	3268	49.90	49.70
8:2	350.70	364.72	10.63	10.95	3.36	3.46	851	901	2978	3119	44.90	45.80
10:2	354.00	371.70	10.73	11.16	3.45	3.59	777	867	2916	3101	41.00	44.10
SEm±	6.09	7.15	0.28	0.29	0.40	0.41	36	41	97	106	-	-
CD (P=0.05)	21.07	24.75	0.98	1.02	NS	NS	125	143	335	368	-	-
Farmyard manure and fertilizer level												
75% RDF + 15% N through FYM	348.17	364.86	10.38	10.74	2.86	2.95	677	724	2442	2664	35.69	36.74
100% RDF* + 15% N through FYM	369.48	387.14	11.55	11.96	3.79	3.91	861	926	3124	3204	45.44	47.07
75% RDF + 30% N through FYM	350.18	366.96	10.44	10.80	3.34	3.45	744	794	2523	2812	39.29	40.38
100% RDF + 30% N through FYM	374.25	392.14	11.63	12.04	3.97	4.10	938	1004	3300	3360	49.48	51.07
SEm±	5.51	6.33	0.17	0.17	0.30	0.30	27	31	68	78	-	-
CD (P=0.05)	16.09	18.47	0.49	0.51	NS	NS	78	89	200	227	-	-
Sole vs Intercrop												
Sole (Control)	400.45	428.48	15.41	16.34	4.23	4.49	1896	1969	6586	6756	100.00	100.00
Intercrop	360.52	377.77	11.00	11.39	3.49	3.60	805	862	2847	3010	42.48	43.82
SEm±	10.95	12.65	0.52	0.55	0.63	0.65	56	65	147	164	-	-
CD (P=0.05)	31.55	36.45	1.51	1.59	NS	NS	162	187	424	471	-	-

*RDF: Recommended dose of 120 N, 60 P_2O_5, 60 K_2O kg ha^{-1}, NS: Non significance

Table 3. Effect of row proportion, farmyard manure and fertilizer level on land equivalent ratio and aggressivity Index of wheat and mustard in wheat + Indian mustard intercropping

Treatment	Land equivalent ratio (LER)						Aggressivity Index			
	Wheat (Lw)		Mustard (LM)		Total (Lw+ Mw)		Wheat (Awm)		Mustard (Amw)	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Wheat + Mustard intercropping (Row proportion)										
8:1	0.908	0.927	0.340	0.356	1.25	1.28	-2.04	-2.16	2.04	2.16
6.2	0.689	0.694	0.499	0.497	1.19	1.19	-1.08	-1.06	1.08	1.06
8:2	0.752	0.757	0.449	0.458	1.20	1.21	-1.30	-1.34	1.30	1.34
10:2	0.835	0.851	0.410	0.442	1.25	1.29	-1.46	-1.63	1.46	1.63
SEm±	0.015	0.017	0.016	0.019	0.02	0.02	0.07	0.08	0.07	0.08
CD (P=0.05)	0.052	0.060	0.054	0.066	0.06	0.06	0.23	0.28	0.23	0.28
Farmyard manure and fertilizer level										
75% RDF + 15% N through FYM	0.743	0.755	0.373	0.375	1.08	1.11	-1.17	-1.23	1.17	1.23
100% RDF* + 15% N through FYM	0.854	0.858	0.468	0.471	1.29	1.31	-1.57	-1.66	1.57	1.66
75% RDF + 30% N through FYM	0.772	0.780	0.408	0.408	1.15	1.17	-1.35	-1.42	1.35	1.42
100% RDF + 30% N through FYM	0.886	0.892	0.508	0.508	1.36	1.39	-1.79	-1.89	1.79	1.89
SEm±	0.013	0.013	0.015	0.015	0.02	0.02	0.05	0.05	0.05	0.05

CD (P=0.05)	0.038	0.039	0.042	0.044	0.04	0.05	0.15	0.15	0.15	0.15

*RDF: Recommended dose of 120 N, 60 P_2O_5, 60 K_2O kg ha^{-1}

Table 4. Effect of row proportion, farmyard manure and fertilizer level on protein content (%),protein yield (kg ha^{-1}), oil content and oil yield of mustard in wheat + mustard intercropping

Treatment	Seed protein content (%)		Seed protein yield (kg ha^{-1})		Seed oil content (%)		Seed oil yield (kg ha^{-1})	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Wheat + Mustard intercropping (Row proportion)								
8:1	18.35	18.52	118.91	130.36	37.80	37.88	244.07	265.52
6:2	19.84	20.10	189.08	198.82	39.38	39.51	370.63	384.41
8:2	19.19	19.44	163.82	175.86	39.19	39.29	333.10	353.51
10:2	18.78	18.94	146.30	165.26	38.83	38.91	301.10	336.73
SEm±	0.29	0.31	9.62	9.92	0.32	0.32	14.72	15.46
CD (P=0.05)	0.99	1.07	33.27	34.34	1.09	1.10	50.94	53.51
Farmyard manure and fertilizer level								
75% RDF + 15% N through FYM	18.17	18.31	123.14	132.74	39.68	39.78	269.09	288.32
100% RDF* + 15% N through FYM	19.47	19.82	168.58	184.68	38.19	38.29	329.57	355.26
75% RDF + 30% N through FYM	18.67	18.75	139.24	149.06	39.38	39.48	293.57	313.99
100% RDF + 30% N through FYM	19.85	20.11	187.16	203.83	37.94	38.04	356.67	382.61
SEm±	0.24	0.27	6.57	7.55	0.22	0.22	10.16	11.50
CD (P=0.05)	0.69	0.80	19.16	22.03	0.63	0.63	29.66	33.56
Sole vs. Intercrop								
Sole (Control)	14.64	14.86	277.45	292.55	40.05	40.18	759.21	790.84
Intercrop	19.04	19.25	154.53	167.58	38.80	38.90	312.22	335.04
SEm±	0.48	0.54	14.15	15.71	0.52	0.56	22.09	24.33
CD (P=0.05)	1.38	1.57	40.76	45.25	1.49	1.62	63.62	70.09

Table 5. Effect of row proportion, farmyard manure and fertilizer level on economics of wheat and mustard in wheat + Indian mustard intercropping

Treatment	Cost of cultivation (x 10^3 Rs. ha^{-1})	Gross return* (x 10^3 Rs. ha^{-1})		Net return (x 10^3 Rs. ha^{-1})		B:C ratio		Monetary advantage (x 10^3 Rs. ha^{-1})	
		2010-11	2011-2012	2010-11	2011-2012	2010-11	2011-2012	2010-11	2011-2012
Wheat + Mustard intercropping (Row proportion)									
8:1	34.97	118.70	126.06	83.73	90.09	2.40	2.61	27.12	35.01
6:2	34.67	110.96	115.60	76.29	80.93	2.20	2.33	21.36	25.63
8:2	34.78	112.47	117.78	77.69	83.00	2.24	2.39	22.14	27.26
10:2	34.85	119.28	127.58	84.43	92.73	2.43	2.66	27.34	37.80
SEm±	-	19.23	23.64	13.06	15.77	0.05	0.07	-	-
CD (P=0.05)	-	66.56	81.82	45.18	54.58	0.18	0.26	-	-
Farmyard manure and fertilizer level									
75% RDF + 15 kg N through FYM	31.89	103.24	109.43	71.35	77.54	2.24	2.43	8.69	12.92
100% RDF* + 15 kg N through FYM	33.74	121.50	127.88	87.76	94.14	2.60	2.79	32.15	40.22
75% RDF + 30 kg N through FYM	35.89	108.71	115.04	72.81	79.14	2.03	2.20	15.51	20.55
100% RDF + 30 kg N through FYM	33.74	127.95	134.68	90.21	96.94	2.39	2.57	41.59	52.00
SEm±	-	18.54	22.82	12.90	14.92	0.05	0.06	-	-
CD (P=0.05)	-	54.10	66.61	37.66	43.56	0.14	0.15	-	-
Sole									
Wheat	27.36	97.44	101.03	69.18	72.77	2.45	2.58	-	-
Mustard	23.60	85.71	88.88	61.37	64.55	2.52	2.65	-	-
SEm±	-	36.21	44.57	25.17	29.32	0.10	0.13	-	-
CD (P=0.05)	-	104.31	128.40	72.49	84.45	0.28	0.38	-	-

*Selling price of wheat grain: Rs.14.00 kg^{-1}, Selling price of wheat straw: Rs. 4.5/kg, Selling price of mustard seed: Rs. 40.00 kg^{-1} and stover: Rs. 1.50 kg^{-1}

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