Indian Journal of Agronomy **61** (4): 460–466 (December 2016)

Research Paper

Production potential and competitive ability of wheat (*Triticum aestivum*) + Indian mustard (*Brassica juncea*) intercropping under varying row ratio, farmyard manure and fertilizer level of middle Gangetic Plain of India

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Received : March 2016; Revised accepted : December 2016

ABSTRACT

A field experiment was conducted during the winter season of 2010–11 and 2011–12 at the research farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, to evaluate the production potential and competitive ability of wheat [*Triticum aestivum* (L.) emend Fiori & Paol.] + Indian mustard [*Brassica juncea* (L.) Czernj. & Cosson] intercropping under different row ratios and fertility levels of Middle Gangetic Plains of India. Among the row proportions, 8:1 row proportion recorded significantly higher yield parameters (grains/spike, spikelets/spike, 1,000-grain weight and yield as well as straw yield in wheat, and number of siliqua/plant and seeds/siliqua of Indian mustard). However, seed and stover yields of Indian mustard was higher in 6 : 2 row ratio which was at par with 8 : 2 and 10 : 2 raw ratios. Significantly higher land-equivalent ratio, aggressivity index and economics were registered with row ratio of 8:1 over 10:2, 8:2, and 6:2. An application of 15% or 30% N through farmyard manure (FYM) + 100% recommended dose of fertilizer (RDF) significantly enhanced yield attributes and yield of wheat and Indian mustard. However, benefit: cost ratio was higher with application 15 % N FYM + 100% RDF.

Key words **:** Competitive indices, Economics, Fertility, Intercropping, Mustard, Row ratio, Wheat

Intercropping is an advanced agro-technique and is considered to be an effective and potential means of increasing crop productivity, 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 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 with Indian mustard 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, increased water and nutrient efficiency. It is also known to intercept more solar energy and give comparatively higher yield stability and insurance during aberrant weather conditions than sole crops (Willey, 1979; Sinha *et al*., 1985; Mandal and Mahapatra, 1990).

Intercropping of wheat with Indian mustard is ecologically suitable, economically viable, operationally feasible and socially acceptable cropping system during the 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 demands for edible oil. This is attributed to improvement in standard of living with better purchasing power of people because of better economic growth as well as the high growth rate of Indian population. Mixed cropping of Indian mustard with wheat is very common in eastern Uttar Pradesh which is one of the ma-

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jor causes of low productivity of Indian mustard in the region. The reason might be use of improper proportion of the component crops.

In intercropping system, the competition between main and subsidiary crops depends 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 + Indian mustard intercropping, the competition offered by Indian mustard is much higher than wheat. However, it can be altered to some extent by modification of row proportion for higher yield advantages and also by proper nutrient management (Verma *et al.*, 1997; Srivastava and Bohra, 2006). Realizing the importance of these facts, the present investigation were therefore, conducted to assess production potential and competitive interaction of wheat + Indian mustard intercropping with under different row ratios and fertility levels of Middle Gangetic Plain of India.

METHODS AND MATERIALS

The experiment was conducted during the winter (*rabi*) season of 2010–11 and 2011–12 at the Agricultural Research Farm, Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (25° 18' N and 83° 03' E, 128.93 m above mean sea-level), Uttar Pradesh. The soil was sandy clay loam (Order Inceptisol, Type Ustochrept). The *p*H of soil was 7.12, with low organic carbon 0.40% and available N, P and K 181.5, 18.32, and 208.43 kg/ha respectively. The experiment was laid out in a split-plot design, comprising 4 ratios (10 : 2, 8 : 2, 8 : 1 and 6 : 2) of wheat + Indian mustard intercropping in replacement series. Each main plot was divided into 4 sub-plots with 2 doses each of farmyard manure (15% N and 30% N) and fertilizer doses (75%, 100% recommended N, P and K to wheat and Indian mustard crop). The sole Indian mustard (cv. 'Vardan') was sown at a recommended seed rate of 4 kg/ha. The recommended N, P and K dose to wheat and Indian mustard were 120 N, 60 P_2O_5 and 60 K_2O kg/ha respectively. Two separate plots of sole wheat and sole Indian mustard were also raised for the estimation of sole crop yield indices. Accordingly, 16 treatment combinations were formed along with 2 sole crops of wheat and Indian mustard. Fertilizer application to the pure crops of wheat and Indian mustard was done at 100% of their recommended dose. However, full doses of $P_,$ K along with 50% N were applied as basal to wheat and Indian mustard in sole as well as to intercrop. However, in wheat crop, remaining N was applied in 2 equal splits at crown-root initiation and maximum tillering stages. Fertilizers used were urea, single superphosphate (SSP), muriate of potash (MoP). The crops were sown in the last week of November during both the years with 120 and 4 kg seed/ha for 'HUW 234' wheat and 'Vardan' Indian mustard respectively. The experimental plot size was 22.95 m^2, being 7.65 m in length and 3.0 m in width. Weekly weather data were recorded at the experimental site from the meteorological observatory, Department of Agronomy, Institute of Agricultural Sciences.

Yield parameters like number of spike-bearing tillers was counted at maturity from randomly selected 0.25 m row length at 5 locations in net plot area. Length of 10 randomly selected spikes in each sample plants of running 0.25 m was measured with scale from the neck node to the tip of the spike. Finally, the average value of spike length was computed in centimeter. Ten spikes selected randomly for the measurement of spike length at 5 places in each plot were counted for number of spikelet present in each spike and the mean was computed. In Indian mustard, siliqua/plant were determined by counting the total number of siliqua on 5 tagged plants and averaging them. Seeds/siliqua were counted from 10 random 5 selected plants. One thousand seeds were counted and dried and then weight was recorded treatment-wise in g. The seed yield of net plot after cleaning and proper drying was recorded in g and converted to kg/ha by multiplying with appropriate conversion factor. After threshing, stem and chaff weight per plot were recorded and added treatment-wise and converted to kg/ha. 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.

Cost of cultivation, gross and net returns under different treatments were worked out on the basis of prevailing cost of different inputs. Power and labour for different operations, i.e. ploughing, harvesting, sowing, weeding, plant protection, harvesting and threshing were calculated per hectare basis as per normal rates prevalent at the Agricultural Research Farm, BHU, and Varanasi. The cost of fertilizers, plant-protection chemicals and seeds etc. were taken from the market rates. Net return (₹/ha) and benefit: cost ratio were calculated.

Land equivalent ratio (LER) and aggressivity index were also calculated for assessing the yield advantage and competition systems

The data pertaining to each of the characters of the experimental crops were tabulated and finally analyzed statistically. 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 $P \geq 0.05$.

RESULTS AND DISCUSSION

Effect of weather

The meteorological data showed marked variation in weather conditions during both the years. Precipitation recorded during crop-growing season was 22.1 and 46.2 mm in 2010–11 and 2011–12 respectively. Consequently during the first year of experimentation, amount of precipitation was distributed unequally and fluctuated variably high during crop-growing period as compared to the second year where the equally distribution of precipitation was occurred. Similarly, the average temperature during February and March, coinciding with the reproductive stages of the component crops, remained milder during the second year than the first. During the first year, an average evapotranspiration was higher than second year. This resulted in a slightly better performance of the crops during 2011–12 than during 2010–2011.

Yield attributes and yields of component crops

Grains/spike, spikelets/spike and 1,000-grain weight in wheat + Indian mustard intercropping system were found significantly lower than sole stand of wheat (Table 1). The significantly higher (grains/spike, spikelets/spike and 1,000-grain weight, grain yield and straw yield of wheat, and **s**iliquae/plant, seed/siliqua, 1,000-grain weight of Indian mustard in wheat + Indian mustard intercropping were recorded at 8:1 row ratio, which was followed by 10:2, 8:2 and 6:2 row ratios except Indian mustard seed yield and stover yield were maximum in 6:2 row ratio and remained at par with 8 : 2 row ratio. 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 support the finds of Sharma *et al*. (1986); Singh *et al*. (1995) and Srivastava *et al*. (2006).

The fertility doses from 15% N by FYM + 75% RDF to 30% N by FYM + 100% RDF applied to wheat and Indian mustard correspondingly (wheat, viz. grains/spike, spikelets/spike and 1,000-grain weight, grain yield and straw yield and mustard, viz. siliquae/plant, seeds/siliqua, 1,000-grain weight, seed yield and stover yield) of wheat and mustard intercropping. Among the fertility doses, (grains/spike, spikelets/spike and 1,000-grain weight, grain yield and straw yield of wheat siliquae/plant, seeds/siliqua, 1,000-grain weight, seed yield and stover yield of Indian mustard were significantly higher at 30% N by FYM + 100% RDF than the other treatments, except

Table 1. Effect of row ratio and fertility levels on yield attributes and grain and straw yields of wheat in wheat + Indian mustard intercropping

Treatment	Grain/spike		Spikelets/spike		1,000-seed weight (g)		Grain yield (kg/ha)		Straw yield (kg/ha)		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
Row ratio (Wheat: Indian mustard)												
8 : 1	43.78	46.41	16.64	16.69	42.11	43.12	4,174	4,358	5,227	5,627	92.8	94.7
6 : 2	34.91	35.95	14.08	14.11	36.77	37.50	3,165	3,265	4,105	4,405	70.4	70.9
8 : 2	37.43	38.93	14.91	14.94	38.51	39.32	3,457	3,557	4,334	4,634	76.9	77.3
10 : 2	39.80	41.79	15.73	15.77	39.93	40.85	3,838	3,938	4,958	5,258	85.3	85.5
SEm±	0.63	0.70	0.23	0.24	0.39	0.40	66	64	74	73	-	-
CD (P=0.05)	2.18	2.42	0.81	0.82	1.36	1.39	228	222	255	252	-	-
Fertility level												
15% N by FYM + 75% RDF	36.79	38.48	14.06	14.10	35.94	36.74	3,338	3,474	4,340	4,665	74.2	75.4
15% N by FYM + 100% RDF	40.26	42.11	16.50	16.53	42.14	43.06	3,841	3,948	4,810	5,135	85.4	85.7
30% N by FYM + 75% RDF	37.79	39.53	14.14	14.17	36.24	37.04	3,471	3,591	4,471	4,796	77.2	78.0
30% N by FYM + 100% RDF	41.07	42.96	16.66	16.70	43.00	43.95	3,983	4,106	5,003	5,328	88.6	89.2
SEm±	0.56	0.59	0.16	0.16	0.38	0.39	59	58	57	67	-	-
CD (P=0.05)	1.63	1.71	0.47	0.48	1.12	1.14	172	170	166	196	-	-
Sole vs. intercrop												
Sole (Control)	49.07	52.50	26.60	26.68	41.23	42.22	4,495	4,602	5,671	5,971	100.0	100.0
Intercrop	38.98	40.77	15.34	15.38	39.33	40.20	3,658	3,780	4,656	4,981	81.3	82.1
SEm±	1.15	1.23	0.61	0.62	1.86	1.90	117	115	121	137	-	-
CD (P=0.05)	3.32	3.54	1.77	1.78	5.35	5.47	337	332	348	393	-	-

RDF, Recommended dose of fertilizer (120 N; 60 P_2O_5; 60 K_2O kg/ha); NS, Non-significant treatment 15% N by FYM + 100% RDF which was at par during both the years.

Examination of the data indicated the adverse effect of Indian mustard on wheat under the different row combinations. Grain-yield index increased with the increasing wheat proportion. On the contrary, the lowest grain-yield index was recorded at the highest Indian mustard proportion on area basis when 2 rows of Indian mustard was sown after every 6 rows of wheat. In the intercropping, the area under wheat reduced by 25, 20, 18 and 16% respectively, in 6 : 2, 10 : 2, 8 : 2 and 8 : 1 row ratios. The corresponding yield reduction in wheat yield on per cent wheat grain-yield index basis was noted 92.85, 85.37, 76.91 and 70.40 during the first year and 94.71, 85.54, 77.31 and 70.94 during the second years respectively. In mustard crop, seed-yield index decreased with every increase in proportion of wheat rows. Accordingly, the seed yield index was maximum with 6 rows of Indian mustard alternated with 2 rows of Indian mustard. Indian Mustard replaced 11.12, 16.67, 20 and 25% area of wheat in 8:1, 10:2, 8:2, and 6:2 row ratio respectively, with corresponding seed yield of 35.73, 42.55, 46.33 and 51.22% during the first years and 37.16, 43.49, 45.12 and 50.38% during the second year, respectively, in comparison to sole stand. It shows that the seed yield of Indian mustard was proportionately higher than area replaced. Application of fertilizer doses from 15% N by FYM + 75% RDF to 30% N by FYM + 100% RDF applied to wheat correspondingly increased grain-yield index of wheat during both the years. In fertilizer doses, grain-yield index was significantly highest at 30% N by FYM + 100% RDF which was at par with 15% N by FYM + 100% RDF during both the years. However, the lowest grain-yield index was observed in 15% N by FYM + 75% RDF and 30% N by FYM + 75% RDF. Our results confirm those of Srivastava and Bohra (2006).

Yield advantage and competitive indices

While comparing the different intercrop combinations, corresponding decrease in wheat LER was noted due to reducing wheat proportion in varying wheat + Indian mustard row ratio. Accordingly, maximum LER_{wheat} was observed under 8 : 1 row ratio, which proved significantly superior to 10 : 2, 8 : 2 and 6 : 2 row combinations. Similarly, row ratio of 10 : 2 (wheat + In-

Table 2. Effect of row ratio and fertility levels on yield attributes yields and stover of mustard in wheat + Indian mustard intercropping

Treatment	Siliquae/plant		Seeds/siliquae		1,000-seed weight (g)		Seed yield (kg/ha)		Stover yield (kg/ha)		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
Row ratio (Wheat: Indian mustard)												
8 : 1	389.9	413.3	12.1	12.7	3.85	4.00	697	783	2,966	3,152	35.7	37.1
6 : 2	347.4	361.3	10.4	10.6	3.29	3.36	995	1,062	3,620	3,868	51.2	50.3
8 : 2	350.7	364.7	10.6	10.9	3.36	3.46	901	951	3,478	3,719	46.3	45.1
10 : 2	354.0	371.7	10.7	11.1	3.45	3.59	826	908	3,316	3,668	42.5	43.4
SEm±	6.0	7.1	0.2	0.2	0.40	0.41	34	34	93	97	-	-
CD (P=0.05)	21.0	24.7	0.9	1.0	NS*	NS	119	117	323	335	-	-
Fertility level (F)												
15% N by FYM + 75% RDF	348.1	364.8	10.3	10.7	2.86	2.95	727	788	2,933	3,256	37.3	37.4
15% N by FYM + 100% RDF	369.4	387.1	11.5	11.9	3.79	3.91	911	992	3,624	3,796	46.8	47.0
30% N by FYM + 75% RDF	350.1	366.9	10.4	10.8	3.34	3.45	794	861	3,023	3,403	40.8	40.8
30% N by FYM + 100% RDF	374.2	392.1	11.6	12.0	3.97	4.10	988	1,062	3,800	3,952	50.7	50.8
SEm±	5.5	6.3	0.1	0.1	0.30	0.30	30	30	61	70	-	-
CD (P=0.05)	16.0	18.4	0.4	0.5	NS	NS	87	88	177	203	-	-
Sole vs. intercrop												
Sole (Control)	400.4	428.4	15.4	16.3	4.23	4.49	1,946	2,108	7,086	7,356	100	100
Intercrop	360.5	377.7	11.0	11.3	3.49	3.60	855	926	3,445	3,602	43.9	44.0
SEm±	10.9	12.6	0.5	0.5	0.63	0.65	61	60	134	147	-	-
CD (P=0.05)	31.5	36.4	1.5	1.5	NS	NS	175	174	387	423	-	-

RDF, Recommended dose of fertilizer (120 N; 60 P_2O_5; 60 K_2O kg/ha); NS, Non-significant dian mustard) produced significantly higher wheat LER over 8:2 and 6:2 row ratio. This trend was common during both the years. In spite of that the reverse trend was observed in mustard crop. However, wheat + Indian mustard intercropping produced marked variation on total LER during both the years. Row ratios of 8 : 1 and 10 : 2 though remained statistically at par, they recorded significantly higher LER than 8 : 2 and 6 : 2 row ratios of wheat + Indian mustard intercropping. This might be due to efficient effect of light, moisture and nutrients, besides reduced competition from taller component (Indian mustard) on shorter component (wheat). Singh and Gupta (1994), Singh and Bohra (2012) and Singh *et al*. (2014) also reported higher yield advantage under wider row ratios of 8 : 1 and 10 : 2 in wheat + Indian mustard intercropping.

Increase in fertility levels from lower to higher markedly enhanced the partial LER_{wheat} and partial $LER_{mustard}$ during both the years. The maximum partial LER_{wheat} and partial $LER_{mustard}$ were recorded with the highest levels of fertility (30% FYM with 100% RDF) which was at par with (15% FYM with 100% RDF). However, the lowest was recorded in (15% FYM with 75% RDF). The maximum total LER were recorded with highest levels of fertility (30% FYM with 100% RDF) over other fertility doses.

The aggressive nature of Indian mustard, made it more competitive than wheat. The aggressivity of Indian mustard was maximum at 8:1 row ratio of wheat + Indian mustard intercropping, followed by 10 : 2, 8 : 2 and 6 : 2 row ratios.

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 Indian mustard uptake quickly in compression to wheat. The maximum total LER was observed at highest fertility levels (30% N by FYM + 100% RDF), followed by (15% N by FYM + 100% RDF). These results are in agreement with the findings of Srivastava *et al*. (2007).

Oil content and oil yield

Lucid effect of row ratio was noticed on seed oil content and oil yield of Indian mustard (Fig. 1). Increasing proportion of wheat to mustard rows from 6 : 2, 8 : 2, 10 : 2 and 8 : 1 resulted in concomitant decline in seed oil percentage and the differences among 6 : 2, 10 : 2 and 8 : 1 row ratio was significant. The increased seed yield of Indian mustard from narrow to wider row ratios of wheat and Indian mustard (Table 2) might have resulted in dilution of seed oil content. Singh and Gupta (1994) also reported enhanced seed oil content at narrow row ratio. This accompanied with 11.12, 16.67, 20 and 25% Indian mustard population respectively in 8 : 1, 10 : 2, 8 : 2 and 6 : 2 row ratio of wheat and Indian mustard, resulted in oil yield in the order 6 : 2 > 8 : 2 >10 : 2 >8 : 1, the differences being significant among three row ratio.

In fertility doses, oil per cent in Indian mustard seeds tend to decrease with the increase in level of fertility up to 30% N by FYM + 100% RDF (Fig. 1). The reduction in oil is due to higher rate of nitrogen appears to be due to

Table 3. Effect of row ratio and fertility levels on land-equivalent ratio and aggressivity index of wheat and Indian mustard in wheat + Indian mustard intercropping

Treatment	Land-equivalent ratio (LER)						Aggressivity index			
	Wheat (Lw)		Mustard (Lm)		Total (Lw+ Lm)		Wheat (Awm)		Indian mustard (Amw)	
	2010–11	2011–12	2010–11	2011–12	2010–11	2011–12	2010–11	2011–12	2010–11	2011–12
Row ratio (Wheat: Indian mustard)										
8 : 1	0.928	0.947	0.357	0.372	1.29	1.32	-2.17	-2.28	2.17	2.28
6 : 2	0.704	0.709	0.512	0.504	1.21	1.21	-1.11	-1.07	1.11	1.07
8 : 2	0.769	0.773	0.463	0.451	1.23	1.22	-1.35	-1.29	1.35	1.29
10 : 2	0.854	0.855	0.426	0.435	1.29	1.29	-1.53	-1.58	1.53	1.58
SEm±	0.015	0.015	0.018	0.018	0.02	0.02	0.13	0.14	0.13	0.14
CD (P=0.05)	0.051	0.053	0.064	0.062	0.06	0.06	0.46	0.49	0.46	0.49
Fertility level										
15% N by FYM + 75% RDF	0.743	0.755	0.373	0.375	1.12	1.13	-1.25	-1.26	1.25	1.26
15% N by FYM + 100% RDF	0.854	0.858	0.468	0.471	1.32	1.33	-1.63	-1.66	1.63	1.66
30% N by FYM + 75% RDF	0.772	0.780	0.408	0.408	1.18	1.19	-1.43	-1.44	1.43	1.44
30% N by FYM + 100% RDF	0.886	0.892	0.508	0.508	1.39	1.40	-1.85	-1.87	1.85	1.87
SEm±	0.013	0.013	0.015	0.015	0.02	0.02	0.07	0.08	0.07	0.08
CD (P=0.05)	0.038	0.039	0.042	0.044	0.04	0.05	0.21	0.23	0.21	0.23

RDF, Recommended dose of Fertilizer 120 N; 60 P_2O_5; 60 K_2O kg/ha; NS, Non-significance

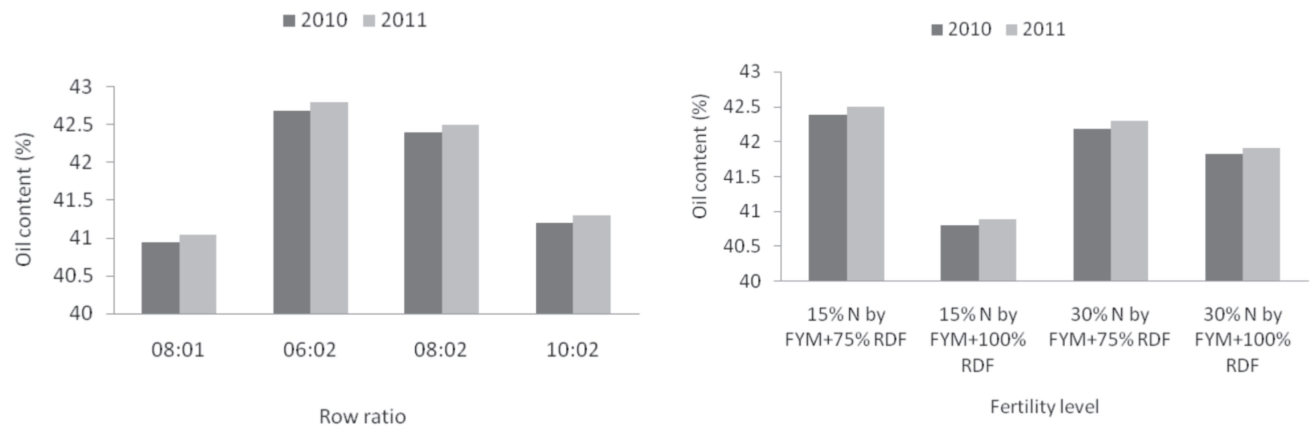

Fig. 1. Effect of row ratio (left) and fertility levels (right) on oil content (%) of Indian mustard in wheat + Indian mustard intercropping

conversion of carbohydrates into protein. Maximum oil content was recorded in with 15% N by FYM + 75% RDF which was at par with 30% N by FYM + 75% RDF. However, the reverse trend was observed in oil yield. This could be attributed to the highest seed yield obtained under the highest fertility levels, which decreased markedly with every curtailment in fertility levels (Fig. 1). Singh (1983) and Tomer *et al*. (1996) also obtained higher oil yield with increasing levels of fertility.

Economics

In general intercropping of wheat and Indian mustard in 8 : 1 and 10 : 2 row ratios was found more remunerative than growing either of the component crops in pure stand as well as wheat + Indian mustard in 6 : 2 row ratio. Among the 4 row ratios in wheat + Indian mustard intercropping, 8 : 1 row ratio recorded the highest gross return and net return, benefit: cost crop productivity and crop profitability closely by 10 : 2 row ratio and both proved remunerative over 8 : 2 and 6 : 2 row ratio during both the years. Nevertheless, the lower yield remained associated with 6:2 row proportion followed by 10 : 2, 8 : 2 and 8 : 1 row ratios. Increase in fertility from lower to higher level markedly increased the net return (₹/ha), crop productivity and crop profitability but decreased the benefit: cost ratio and due to increased cost of cultivation. Accordingly,

Table 4. Effect of row ratio and fertility levels on economics of wheat and mustard in wheat + Indian mustard intercropping

Treatment	Cost of cultivation ($\times$₹10^3/ha)	Gross returns ($\times$₹10^3/ha)		Net returns ($\times$₹10^3/ha)		Benefit: cost ratio		Crop productivity (kg/ha/day)		Crop profitability (₹/ha/day)	
		2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Row ratio (Wheat: Indian mustard)											
8 : 1	27.44	95.13	102.74	67.70	75.31	2.48	2.76	53.09	56.44	589	655
6 : 2	27.14	89.07	94.57	61.93	67.43	2.28	2.49	51.52	53.53	539	586
8 : 2	27.25	90.23	95.27	62.98	68.03	2.32	2.51	51.78	53.45	548	592
10 : 2	27.32	94.72	101.22	67.40	73.90	2.48	2.72	53.30	55.95	586	643
Fertility level											
15% N by FYM + 75% RDF	24.60	82.82	88.82	58.23	64.22	2.37	2.61	46.56	48.87	506	558
15% N by FYM + 100% RDF	25.97	97.12	103.28	71.14	77.31	2.74	2.98	55.36	57.83	619	672
30% N by FYM + 75% RDF	28.60	87.06	93.16	58.47	64.56	2.04	2.26	49.33	51.61	508	561
30% N by FYM + 100% RDF	29.97	102.19	108.54	72.18	78.57	2.41	2.62	58.44	61.05	628	683
Sole crop											
Wheat	22.36	74.65	78.42	52.29	50.00	2.34	2.51	39.09	40.02	682	455
Indian mustard	19.97	69.97	75.32	56.05	55.35	2.50	2.77	52.19	54.82	655	487

Selling price of wheat, ₹11/kg in 2011 and ₹11.20/kg in 2012; selling price of wheat straw ₹4.5/kg in 2010 and 2011; commercial price of Indian mustard ₹30.50/kg and stover ₹1.50/kg
RDF, Recommended dose of fertilizer

application of 30 % N by FYM + 100 % RDF resulted significantly higher gross returns, net returns and also increased cost of cultivation. However, benefit: cost ratio was highest with 15% N by FYM + 100% RDF significantly.

Thus to achieve higher yield advantage and efficient resources utilization in wheat + Indian mustard intercropping, 8 rows of wheat be taken after every 1 row of Indian mustard and the component crops be fertilized with 15% N by FYM + 100% recommended fertilizer dose.

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