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Potential yield gap and agro-economic feasibility of frontline demonstration on mustard (*Brassica juncea*) in Rajasthan

D.S. Meena*, J.P. Tetarwal and Baldev Ram

Agricultural Research Station, Maharana Pratap University of Agriculture and Technology, Udaipur, Ummedganj, Kota-324 001 (Rajasthan)
**e-mail: dsmeena1967@gmail.com*

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Abstract

Frontline demonstrations of mustard were organized from 2005-06 to 2010-11 in the Rajasthan to demonstrate the impact of improved production technologies. The selection of farmers was done on the basis of Participatory Rural Appraisal (PRA) action plan. The results indicated that 18.89% yield and 21.91% net return can be obtained by adoption of improved production technology over farmers' practices. The main yield attributing factors were; recommended high yielding varieties, plant geometry, fertilizer application, weed management, plant protection measures and irrigation scheduling responsible for higher yield. Path coefficient showed that above six factors are directly responsible for increasing the yield while factors like poor soil fertility levels, damage by stray cattle and poor technical knowledge are for low yield. Hence' the farmers of the area are advised to adapt the improved technology for higher return and boost up the productivity of mustard in Rajasthan.

Key words: Improved technology, farmer's practices, yield gap, benefit: cost ratio, correlation coefficients, path coefficient.

Mustard is a major *rabi* oilseed crop of the country cultivated in 6.3 million hectares with 7.2 million tonnes production and 1143 kg/ha productivity (2008-09). Rajasthan state contributed major part of 2.83 million hectares with 3.50 million tonnes production and 1234 kg/ha productivity (2008-09), thus it has major share in area (46%) and production (49%) of rapeseed mustard in India. (Anonymous 2009-10).

The productivity of mustard in Rajasthan is far below the national average productivity and there is huge horizontal gap between nation and state. Gap between the state average productivity and potential is very high owing to technology adoption and inputs. Therefore, bridging the existing yield gaps by making adequate availability of quality seeds and other technical inputs to farmers would be the first and foremost requirement for improvement of crop productivity. Crop specific and zone specific strategies should be adopted at farmer level to derive maximum benefit. The major thrust will be given to increase seed replacement rate (SRR) and use of full package of practices *viz.*, recommended dose of fertilizer along with sulphur, biofertilizers like *Rhizobium* culture and PSB, weed management and IPM technologies.

Due to lack of suitable high yielding varieties, improved production technology as well as poor knowledge of package of practices is ascribed as main reasons for low productivity of mustard. The productivity of mustard per unit area could be increased by adopting improved variety and improved production technology. Keeping view of above facts, frontline demonstrations were carried out at farmers' field under real farm situations to show the worth of a improved variety with full package of practices and convincing farmers to adopt improved production technology of mustard for enhancing productivity of mustard.

Materials and Methods

Frontline demonstrations (125) were organized on farmer's field to demonstrate the impact of research emanated production technology on mustard productivity over six years during *rabi* 2005-06 to 2010-11. The selection of cultivators was done on the basis of Participator Rural Appraisal (PRA) action plan and care has been taken to layout the demonstrations on road side to popularize the improved technology. Each frontline demonstration was laid out on 0.4 ha area, adjacent 0.4 ha was considered as control for comparison (farmer's practice). The improved package of practices included short/medium duration improved varieties (Jagannath, Bio-902, Laxmi, Vasundhara, NRCDR-2 & RGN-73), seed treatment with fungicides (2.0 g mancozeb or 3 g thiram/kg seed and Apron 35 SD 6 g/kg seed for white rust) and inoculated with bio-fertilizers (*Azotobacter* and phosphorus solubilizing bacteria culture), recommended dose of fertilizer (80 kg N, 40 kg P & 60 kg S/ha), weed management (fluchlorolin @ 1.0 l/ha) and insect-pest management (Endosulphan 4 % dust 7-10 days after germination followed by one spray of diamethoate 30 EC, 875 ml/ha and one spray of acephate 75 SP @ 700g/ha) at 20-25 days after sowing. Half dose of nitrogen and full dose phosphorus and potash were applied as basal and rest of the half nitrogen was applied at the time of irrigation.

The performance of mustard under these demonstrations using scientific interventions *viz*.; optimum seed rate 4.0 kg/ha, crop geometry (30 × 10 cm), recommended dose of fertilizer (80 kg N + 40 kg P_2O_5/ha) were compared with the farmer's practice which included 6 kg own seed/ha without seed treatment, 100 kg N + 40 kg P_2O_5/ha. Maximum demonstrations were sown in the first fortnight of October.

The extent of per cent yield gap was computed using the formula described by Patil *et al*. (1986). Based on per cent yield gap (minimum 10 per cent and above) the farmers were grouped into four categories viz. large yield gap (yield gap > 25 %), medium yield gap (yield gap between 20 to 25 %), small yield gap (yield gap up to 15 to 20 %) and very small yield gap (yield gap less than 10 to 15 % and no or very less yield gap (less than 10 %) to frontline demonstration (FLD) plots. The yield difference between demonstration and farmers was treated as the yield gap. The statistical analysis was used to compute the role of factors determining yield gap while, the cost concept was used in the crop production to work out various cost components. The results were analysed economically in terms of B: C ratio and net returns.

Constraints in mustard production were identified through participatory approach. Preferential ranking technique was utilized to identify the constraints faced by the respondent farmers in mustard production. The quantification of data was done by first ranking the constraints and then calculating the rank based quotient (RBQ) as given by Sabarathnam (1988), which is as follows:

$$RBQ = \frac{\Sigma \text{ fi } (n+l-i)}{N \times n} \times 100$$

where

fi= Number of farmers reporting a particular problem under i^{th} rank
N= Number of farmers
n= number of problems identified

The same per cent values were subjected to correlation coefficient and path coefficient as used in breeding programme.

The correlation coefficients of yield with all other characters and among themselves were computed in the formulae suggested by Fisher (1936) and Al-Jibouri *et al*. (1958) used for the analysis in breeding experiments.

Path coefficient were calculated by using the methodology by Wright (1921), Li (1955), and Dewey and Lu (1959) to asses the direct and indirect effects of nine variables on yield .The characters used for computing path coefficient analysis for yield were suitable HYV, poor soil fertility levels, plant geometry, fertilizer application, weed management, damage by stray cattle, IPM, irrigation and poor technical knowledge.

Results and Discussion

The results indicated that imparted technology could lead to average seed yield levels in the range of 1712 to 2092 kg/ha as compared to 1448 to 1803 kg/ha under farmers practice. The highest level of yield in these demonstrations was in the range of 1765 to 3000 kg/ha. Average yield of 125 demonstrations worked out to 1900 kg/ha from improved technology where as the average yield obtained in case of farmers practice was 1598 kg/ha. This reveals that the adoption of improved production technology of mustard cultivation is capable to enhance the productivity by 18.89 percent over farmers practice. Bhatnagar (2001) reported that the research emanated production technologies are capable in increasing production of soybean by 32-26 percent through frontline demonstration on farmer's field. Similarly, Dhaka *et al*. (2010) observed 26.7 percent increase in yield over local check in case of maize. Similar yield enhancement in different crops in frontline demonstration has amply been documented by Mishra *et al.* (2009).

Among mustard varieties (Table 1), variety Pusa Jagannath gave the highest (3000 kg/ha) yield in the year 2006-07. The next best was Laxmi (2625 kg/ha) in the same year followed by Bio-902 (2470 kg/ha) in the year 2005-06, Pusa Jagannath (2284 kg/ha) in the year 2005-06, Vasundhara (2125 kg/ha) in the year 2006-07 and again Bio-902 (2040 kg/ha) in the year 2009-10 and 2010-11 and thus recorded 18.00, 15.81, 19.90, 10.70, 14.07, 26.44 and 24.00 per cent higher seed yield under recommended package of practices over local varieties with farmer's practice, respectively. The performances of improved varieties were found better than the local checks.

There has been year to year variation in average yield of mustard which varied from 1712-2092 kg/ha in case of improved practices and 1448-1803 kg/ha in farmers practices (Table 1). It could partly be accounted by the interaction between low temperature and nature of mustard varieties. A medium maturity variety in 2008-09, then the minimum temperature was -5^{0}C must have caused cold injury in the season must have suppressed the performance of the variety.

The data indicated that (Table 2) seed yield of 1991, 1996, 1868, 1779, 1874 and 1903 kg/ha could be obtained with improved technology as compared to 1729, 1730, 1534, 1497, 1489 and 1592 kg/ha with farmer's practices in respective years. Thus in comparison to farmer's practices, there was an increase of 15.30, 15.96, 21.87, 18.95, 25.87 and 20.00 per cent in productivity from the demonstrations plots during *Rabi* 2005-06, 2006-07, 2007-08, 2008-09, 2009-10 and 2010-11, respectively. The higher yield of mustard could be attributed due to adoption of high yielding improved varieties, line sowing with 30 cm row spacing, weed management and plant protection measures. These results are supported by Ali and Singh (2002) in soybean, Dubey and Ali (1999) in Linseed and Dhaka *et al.* (2010) in Maize.

The economic evaluation, made on the basis of prevailing market rates (Table 3) showed that the demonstrations gave higher net return of Rs. 24,283, 24,082, 20,738, 18,413, 23,874 and 32,419 per ha in improved technology as compared to Rs. 20,996, 19,782, 16,644, 14,983, 18,753 and 26,801 per ha under farmer's practice in the corresponding seasons. There was an additional increase of Rs. 3287 in *rabi* 2005-06, Rs. 4,300 in 2006-07, Rs. 6,006 in 2007-08, Rs. 5,076 in 2008-09, Rs. 7,713 in 2009-10 and Rs. 7,476 per ha in 2010-11 with respective incremental benefit: cost ratio of 3.79, 4.28, 3.14, 3.10, 2.97 and 3.48 respectively.

Thus on the basis of average of six years (Table 4), the per hectare gross return of Rs. 36,213 were obtained in demonstration plots while Rs. 30,323 in farmers practice resulting in additional return of Rs. 5,890 against the additional cost Rs. 1,582. The average net return of Rs. 23,968 was obtained in demonstrations which were 21.91 per cent higher than farmers practice (Rs. 19,660).The B: C ratio of improved technologies (2.51) was higher over farmer's practice (2.37).

Table. 1. Performance of improved mustard varieties against local varieties on farmer's field

Years	Varieties	No. of Demon-strations	Seed yield (kg/ha)			Additional yield over farmer's practice (kg/ha)	Increase in yield over farmer's practice (%)
			Improved technology		Farmer's practice (Adverage)		
			Maximum	Average			
2005-06	Bio-902	10	2470	1985	1655	330	19.90
	Pusa Jagannath	5	2284	1996	1803	193	10.70
2006-07	Vasundhara	11	2125	1825	1602	223	14.07
	Laxmi Pusa	9	2625	2072	1800	272	15.81
	Pusa Jagannath	10	3000	2092	1787	305	18.00
2007-08	Vasundhara	10	1950	1900	1558	342	22.00
	Pusa Jagnnath	10	2000	1836	1510	326	21.70
2008-09	NRCDR-2	6	2000	1858	1553	305	19.61
	RGN-73	5	1765	1712	1448	264	18.63
	Bio-902	9	1890	1767	1490	277	18.61
2009-10	Vasundhara	10	2025	1868	1490	378	25.30
	Bio-902	10	2040	1880	1487	393	26.44
2010-11	Bio-902	20	2040	1903	1592	311	24.00
Mean		125		1900	1598		18.89

Table. 2. Yield of mustard in improved and farmers' practices through frontline demonstration under real farm situation

Years	No. of demonstrations	Seed yield (kg/ha)		Increase in seed yield over check (%)
		Improved technology Mean	Farmer's practice Mean	
2005-06	15	1991	1729	15.30
2006-07	30	1996	1730	15.96
2007-08	20	1868	1534	21.87
2008-09	20	1779	1497	18.95
2009-10	20	1874	1489	25.87
2010-11	20	1903	1592	20.00

Table. 3. Cost and return of front line demonstrations of mustard

Year	Cost of cultivation (Rs./ha)		Net returns (Rs./ha)		Additional cost of cultivation (Rs/ha)	Additional net returns (Rs./ha)	Incremental benefit: cost ratio
	IT*	FP**	IT*	FP**			
2005-06	9,960	8,745	24,283	20,996	1,214	3,287	2.71
2006-07	10,127	9,059	24,082	19,782	1,068	4,568	4.28
2007-08	12,883	10,972	20,738	16,644	1,911	6,006	3.14
2008-09	13,631	11,985	18,413	14,983	1,646	5,076	3.10
2009-10	13,614	11,022	23,874	18,753	2,592	7,713	2.97
2010-11	13,253	11,396	32,419	26,801	1,858	7,476	3.48
Average	12,245	10,530	23,968	19,660	1,715	5,688	3.28

* Improved technogy; ** Farmer's practice

Table. 4. Comparative economics of mustard improved technology and farmers' practices

Particulars	Farmer's practice	Improved technology	Actual increase over farmer's practice	Increase over farmer's practice (%)
Average yield (kg/ha)	1598	1900	302	18.89
Gross return (Rs/ha)	30323	36213	5890	19.42
Cost of cultivation (Rs/ha)	10663	12245	1582	14.84
Net return (Rs/ha)	19660	23968	4308	21.91
B:C ratio	2.37	2.51	0.14	5.91

Table. 5. Yield gap over potential yield under real farm situation

Yield gap	< 10 %	10-15%	15-20%	20-25%	> 25 %	Total
2005-06	6.67	33.33	40.00	13.33	6.67	15
2006-07	6.67	26.67	33.33	20.00	13.33	30
2007-08	5.00	25.00	40.00	20.00	10.00	20
2008-09	0.00	35.00	35.00	25.00	5.00	20
2009-10	0.00	30.00	45.00	20.00	5.00	20
2010-11	0.00	25.00	50.00	15.00	10.00	20
Total	3.20	28.80	40.00	19.20	8.80	125

The data revealed that the yield gap ranged from 10.70 to 26.44% with a mean value of 18.89% between improved technology and farmers' practices under different categories *viz*. large, medium, small and very small yield gap groups. It was also observed that all the respondent farmers realized higher yield although the ranges varied from 10.70 to 26.44 per cent over the farmers practices which clearly showed the potential productivity of mustard under real farming situation. The majority (40.0%) of respondents had the yield gap ranging from 15 to 20% and minimum yield gap less than 10% was observed by 3.20% farmers.

Association studies will provide reliable information on characters for higher seed yield. On pooled analysis of correlation coefficients over six years the seed yield exhibited strong to very strong positive association with suitable HYV (1.003), plant geometry (0.832), fertilizer application (0.935), weed management (0.627), IPM (0.733) and irrigation (0.810), respectively in all the years of experimentation but negative associations were observed by some characters like poor soil fertility level (-0.725), damage by stray cattle's (-0.425) and poor technical knowledge (-0.325).

Similarly, suitable high yielding varieties exhibited positive correlation with plant geometry (0.865), fertilizer application (0.895), weed management (1.007), IPM (0.895) and irrigation (0.759), while poor soil fertility level had strong positive correlation with fertilizer application (0.725). On the other hand, plant geometry had significant positive association with fertilizer application (0.625), IPM (0.673) and irrigation (0.745). Fertilizer application also has positive correlation with IPM (0.735), while IPM had positive correlation coefficient with irrigation (0.537). These characters have significant and positive correlation with seed yield and responsible for higher yield in FLD as compare to farmers practices. Remaining three characters poor soil fertility level (-0.725), damaged by stray animals (-0.425) and poor technical knowledge (-0.325), though affect the seed yield but had negative association with seed yield.

In the present study, path coefficients (Table 7) were analyzed for all the ten characters over the years. On the basis of correlation studies, it was evident that suitable HYV, plant geometry, fertilizer application, weed management, IPM and irrigation were positively associated with seed yield. Suitable HYV showed direct effect of high order and positive (4.683). It also showed indirect and positive effects of high to moderate order via fertilizer application (2.937), weed management (2.385), IPM (3.275) and irrigation (4.687) and plant geometry (2.503).

Indirect effect via low soil fertility level (-2.680), plant geometry (-0.483) damage by stray cattle's (-0.084) and poor technical knowledge (-0.685) were of moderate to low order but negative in direction while positive and high magnitude were observed with fertilizer application (2.103) and irrigation (1.835) and were of moderate magnitude with weed management (1.005) and IPM (1.017). On the basis of correlation studies, it was evident that HYV, plant geometry, fertilizer application, weed management, IPM and irrigation were positively associated with seed yield and these characters were responsible for sustainable seed yield in the FLD. In farmer's practices, these are missing either one or other factors hence the yield was less as compared to improved technology at farmer's field. The others characters poor soil fertility level of farmer's field, damage by stray cattle's and poor technical knowledge indirect affect the yield levels.

The results of frontline demonstrations of mustard have clearly showed that growing of improved mustard varieties under improved technologies including seed of suitable HYV, recommended plant geometry, balance dose of fertilizer, weed management at proper time, integrated pest management and proper irrigation scheduling proved more productive and remunerative as compare to traditional farmers practices. It is clear from correlation coefficient and path coefficient analysis that above six factors are directly responsible for increasing the yield in improved technology

Table. 6. Pooled correlation coefficient among the characters responsible for net return

S. No.	Factors	Suitable HYV	Poor soil fertility levels	Plant geometry	Fertilizer application	Weed management	Damage by stray cattle	IPM	Irrigation	Poor technical knowledge	Seed yield
1.	Suitable HYV	-	0.445**	0.865	0.895**	0.107**	-0.420*	0.895**	0.759**	-0.435*	0.995**
2.	Poor soil fertility levels		-	0.443*	0.725**	0.137	-0.126	0.247	0.245	-0.070	-0.725**
3.	Plant geometry			-	0.625**	0.435*	0.116	0.673**	0.645**	0.135	0.832**
4.	Fertilizer application				-	0.070	-0.089	0.735**	0.135	0.082	0.935**
5.	Weed management					-	-0.011	0.345	0.427**	0.137	0.627**
6.	Damage by stray cattle						-	0.245	0.135	-0.011	-0.425**
7.	IPM							-	0.537**	0.432*	0.733**
8.	Irrigation								-	0.185	0.810**
9.	Poor technical knowledge									-	0.325

*, ** Significant at 5% and 1% levels of probability respectively

Table. 7. Pooled path coefficient analysis to determine the direct and indirect effects of different variables

Component	Correlation (yield)	HYV	Low soil fertility levels	Plant geometry	Fertilizer application	Weed management	Damage by stray cattle	IPM	Irrigation	Poor technology known
Direct effect of suitable HYV vs. yield	4.675	4.683	(-)1.683	-2.503	2.937	2.385	-1.684	3.275	4.687	-0.483
Indirect effect via low soil fertility levels	2.324	-1.685	-2.680	-0.483	2.103	1.005	-0.084	1.017	1.835	-0.685
Indirect effect via plant geometry	1.324	0.984	-0.985	2.321	2.113	1.245	-0.163	2.845	3.2428	-0.324
Indirect effect via fertilizer application	4.328	3.685	1.645	0.684	1.234	0.984	-0.234	1.843	1.284	1.234
Indirect effect via weed management	3.284	-2.843	1.483	0.084	1.844	0.834	0.324	0.984	0.883	0.374
Indirect effect via damage by stray cattle	-0.914	-1.281	0.093	0.083	0.015	0.183	-0.094	-0.040	-0.037	0.181
Indirect effect via IPM	3.814	-0.138	-0.087	1.845	1.887	1.284	-0.137	+1.845	1.244	0.137
Indirect effect via irrigation	1.117	2.458	-0.187	-1.324	-1.115	-0.345	-1.187	-0.080	1.144	0.080
Indirect effect via poor technology knowledge	-1.134	-0.873	-0.665	-0.854	-0.137	-0.315	-0.344	-0.085	0.377	-0.137

while others factors like poor soil fertility levels, damage by stray cattle and poor technical knowledge are the factors indirectly affect the yield. Hence it, could be concluded that the yield gap may be reduced through adoption of the improved technologies in mustard production.

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