Technology Inputs and its Impact on Farm Profits : A Case Study of Rapeseed-Mustard

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ABSTRACT

Oilseed crops form a significant part of the agricultural economy in India. Under the All India Coordinated Research Project on Rapeseed-Mustard (AICRPRM), the technologies developed through research are demonstrated under field conditions through Frontline Demonstrations (FLDs). From these demonstrations an understanding of the economic potential of each of the improved technology is possible. This paper attempts to study the economic performance of technologies recommended for Indian mustard using the data from frontline demonstrations conducted under AICRPRM. Technical and economic assessment of the technology using parameters like Yield Increase over Farmers Practice (YIOFP), Additional Net Monetary returns (ANMR) and Incremental Benefit Cost Ratio (IBCR) are used to judge the economic potential of the technology. The whole package technology in Indian mustard gave an yield advantage of 24.9 per cent over the farmers practice under irrigated condition and the varietal component gave an yield advantage of 13.5 per cent. The IBCR values for component technology ranges from 3.2 for plant disease management to 6.2 in case of pest management technology. Technologies like Sulphur nutrition and weed control are found to have higher potential in terms of increase in B:C ratio and yield advantage. A conservative ex-ante estimate of potential impact on rapeseed-mustard production indicates that the production could be raised by 0.55 million tonnes on existing crop area if 50 percent of farmers adopt the improved technology. The study shows variation between the technologies with regard to their economic potential and technical potential parameters which calls for informed selection of technologies for popularization.

Key words: *Indian mustard; Frontline demonstration; Additional net monetary returns (ANMR); Farmers' practice;*

Oilseed crops form a significant part of the agricultural economy in India. In terms of acreage, production and economic value, oilseeds are second only to food grains. Oilseeds contributed 6.3 per cent of the total value of output from agriculture and allied activities during the year 2009-10. India had a share of 7.8 per cent of the world oilseed production in triennium ending 2010-11(*CACP, 2012*). The area and production under the nine annual edible oilseeds was 26.8 million hectares and 31.1 million tonnes during 2010-11, whereas the total edible oil production in the country stood at 6.6 million tonnes during 2010-11 (*GoI, 2011*). Among the annual oilseeds, groundnut, rapeseed-mustard and soybean accounted for nearly 80 per cent of oilseeds area and 89 per cent of oilseeds production in the country during 2010-11. Rapeseed-Mustard group of crops is one of the major *rabi* oilseed crop in India. The area and production of rapeseed-mustard during 2010-11 was estimated to be 6.33 million hectares and 7.67 million tonnes respectively. This crop commodity is the major source of income especially even to the marginal and small farmers in rainfed areas. The livelihood security of a multitude of stakeholders (oilseed cultivators, oilseed processors, consumers and other intermediaries) is dependent on this crop and its value chain. Rajasthan, UP, MP, Gujarat and Haryana are the major rapeseed-mustard producing states. Since the cultivation of rapeseed-mustard is mainly undertaken in high risk regions with rainfed conditions and poor investment in technology, the returns to the rapeseed mustard cultivators are often uncertain. The role of technology in improving the profitability of rapeseed-mustard cultivation gains significance in this context.

The Technology Mission on Oilseeds (TMO), established in 1986 was aimed at attaining self reliance in oilseeds (*DOR, 2006*). The initial success of the mission lead to near self-sufficiency in edible oils during the early 90's. But this proved to be a temporary phenomenon as the country began to depend heavily on imports from the later part of the decade to meet its domestic edible oil requirement. India's import bill for edible oil was 29442 crores in 2010-11 (*GoI, 2011*). The quantity of edible oil imported also shows an increasing trend causing a significant drain of foreign exchange and widening the trade deficit. Therefore an increase in production and productivity of oilseeds is essential for reducing import dependency for edible oil needs. The benefits accrued from TMO were further strengthened through the ad hoc project on "*Frontline Demonstrations in Oilseed Crops*" launched from Kharif 1990-91 sponsored by Department of Agriculture and cooperation, Government of India. Under the All India Coordinated Research Project on Rapeseed Mustard, the technologies developed through research activities are demonstrated under actual field conditions of the farmers through Frontline Demonstrations (*DOR, 2012*). An overall appraisal of the performance of technologies in the farmers' field in improving the profitability of rapeseed-mustard production is important to understand the role played by improved technology and the returns to research investments (*Kiresur et al., 2001*).

Significant difference in yield persists between potential yield recorded at Research Station and the frontline demonstrations / on-farm trials. Further, untapped yield reservoir exists between yield obtained in frontline demonstrations and the State / National yield. With the available technologies, it is possible to further increase the rapeseed-mustard production. A targeted and focused approach in spreading the awareness about the improved technologies shall increase the rate of adoption and raise the productivity of the crop. Investment in extension activities and popularization of technology can be assessed only with a measurement of the economic potential and benefits that can be transferred to actual field condition through the adoption of various components of improved technology. This paper attempts to study the economic performance of individual component technologies recommended for Indian mustard using the data from Frontline Demonstrations conducted during 2007-08 to 2011-12.

METHODOLOGY

Technology demonstration in the farmer's field is usually done through Frontline Demonstrations where crop cultivation is done with the incorporation of the demonstrated technology and the results are compared with the farmers practice. The Directorate of Rapeseed -Mustard Research is the coordinating agency vested with responsibility for overseeing the All India Coordinated Research Project on Rapeseed- Mustard (AICRPRM). Under this project, Frontline Demonstrations (FLDs) on technology demonstration are conducted during every cropping season. The exhaustive data collected from these demonstrations are published in the Annual Progress Reports of the AICRPRM. The data on Frontline Demonstrations conducted during the period 2007-2012 (Coinciding with the 12th Five Year Plan) was used to study the economic benefits arising from technology inputs developed by the research system. The present study is based on the data from all the frontline demonstrations conducted over a period of five years in Indian mustard which contributes more than 80 per cent of the total area under rapeseed-mustard. The analysis was done separately for whole package, varietal and component technology demonstrations conducted in Indian mustard. The weighted average using the number of demonstrations in each year as weights for the 'Percentage Yield Improvement over Farmers' Practice (%YIOFP) obtained in demonstration plots is used as a measure of the yield advantage offered by the new technology. We assume that the error due to change in locations of the trials over different years will be nullified as the number of trials and the number of locations were fairly large. The Additional Net Monetary Returns (ANMR) for each of the trials is calculated based on the data on cost of cultivation for farmer managed field and technology demonstrated field. The ANMR represents the net additional monetary returns received by the farmer who adopts the improved technology as compared to the farmer's traditional practice. To determine the benefits per additional rupee invested on improved technology, Incremental Bbenefit Cost Ratio (IBCR) has been calculated as per the following formula:

$$\mathrm{IBCR} = \frac{\mathrm{AGRDT}}{\mathrm{ACIDT}}$$

AGRDT= Additional gross return from demonstrated technology

ACIDT= Additional cost involved in demonstrated technology

RESULTS AND DISCUSSION

General trends for rapeseed-mustard in India: Rapeseed-mustard accounted for 24.6 per cent of the total annual oilseed production in the country during 2010-11. The productivity of the crop has shown significant increase during the last two decades. The productivity increased from a level of 498 kg/ha for the TE 1980-81 to 922 kg/ha for the TE 2000-01. Productivity of rapeseed-mustard was 1083 kg/ha for the triennium ending 2006-07 and it increased to 1168 kg/ha for the TE 2011-12. During the period considered in this analysis there was an increasing trend in the productivity of the crop, mainly attributable to increased input usage and other technology inputs. The period from 1980-81 to 2009-10 saw the productivity in rapeseed-mustard grow at a significant rate with a compound annual growth rate of 2.34 per cent. During the first decade of this century the growth rate in production and productivity of rapeseed-mustard was 4.97 and 2.08 per cent respectively. The growth rate in productivity during the 2000-01 to 2009-10 was the highest among the major annual oilseed crops in the country.

Frontline demonstrations in Indian mustard: The number of frontline Demonstrations conducted can be broadly classified into whole package demonstrations where the entire recommended package of practices for the crop is demonstrated against the prevailing farmers' practice and the component technology demonstrations where the advantage of each component of the package is demonstrated. Table 1 shows the details of the number of FLDs conducted under AICRP (RM) for the period 2007-08 to 2011-12. The bulk of the Frontline Demonstrations were conducted on Indian mustard which is the major species of oilseed brassica grown in India accounting for more than 80 per cent of the area sown under this crop group. Out of the total, FLDs conducted on Indian mustard accounted for 68.7 per cent over the five year period reflecting the importance of Indian mustard amongst the rapeseed-mustard group. Varietal component demonstration accounted for 41.3 per cent of the FLDs in Indian mustard whereas whole package demonstrations and component technology demonstration accounted for 31.6 and 27.1 per cent respectively.

The situation under which the technology is demonstrated is very important from the point of technology adoption. The farmers growing rapeseed-mustard under rainfed condition are more reluctant for technology adoption and therefore the role of technology demonstration suited for rainfed regions is much more than their role in irrigated conditions where income risk from crop failure arising from adverse climatic conditions is limited. The location wise data on FLD conducted for the rapeseed-mustard group for whole package and varietal components over the last five crop seasons is presented in Table 2. The technology demonstrations conducted in irrigated conditions are significantly higher

Table 1: Year wise breakup of FLDs in Indian mustard

Year	FLDs in Indian Mustard	Whole Package	Varietal Component	Component Technology	Total FLDs in RM	2 as % of 6
2007-08	353	144	94	115	581	60.75
2008-09	434	102	211	121	612	70.9
2009-10	405	179	130	96	540	75.0
2010-11	305	68	134	103	429	71.09
2011-12	343	88	191	64	528	64.96

Source: compiled by authors from various Annual Progress Reports of AICRP (RM)

Table 2: Technology demonstration in rainfed and irrigated regions

Year	Whole Package			Varietal Component		
	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total
2007-08	190 (60.5)	124 (39.5)	314 (100.0)	92 (68.7)	42 (31.3)	134 (100.0)
2008-09	144 (72.4)	55 (27.6)	199 (100.0)	217 (89.3)	26 (10.7)	243 (100.0)
2009-10	90 (58.1)	65 (41.9)	155 (100.0)	151 (90.4)	16 (9.6)	167 (100.0)
2010-11	82 (67.8)	39 (32.2)	121 (100.0)	153 (95.0)	8 (5.0)	161 (100.0)
2011-12	124 (67.0)	61 (33.0)	185 (100.0)	212 (81.5)	48 (18.5)	260 (100.0)
Av. share (%)	65.1	34.9		85.0	15.0	

Note: The figures in parenthesis are percentages to total.

for both the categories consistently across the years. The varietal component demonstrations under rainfed conditions contributed only 15.0 per cent of the total number of varietal component trials. This trend indicates either a lack of technology suitable for rainfed conditions or an attempt to maximize the gains from demonstration by conducting them in irrigated regions where the absolute yield gain from the technology may be higher. A better balance in allocation of technology demonstration between the rainfed and irrigated regions shall benefit the rainfed regions since the technology adoption level in these regions is lower than in irrigated regions. The effect of technology demonstration can be expected to provide better returns in terms of adoption and technology spread in such areas.

Impact of technology inputs in Indian mustard:

Whole package and varietal Technology : During the period 2007-08 to 2011-12, a total of 974 demonstrations of the whole package of technology developed were conducted for Indian mustard out of which 630 were conducted under irrigated condition. Similarly, varietal component technology was demonstrated in 825 irrigated locations. The varietal technology is one of the most important technology component developed for rapeseed-mustard and its performance under irrigated condition is indicative of the potential of the crop. The irrigated condition provides the best chances for the success of the developed technology and an analysis of the technology demonstration conducted under such condition can be used as an indicator for the potential of the technology. Using the data on these demonstrations, the average value of parameters like yield improvement over farmers practice (YIOFP), Increase in cost of cultivation (CoC), additional Net monetary returns (ANMR) and increase in benefit cost ratio has been calculated over a period of five years using the number of trials at different locations as weights. The results are presented in Table 3.

Table 3: Impact of technology input in Indian mustard (2007-08 to 2011-12)

Description	Whole Package	Varietal Component
Increase in CoC (Rs/ ha)	1847 (14.8)	-
YIOFP (Kg/ha)	323 (24.9)	194 (13.5)
ANMR (Rs/ha)	6012	4645
ANMR as a share of CoC (%)	42.1	32.3
Increase in B:C Ratio (%)	10.7	11.1
Incremental Benefit Cost Ratio	4.5	-

Note:

1. The figures in parenthesis represent the percentage change.
2. The additional cost of change in variety is often negligible and hence the increase in CoC and IBCR for varietal component was not calculated .

The whole package technology gave 24.9 per cent yield more than the comparable farmers' practice in Indian mustard under irrigated condition whereas the yield increase was 13.5 per cent with adoption of varietal technology alone. The increase in yield was proportionately higher than the increase in cost of cultivation due to adoption of technology resulting in higher monetary returns from technology adoption. The share of additional net monetary returns in cost of cultivation was also higher for whole package technology compared to varietal component alone.

The returns to investment determine the profitability and ultimately the extent of adoption of a technology. From each rupee invested on the adoption of technology package, additional benefit of 4.5 rupees was obtained in cultivation of Indian mustard. This shows that the farmers will improve their farm income on adoption of technology and the technologies developed are economically viable in terms of their potential to yield returns on invested capital.

Impact of component technology and returns to investment : The effectiveness of a technology component is dependent on a number of factors including its cost, yield advantage and the monetary returns from its adoption. An analysis of selected component technologies in Indian mustard presents the differences in these parameters of different technologies (Table 4). This has implications for the potential level and ease of adoption of the technology. The incremental benefit cost ratio is the highest for pest management technology where the cost of technology for disease management is the lowest with an increase in cost of cultivation of 7.6 per cent over the existing practice. Sulphur nutrition (YIOFP = 19.4 %) offers the highest increase in net monetary returns over the existing practice at 6973 Rs/ha. The additional cost of adoption of Sulphur application technology is only 10.5 per cent. This indicates that this technology has large potential for being effectively adopted by the farmers. The application of Sulphur has been recommended through such mixed fertilizers which supply Sulphur nutrient along with the basic nutrients like Nitrogen and Phosphorus.

Table 4: Impact of component technology in Indian mustard (2007-08 to 2011-12)

Technology	Increase in CoC (Rs/ ha)	YIOFP (Kg/ha)	ANMR (Rs/ha)	B:C Ratio	IBCR
Plant Disease Management	1854 (9.1)	277.5 (17.4)	5005	1.5 (7.8)	3.2
Thinning	2073.9 (12.4)	312.3 (16.3)	5947	3.1 (3.2)	3.7
Sulphur Application	1897 (10.5)	333.2 (19.4)	6973	2.5 (10.7)	5.1
Pest management	1310 (7.6)	256.5 (16.2)	5721	2.1 (8.1)	6.2
Weed Control	2778 (16.0)	365 (19.6)	6429	2.8 (3.5)	3.3

Note:

1. Technology for Sclerotinia rot, White rust and Powdery mildew were considered under disease management technology
2. Technology for controlling painted bug and mustard aphid were considered under pest management technology.
3. The figures in parentheses for Increase in CoC and YIOFP indicate the percentage increase in cost of cultivation and yield respectively.
4. The figures in parentheses for B: C ratio values indicate the increase in B:C ratio of improved practice over farmers practice.

This involves only changes in fertilizer composition and does not involve additional labour cost for fertilizer application or other associated incidental costs.

The practice of weed control through intercultural operations is one of the least adopted technologies in cultivation of rapeseed-mustard. A reason for this situation may be the significant increase in cost of cultivation arising from adoption of weed control measures. An increase in cost of cultivation by 16.0 per cent is perceived as an unviable investment even though the yield advantage on offer is 19.6 per cent. The high impact of weed control demonstration over farmers' practice might be due to the general apathy among farmers to go for weeding practices in view of high cost and non availability of labour during crop season. The absence of explicit visual evidence of the effect of the technology for weed control, unlike in the case of pest and disease management technologies, could also be the reason for its poor adoption among the rapeseed-mustard farmers. In terms of returns to additional investment on technology adoption, pest management technology gave the maximum returns followed by sulphur nutrition and thinning.

The lowest ANMR and B:C ratio were recorded by Plant Disease Management Technology. The low IBCR calculated for disease management technology is reflective of the relatively higher cost of plant protection chemicals among all the inputs used in crop production. In this context, development of cost effective plant protection technologies in rapeseed-mustard assumes significance. The fact that all the component technologies have an IBCR value above unity shows that the technologies demonstrated for potential adoption by farmers were economically viable. The differences in IBCR values between technologies may cause differential rate of adoption between technologies. The demonstrations for Integrated Pest Management (IPM) technology were few and hence an independent analysis for IPM was not done. However the analysis of earlier demonstration of IPM clearly shows that adoption of IPM strategies need not compromise on yield potential and it can be an attractive option for the farmers.

Potential impact of technology adoption in rapeseed-mustard : The demonstrated yields under front line demonstrations indicate the potential for increase in yield and it represents an untapped yield reservoir for the future. The yield gap in rapeseed-mustard at the national level for the biennium ending 2008-09 was 21 per cent (*Jha and Thomas, 2012*). Our estimates for the yield difference between frontline demonstration with whole package of technology for Indian mustard in irrigated condition and the comparable farmer practice indicate that yield gap is 24.9 per cent. This represents the difference between yield obtained in frontline demonstrations and that obtained in the farmers' field. The expected increase in production of rapeseed-mustard was made using available data on average area, production, productivity and yield of last five crop seasons at the national level. The estimate of the impact of technology adoption developed based on available data indicate that the total production of rapeseed-mustard could be increased by 0.55 million tonnes without any increase in area if half of the farmers growing mustard under irrigated condition adopt the technology package developed for Indian mustard. If we include the demonstration effect of the adoption and the positive impact of improvement in farm income from improved productivity, the returns to investment on popularization of technology and its adoption by the farmers can be highly significant.

CONCLUSION

Increasing the productivity of oilseed crops is a matter of priority given the current and projected scenarios of edible oil demand and supply in India. The technologies developed in rapeseed-mustard group of crop, which is one of the three major annual edible oil crop was assessed for its economic and technical potential using the data on technology demonstrations conducted in farmers' field over five crop seasons (2007-08 to 2011-12). The analysis of the economic efficiency of technologies released for use by the farmers performs the role of an audit with respect to the usefulness and adaptability of the technologies. The study shows that there are differences between the technologies with respect to their technical advantage and economic potential. Since these variables can affect the adoption rate of technology and the cost involved in improving the adoption, informed decisions on selection of technology for popularization is necessary. The individual parameters does not fully capture the yield advantage due to the adoption of technology, hence an integrative method using a combination of parameters should be used in prioritization of technology for the farmers.

The integration of the different economic criteria into a comprehensive selection criterion needs to be explored for better utilization of these criteria. Sufficient data on agro-climatic parameters associated with the demonstration of technology is not available for analysis. This puts limit on the applicability of the findings across farm classes and agro-climatic zones. All the technologies developed for the crop showed positive returns to the additional investment undertaken for adoption of technology. The scope and economic viability of the technologies brings out the impact of the technology in terms of yield and production. Technology adoption could have significant impact on the production and productivity of rapeseed-mustard in India and contribute towards enhancing self sufficiency and nutritional security in edible oils.

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