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Impact of integrated crop management practices on productivity, profitability and energy budgeting of mustard in South-Eastern Rajasthan

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Abstract

In the present study impact of integrated crop management (ICM) practices of mustard were studied at 225 farmers' fields in heavy soils of South-Eastern Rajasthan during 2019-20 to 2021-22. Baseline information and soil fertility status of the area were collected before organizing cluster front line demonstrations (CFLDs), and then after demonstrated ICM practices recommended by Agriculture University, Kota (Rajasthan). It is evident from results that the yield of mustard in ICM plots was ranged between 2.31-2.36 t/ha which was higher over the farmers practice (FP). Similarly, ICM plots recorded higher gross returns (Rs.129780-154995/ha), net returns (Rs.102100-122445/ha) and B:C ratio (3.51-3.76). Whereas, ICM plots recorded lower energy input (11.95%) and cost of cultivation (5.45%) over the FP. Thus, adoption of ICM practices enhanced the productivity, profitability and can save input energy consumption substantially over the existing farmer's practices of mustard cultivation.

Keywords: *CFLDs, economics, energy indicators, ICM, Indian mustard, productivity, profitability*

Introduction

India is the fifth largest oilseed producing country in the world and also one of the largest importers of vegetable oils. The demand-supply gap in the edible oils has necessitated huge imports accounting for 55.7 % of the country's requirement (GOI, 2021). Despite commendable performance in domestic oilseeds production, it could not match the galloping rate of per capita demand due to enhanced per capita consumption (18 kg oil/ year) driven by an increase in population and enhanced per capita income. Soybean followed by rapeseed-mustard is having the highest area as well as production among the oilseeds in India. Area, production and productivity of rapeseed-mustard in India was 68.56 lakh ha, 91.24 lakh tonnes, and 1331 kg/ha, respectively during 2019-20 (GOI, 2020). It is cultivated across the country mainly in Rajasthan, Madhya Pradesh, Uttar Pradesh, West Bengal, Haryana, and Gujarat. In Rajasthan, it is cultivated over 30.76 lakh ha with production and productivity of 42.02 lakh tonnes and 1366 kg/ha, respectively (GOI, 2020).

Due to the low water requirement and feasibility of rapeseed-mustard, it suits and adapts well to different cropping systems. Farmer's preference to grow mustard in Rajasthan is gaining more importance because of the premium price to the farmers but lack of appropriate technologies and cultivation under input-starved conditions are some of the major causes of poor productivity. The wide gap exists between the potential and farmer's yield in mustard which might be due to technology gap and also a lack of awareness about new technology though soils of South-Eastern Rajasthan fertile and irrigation facilities are available.

Integrated crop management (ICM) is a holistic and site-specific approach of sustainable agriculture which considers the production factors across the whole farm, including on-farm resources, socio-economic and environmental factors; to deliver the most suitable and safe approach for long-term benefits (Choudhary *et al.* 2018). Cluster front Line demonstration (CFLDs) is a unique approach to provide a direct interface between scientists and farmers as the scientists are directly involved in planning, execution, and monitoring of the demonstrations. Scientists get direct feedback from the farmers' field about the crop production and technology being demonstrated in a particular situation. This enables the scientists to improvise upon the research programme accordingly. CFLDs provide an opportunity for researchers and extension personnel for understanding the farmer's resources and requirements to fine tune and modify the technologies for easy adaptability in farmers' fields. In this study, an attempt has been made to examine the impact of CFLDs on integrated crop management (ICM) practices of mustard in heavy soils of South-Eastern Rajasthan.

Materials and Methods

The study was conducted at the farmer's field of Baran district in Rajasthan state during *Rabi* seasons from 2019-20 to 2021-22. The study area is situated at the South-Eastern corner of the state at 26.0982° N, 87.9450° E latitude, and longitude, respectively. The predominant soil of the zone is black soil of alluvial origin with clay loam in texture. The major cropping patterns of the area are soybean / blackgram / paddy/maize-wheat/mustard/gram/garlic/coriander. Before organizing CFLDs, a team of scientists had collected baseline information and soil fertility status of the area in the year 2019. The farmers were trained to follow the ICM practices of mustard recommended by Agriculture University, Kota (Rajasthan). The farmer practice was considered a local check in the cluster. In the CFLD plots, ICM practices were adopted like the treated seed of improved variety DRMRIJ-31 (Giriraj), optimum seed rate (4.0 kg/ha), seed treatment with insecticide (Imidacloprid 48 FS @ 6 ml/kg seed), fungicide (Metalaxyl 35% WS @ 6 g/kg seed) and culture (Azotobacter + PSB @ 5 g/kg seed) and sown at optimum spacing (30 cm × 10 cm). The weeds were managed with the application of pre-emergence herbicide pendimethalin 30% EC @ 1.0 kg *a.i.*/ha. A full dose of P: K: S: Zn (50:30:50:5 kg/ha) and half dose (50 kg/ha) of N were applied as a basal dose and the remaining half dose of N was top-dressed at 35-45 DAS after 1st irrigation through urea. The infestation of mustard aphid (*Lipaphis erysimi*) was controlled by the establishment of yellow sticky traps and application of imidacloprid 17.8 SL @ 250 ml/ha at ETL level.

A total of 225 farmers was selected for the conducting of CFLDs on ICM of mustard. Therefore, the same numbers of farmers were selected purposively as the samples for the present investigation. The study was conducted in experimental designs ('Control-Treatment' and 'Before-After') of social research. The yield data of demonstration plots as well as control plots were collected immediately after harvesting to assess the impact of CFLDs intervention on different parameters of mustard. The inputs and outputs prices of commodities prevailed in the district during the study of demonstration years were taken for calculating net return and benefit-cost ratio. However, a structured and pre-tested interview schedule was used to elicit the information from beneficiary farmers about the adoption, horizontal spread of production technologies, economics, and energy budgeting in the study area. The personal interview was conducted with the beneficiary farmers after the completion of each year. The following formulas were used to assess the impact of CFLDs on the different parameters of the mustard crop (Kumar *et al.,* 2021).

Impact on yield (% change):

$$[\{\text{Yield of ICM plot (t/ha)} - \text{Yield of FP plot (t/ha)}\}/\{\text{Yield of FP plot (t/ ha)}\}] \times 100$$

Impact on adoption (% change):

$$\{(\text{No. of adopters after CFLD} - \text{No. of adopters before CFLD})/\text{No. of adopters before CFLD}\} \times 100$$

The cost of cultivation and energy analysis were calculated by conducting a personal interview with the beneficiary farmers during 2021-22. The input amount and energy requirement from sowing to transportation for each input item were determined and quantified. The total dry weight of the mustard crop was considered output, which comprised both grain and stover yield. For estimation of energy input and output (expressed in MJ/ha) for each item of inputs and agronomic practices, equivalents were used from the published literature given in Table 1. Based on energy inputs and outputs, energy balance, energy productivity, net energy returns, energy use efficiency, and specific energy were calculated as given by Choudhary *et al.* (2017), and Choudhary and Behera (2021).

Net energy (MJ/ ha): Energy output - Energy input

Energy use efficiency: Energy output (MJ/ha)/ Energy input (MJ/ha)

Energy productivity (kg/MJ): Economic yield/ Energy input

Energy intensiveness (MJ/INR): Energy input/ Cost of cultivation

Energy profitability: Net energy/ Energy input

Specific energy (MJ/kg): Energy input/ Seed yield

Energy intensity in physical terms (MJ/kg): Total energy input/ Total biological yield

Energy intensity in economic terms (MJ/INR): Total energy output/ Cost of cultivation

Results and Discussion

The productivity level comparison between FP and ICM practices is shown in Table 2. It revealed that the average seed yield of mustard under ICM practices was recorded higher (2.31 to 2.36 t/ha) over the FP (1.93 to 2.08 t/ha) during all the three years of study. The ICM practices showed significant increase in yield of mustard over the FP by 13.5, 16.0, and 19.8 % during 2019-20, 2020-21, and 2021-22, respectively.

The economic evaluation revealed that the adoption of ICM practices in CFLDs recorded a lower cost of

Table 1: Energy equivalent of inputs and output in mustard

Particulars	Unit	Energy Equivalent (MJ/unit)	References
A. Input			
1. Human labour	MJ/ h	01.96	Choudhary *et al.,* 2021
2. Machinery	MJ/ h	62.70	Choudhary *et al*., 2017
3. Diesel	MJ/ l	56.31	Choudhary *et al*., 2021
4. Nitrogen	MJ/ kg	60.60	Choudhary *et al*., 2021
5. Phosphorus	MJ/ kg	11.10	Choudhary *et al*., 2021
6. Potash	MJ/ kg	6.70	Choudhary *et al*., 2021
7. Sulphur	MJ/ kg	01.12	Gokdogan and Erdogan, 2021
8. Micronutrient (Zn)	MJ/ kg	08.40	Kumar *et al*., 2021
9. Water for irrigation	MJ/ m^{-3}	01.02	Choudhary *et al*., 2021
10. Seed (mustard)	MJ/ kg	14.70	Parihar *et al*., 2013
11. Bio-inoculant	MJ/ kg	14.50	Mihov and Tringovska, 2010
12. Herbicide	MJ/ kg	254.45	Choudhary *et al*., 2021
11. Insecticide	MJ/ kg	184.63	Choudhary *et al*., 2021
12. Fungicide	MJ/ kg	97.00	Choudhary *et al*., 2017
B. Output			
1. Seed (mustard)	MJ/ kg	14.70	Prihar *et al*., 2013
2. Stover	MJ/ kg	12.50	Prihar *et al*., 2013

Table 2: Impact of integrated crop management practices on yield performance of mustard

Year	ICM demonstration area (ha)	No. of ICM demonstrations	Average yield of ICM (t/ha)		Average yield of FP (t/ha)		Impact over FP (% change in grain yield)
			Grain yield	Stover yield	Grain yield	Stover yield	
2019-20	20	50	2.3.6	4.11	2.08	3.70	13.5
2020-21	50	125	2.3.2	3.85	2.00	3.48	16.0
2021-22	20	50	2.3.1	3.69	1.93	3.20	19.8

cultivation (5.31-7.76 %) and higher gross returns (Rs.129780-154995), net returns (Rs.102100-122445) and B:C ratio (3.51-3.76) as compared to FP during all the years of study (Table 3). The main reasons for the higher yield of mustard in ICM plots were the use of improved variety DRMR IJ-31 (Giriraj), optimum seed rate, plant geometry, seed treatment, nutrient management, water management, and integrated pest management. The reason for low yield from FP might be due to higher seed rate, dense planting, and early irrigation (25-30 DAS) which gives excessive growth to crop and lower yield attributes. In the study area incidence of weeds like *Chenopodium album, Orobanche, Rumex dentatus, Melilotus indicus, Convolvulus arvensis,* and *Asphodelus tenuifolius* were observed which was also not managed effectively in FP plots whereas, in ICM plots pre-emergence herbicide application gave good control on weeds and later on smothering effect of mustard managed weeds effectively except *Orobanche*. In addition to these, need-based nutrient supply and IPM also contributed to higher yield in ICM plots. In ICM plots higher B:C ratio was recorded because of the lower cost of cultivation and higher yield. In different places of the world, various research workers have conclusively proved that ICM practices gave more yield and B:C ratio. Dutta (2016) and Ghintala *et al*. (2018) reported higher net returns and benefit-cost ratio with improved production technologies over the FP in the mustard crop. Such results concerning yield and economics were reported earlier by Ojha and Bisht (2020) and Kumar *et al*. (2021). Sharma *et al*. (2020) and Jha *et al*. (2021) also reported that improved production techniques are more beneficial as compared to existing farmer's practices in mustard. The cost of cultivation of ICM demonstration plots was Rs.32550/ha whereas in FP plots it was Rs.34324/ha during 2021-22. In ICM plots, the highest cost incurred on fertilizers (23.89%) followed by harvesting

(17.81%), irrigation (15.36%), threshing (13.82%), field preparation (9.22%), sowing (4.61%), herbicide (6.69%), transportation (3.07%), insecticide (1.69%), seed (0.98) and seed treatment (0.45%). In case of FP plots cost of cultivation incurred in order of seed > harvesting > irrigation > fertilizers > field preparation > threshing > field sowing > transportation. It is also evident from Table 3 that the overall 5.31 to 7.76% higher cost incurred in the cultivation of mustard under farmer's practices over the ICM during 2019-20 to 2021-22. The total output from ICM plots was 6000 kg/ha (value of Rs.154995/ha) which includes grain, and stover yield whereas in the FP plots it was only 5093 kg/ha yield (value of Rs.129615/ ha). In ICM practices, 5.31 % lower cost incurred on mustard cultivation over the FP was might be due to more cost incurred on seed and field preparation which was lower in ICM plots during 2021-22.

Table 3: Impact of integrated crop management practices on economics of mustard

Year	ICM				FP			
	Cost (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C ratio	Cost (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C ratio
2019-20	27680	129780	102100	3.69	29914	114460	84546	2.83
2020-21	30186	136090	105904	3.51	32439	117480	85041	2.62
2021-22	32550	1549951	22445	3.76	34324	129615	95291	2.78

The lower cost of cultivation in ICM plots was due to less cost incurred of seed whereas farmers were used private company hybrid seed which was ten times more costly than the variety. The demonstrated variety DRMRIJ-31 seed may also be used in subsequent years by adopting roughing, whereas FP plots used hybrid which cannot be used in subsequent years. In addition to that one extra tillage operation and higher seed rate also increase the cost of cultivation in FP plots though additional expenditure occurred on seed treatment, fertilizers, insecticide, etc. in ICM plots. Sahu *et al.* (2018) found that out of the total cost of mustard 28.29%, 15.39%, 9.03%, and 7.11% spent on human labor, irrigation, machinery, and fertilizer, respectively.

Mustard ICM practices adoption data is given in Table 4. It was observed that the number of adopters of improved variety DRMRIJ-31 of mustard was nil before demonstrations, which reached up to 100 % after the demonstrations. A very good adoption was also observed in the case of irrigation scheduling, seed treatment, seed rate, spacing and insect management as an increase in the percentage of adopters from 8.44 to 92.89, 4.00 to 84.89, 3.11-79.56, 4.44-80.44 and 6.67-82.67 %, respectively. The number of adopters of nutrient and weed management increased significantly during the pre and post-demonstrations period from 4.89 to 68.44 and 2.67 to 63.56 %, respectively. Kumar and Jakhar (2022) reported that adoption of improved variety, proper seed rate, and seed treatment, the gap was 60, 90, and 100 %, respectively. Similar results were also recorded in mustard crop by and Jha *et al.* (2021).

The input energy requirement of ICM demonstrations was 9998 MJ/ha which was 11.28% lower than FP plots (11193 MJ/ ha). In ICM plots, the maximum input energy was used in nitrogen (60.61%) followed by diesel (19.01%), machinery use (6.37%), and phosphorus (5.55%). Herbicide, potash, and irrigation constituted 2.55, 2.01, and 1.22 %, respectively, of the input energy in ICM plots. The minimum input energy was consumed in seed, human labour, sulphur, insecticide, micronutrients, fungicide and bio inoculants *i.e.*, 0.59, 0.59, 0.56, 0.50, 0.42, 0.02 and 0.01 %, respectively in ICM plots. In the case of FP plots, 85.04% of total input energy was utilized in terms of nitrogen (67.68%) and diesel (17.36%) only. In FP plots excessive use of nitrogenous fertilizers and one extra tillage operation increased total input energy consumption though there was no energy consumption on potassic, sulphur, micronutrient fertilizers, bio inoculants, herbicides, insecticides, and fungicides. It is evident from Table 5 that the total output energy from ICM plots was 112220 MJ/ha which includes grain and stover yield whereas, in the FP plots it was only 94946 MJ/ha. The ICM plots recorded 18.17, 24.42, 26.19, 26.81, and 19.71 % higher net energy, energy use efficiency, energy productivity, energy profitability, and energy intensity in economic terms, respectively. Whereas, energy intensiveness, specific energy, and energy intensity in physical terms were recorded (6.45, 36.72, and 31.62 %, respectively) lower in ICM plots. Similar results were also reported by Parihar *et al.* (2013). This might be due to lower input energy, cost of cultivation, and higher yield, and return in ICM plots as compared to FP. The higher input energy consumed in FP was might be due to more energy consumed on one extra tillage operation, higher seed rate and indiscriminate use of insecticide increased total energy input. Kumar *et al.* (2021) reported that the total

Table 4: Impact of integrated crop management practices of mustard on adoption of production technologies

Technology	No. of adopters (N=225		Change in no. of adopters	Impact (% change)
	Before ICM	After ICM		
Improved variety: DRMR IJ-31	0 (00)	225 (100)	+225	-
Seed treatment: Insecticide; Imidacloprid 48 FS @ 6 ml/kg seed, Fungicide; Metalaxyl 35% WS @ 6 g & Culture; Azotobacter + PSB	9 (4.00)	191 (84.89)	+182	2022
Seed rate @ 4.0 kg/ha	7 (3.11)	179 (79.56)	+172	2457
Spacing: 30 cm × 10 cm	10 (4.44)	181 (80.44)	+171	1710
Herbicide: Pendimethalin 30% EC @ 1.0 kg *a.i.*/ha	6 (2.67)	143 (63.56)	+137	2283
Nutrient management: N:P:K:S:Zn @	11 (4.89)	154 (68.44)	+143	1300
100:50:30:50:5 kg/ha Irrigation at 35-45 DAS	19 (8.44)	209 (92.89)	+190	1000
Insect management: Imidacloprid 17.8 SL @ 250 ml/ha	15 (6.67)	186 (82.67)	+171	1140

Figures in parentheses indicate percentage; Source: Field survey of 2021.

Table 5: Impact of integrated crop management practices on energy budgeting of mustard

Particulars	Total energy equivalents (MJ/ha)	
	ICM	FP
A. Inputs		
Human labour	59 (0.59)	54 (0.49)
Machinery	636 (6.37)	709 (6.33)
Diesel	1900 (19.01)	1943 (17.36)
Nitrogen (N)	6060 (60.61)	7575 (67.68)
Phosphorus (P)	555 (5.55)	666 (5.95)
Potash (K)	201 (2.01)	0
Sulphur (S)	56 (0.56)	0
Micronutrient (Zn)	42 (0.42)	0
Water for irrigation	122 (1.22)	122. (1.09)
Seed	59 (0.59)	118 (1.05)
Bio-inoculant	0.58 (0.01)	0
Herbicide	254 (2.55)	0
Insecticide	50 (0.50)	6 (0.05)
Fungicide	2 (0.02)	0
Total	9998 (100)	11193 (100)
B. Output		
Seed (kg)	33957	27783
By product (kg)	78263	67163
Total11222094946		
C. Net energy (MJ/ha)	102222	83753
D. Energy use efficiency	11.22	8.4
E. Energy productivity (kg/MJ)	0.23	0.17
F. Energy intensiveness (MJ/INR)	0.31	0.33
G. Energy profitability	10.22	7.48

H. Specific energy (MJ/ kg)	4.33	5.92
I. Energy intensity in physical terms (MJ/ kg)	1.17	1.54
J. Energy intensity in economic terms (MJ/ INR)	3.45	2.77

Figures in parentheses indicate percentage contribution of total input energy consumption.

input energy of integrated crop management practices of chickpea was 5873 MJ/ha which was 7.03% lower than traditional farmer practices (6317 MJ/ha) in irrigated clay loam soils. The energy inputs in the production of *the Rabi* annual crop have been in the order of fuel energy, chemical fertilizers energy, seed energy, machinery energy, farmyard manure energy, human labor energy, and chemicals energy inputs (Patil *et al.,* 2014; Abshar and Sami, 2016; Yadav *et al.,* 2018).

Conclusion

A wide gap exists between the potential yield and actual yield obtained at farmer's fields in mustard crop due to technology and extension gaps among the farmers. The CFLDs on integrated crop management practices (ICM) increased mustard yield (13.5-19.8%) and were also helpful in the speedy spread of recommended production technologies of mustard. In addition to that ICM plots were recorded higher net energy and energy use efficiency over to the farmers practices. The recipient farmers of CFLDs played an important role as a source of information and wider dissemination of the improved variety DRMRIJ-31. Hence, it is can be concluded that by imparting scientific knowledge of ICM practices to the farmers, providing the need-based quality inputs and their proper utilization can enhance the productivity, profitability and energy use efficiency of mustard.

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