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Research Article

HARVEST BUMPER YIELD OF MUSTARD THROUGH- SYSTEM OF MUSTARD INTENSIFICATION (SMI)

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Abstract: Total number of 36 SMI demonstrations were conducted with adjacent plot of local practices by Krishi Vigyan Kendra, Mandla (Zone-III, Northern hill of Chhattisgarh) in 14 villages in an area of 15 hectors. Farmers were selected through their knowledge basis. Cultivation of improve variety of mustard RP-09 was grown with transplanting method. This technology requires small quantity of seed as compare to normal sowing (*i.e.*, 250 g seed/ha). After 15 to35 days of transplanting nipping was done thrice at an interval of seven days. The crop was harvested after 110 -120 DAT at maturity stage. Out of nine parameters, full gap was found in six parameters *i.e.*, use of traditional varieties & degenerated seeds, higher seed rate, no seed treatment, no use of plant protection measures and without inoculation. Whereas, partial gap was observed in two parameters *i.e.*, Manures, Fertilizers, method of sowing and spacing. However, no gap was found in land preparation. Average plant height 176 cm. in SMI while in traditional method it was 127cm.Mean number of branches/plans clearly indicate the effectiveness of branches *i.e.*, 11 in SMI however 04 branches in farmer's practice. Mean of thee years760siliqua/plant in SMI as against 64 in farmer's practice. Yield/ plant were found 485g. in SMI while only 86g. in farmer's practice. SMI showed better response in all yield attributing characters and yield. Yield of 36 SMI demonstrations gave 33.05q/ha yield as against 9.08 q/ha in traditional practice. The percent increase in yield over farmers practice was 265.50 % over farmers practice (FP). Average extension gap was 23.98 q/ha., technological gap + 12.99 q/ha indicate that technology provide more yield than potential yield. Mean of three years yield index indicate *i.e.*, 63.93% higher over farmer's practice.

Average cost of cultivation of SMI and traditional practice indicates that cost of cultivation Rs.26,166/-ha^{-1} in SMI and 13,667/- ha^{-1} in traditional practice. The average gross return Rs.168572 under SMI as against Rs.46291/- ha^{-1} in farmer's practice which was just 25% of SMI. Average net return Rs.142405/-ha^{-1} was found in SMI demonstrated plots as against Rs. 32624/-ha^{-1} in farmer's practice. The pooled mean of three years B:C ratio revealed that it was 6.45 in SMI and 3.39 in farmers practices.

Keywords: *Mustard, SMI, Nipping, Sarson*

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Introduction

System of Mustard Intensification (SMI) follows the same principle like System of Rice Intensification. The program to cultivate mustard using the SRI principle was initiated during 2009-10. First it was initiated and supported by ATMA (Agriculture Technology Management Agency) and PRADAN, an NGO in Bihar with World Bank-funded project. Later during 2011-12 Sir Dorabji Tata Trust came forward to spread it among the farmers and in that season around 1600 farmers were able to experience the innovative technique, known as system of mustard intensification (SMI). In Madhya Pradesh the higher yield was recorded in Umariya district with an average yield of 2.6 ton/ hectare for the genetically modified (GM) DMH-11 mustard variety developed by Delhi University's Centre for Genetic Manipulation of Crop Plants. Current non-GM mustard show average yield 1.7 ton/ hectare, although it is not approved Genetic Engineering Appraisal Committee (GEAC), the nodal regulator for GM crops in India. The success of using SMI in mustard is not only limited to Madhya Pradesh, but also in Bihar, Odisha, and West Bengal. The technology was tried and reported higher yields. SMI was an innovative approach to increase the rape seed and mustard production through front line demonstration conducted at farmer's field of an approach to increase productivity of mustard by changing the management pattern of soil, plant, moisture, and nutrient. In India, rapeseed-mustard crops comprise indigenously grown species, like brown sarson (*Brassica rapa L*. var. brown sarson), toria (*Brassica rapa*. var. toria), black mustard (*Brassica nigra*), yellow sarson (*Brassica rapa* L. var. yellow sarson), Indian mustard (*Brassica juncea*), and Taramira (*Eruca sativa/vesicaria*), which have been grown since about 3,500 BC with exotic species like gobhi sarson (*Brassica napus*) and Ethiopian mustard or karan rai (*Brassica carinata*) [1]. India ranks first in total rapeseed mustard production. The major rapeseed mustard growing states in India are Rajasthan, Madhya Pradesh, Utter Pradesh, Haryana, Punjab, West Bengal, Gujarat, Bihar and Assam occupies approximately 86.5% of total area which is 5.76 million hectares in the country and 91% of total production of 6.82 million tonnes. Among the nine oil seed crops grown in India rapeseed mustard contribute about one third of the oil to the country. This can be cultivated both rains fed as under irrigated condition to fetch higher market price, thus adding to the rural income specially of marginal and small Farmer's with the productivity of 1169 kg/ha. In Madhya Pradesh, this crop occupies 747.90 thousand hectors area with the production of 975.79 thousand tones with productivity of 1305 kg/ha [2]. The production and productivity of India mustard in India have been declined since last few years due to various biotic and abiotic stresses. Productivity of Indian mustard in Madhya Pradesh is less as compared to other states and this was mainly due to very old conventional practices, improper crop geometry, imbalance use of manures and fertilizers and climatic variability. To enhance the production and productivity of mustard, Krishi Vigyan Kendra conducted various front-line demonstrations (FLDs) in the farmers' field to disseminate the new technological interventions among the farmers. It is a unique approach to provide direct interface between the agricultural extension scientists and farmers.

Table-1 *Gap analysis of Mustard cultivation between SMI and farmers practices*

SN	Technologies	Demonstration Practices	Farmer's practices	Gap
1	Land preparation	Two ploughing and pits digging	Two ploughing	partial gap
2	Variety	RP- 09	Local variety and degenerated seed	Full gap
3	Seed rate (kg/ha)	250g/ha	7-8 kg/ha	Partial gap
4	Seed priming and seed treatment	Seeds should be primed in a mixture of lukewarm water, cow urine, jaggery and vermicompost. Amount of water must be just double the number of seed and the other ingredients should be just half of the seed. After 6-8 hours of priming seed can be mixed with *Trichoderma* @ 10 g, *Rhizobium* 20g and Phosphorus solubilizing bacteria (PSB) 20g /kg of seed.	No seed primed and without seed treatment	Full gap
5	Nursery raising and transplanting method & spacing	About 4-5 inch above the ground ridge bed nursery were prepared with 1meter width. Seed primed with 6-8 hours can be mixed with *Trichoderma* @ 20 g/kg of seed. Sprouted seeds should be placed at a depth of 1-1.5 cm maintaining a spacing of 5×5 cm. Seeds should be covered with vermicompost and paddy straw mulch. Sprinkling of water must be maintained at morning and evening after nursery sowing. Area of nursery should be 50 m^2 for 100-120 days variety.	Direct seeding by broad costing method.	Fully gap
6	Manures & Fertilizers	20 tons FYM/ vermicompost +75:100:60:40 NPKS kg/ha	Little amount about 25-30 kg/ha of DAP suboptimal dose of fertilizer	Partial gap
7	Weed management	Three hand weeding at15-20, 25-30 and35-40 DAT	No weeding	Fully gap
8	Plant Protection measure	Emidaclorprid 17.8% SL@125ml./ha. Redomil 1.50kg/ha.	No plant protection measures were adopted	Full gap
9	Inoculation	*Trichoderma* @ 4 kg, *Rhizobium* kg @ 4 kg, PSB@ 4 kg/ha. mixed with 20 tons of FYM/ Vermicompost /ha.	Not inoculation	Full gap

Table-2 *Mean of Yield attributing characters influenced by System of Mustard Intensification (Mean of 0.5 ha. of each year)*

Yield Influencing characters	2012-13		2013-14		2014-15		Total		Mean	
	FP	SMI	FP	SMI	FP	SMI	FP	SMI	FP	SMI
Plant height (cm)	122	185	134	176	126	166	382	527	127	175.67
No. of branches/plant	03	08	05	11	04	13	12	33	04	11
No. of siliqua/plant	55	632	75	780	62	868	192	2280	64	760
Yield/Plant(g)	86	470	83	487	89	498	258	1455	86	485
Yield (q/ha)	9.78	32.86	8.56	33.98	8.89	32.32	27.23	99.16	9.08	33.05

Table-3 *Productivity, extension gap, technology gap and technology index of Mustard as grown under SMI and Traditional practice*

Year	Area (ha)	No. of FLD's	Variety	Average yield (q/ha)			Increase yield over F.P. (%)	Extension Gap (q/ha)	Tech.gap (q/ha)	Yield Index (%)
				Potential	SMI	Farmers				
2012-13	05	12	RP-09	20.00	32.86	9.78	235.99	23.08	+12.86	64.30
2013-14	05	12	RP-09	20.00	33.98	8.56	296.96	25.42	+13.98	66.90
2014-15	05	12	RP-09	20.00	32.32	8.89	263.55	23.43	+12.12	60.60
Total	15	36	-	-	99.16	27.23	796.50	71.93	+38.96	191.80
Average	05	12	-	-	33.05	9.08	265.50	23.98	+12.99	63.93

Table-4 *Profitability of mustard grown under SMI technology and Traditional practice/farmer's practices*

Year	Average cost of cultivation (Rs./ha.)		Average gross return (Rs./ha.)		Average Net Return (Rs./ha.)		B:C Ratio	
	SMI	FP	SMI	FP	SMI	FP	SMI	FP
2012-13	25200	13200	167586	49878	142386	36678	6.65	3.78
2013-14	26500	13600	173298	43656	146798	30056	6.54	3.21
2014-15	26800	14200	164832	45339	138032	31139	6.15	3.19
Total	78500	41000	505716	138873	427216	97873	19.34	10.18
Average	26166	13667	168572	46291	142405	32624	6.45	3.39

The scientists are directly involved in planning, execution, and monitoring of the demonstrations for the improved technologies developed by them and having close contact to get feedback from the beneficiaries' farmers about the crop production. Many farmers are deprived of benefit of the new improved agricultural technologies. Looking to the above facts, present studies on front line demonstration was conducted on farmers' field with a view to demonstrate the performance of improve technology SMI towards the enhancement of mustard production in adopted villages. This was an innovative approach to increase productivity of mustard by changing the management pattern of soil, plant, moisture, and nutrient.

The National Bureau of Plant Genetic Resources has listed 664 varieties of mustard in its collection and India needs to promote research and explore the use of SMI on these varieties is also supported by Association for Sustainable and Holistic Agriculture (ASHA). SMI allows resource-poor farmers to use less water and seed to achieve significantly higher yields over traditional practices.

Materials and Methods

Principles of SMI / Seed Rate

Seed rate must be lower than normal planting *i.e.*, 200-250 g/ha. Seed required for 100-120 days maturing cultivars. For longer duration cultivars seed rate should be higher than shorter duration.

Nursery Management and Nursery Sowing

The performance of system of mustard intensification1 SMI require a raised bed of 4-6 inch above the ground and width should be 1m width. After 6-8 hours of priming of seed can be treated with *Trichoderma*@20 g/kg of seed. Sprouted seeds should be placed at a depth of 1-1.5 cm maintaining a spacing of 5×5 cm. Seeds should be covered with vermin compost and paddy straw mulch. Sprinkling of water was done to maintain moisture at morning and evening after nursery swing. Area of nursery should be 50 m^2/ha. for 100-120 days variety.

Preparation of Main Field

Fields were ploughed 2-3 times by farmers, one supplemental irrigation was applied where it is needed and weeds were removed. Marks were made by using a rake or spade maintaining the spacing. Each marked place was filled with a mixture. Mixture was prepared with 20 tons compost, 4 kg *Trichoderma*, 70 kg DAP, and 35 kg MOP per hector.

Transplanting

Nursery was well irrigated for easy uprooting of seedlings. Seedlings were transplanted at 8-12.

Days old or 3-4 leaf stage. Square planting was followed with 45 cm × 45 cm for 100-120 days crop. Seedlings were transplanted at a shallow depth in every marks made at the time of final land preparation.

Managements after Transplanting

At 15 DAT plants were supplied with 30 kg N/ha., weeding was within 20 DAT to reduce the weed competition (only hand weeding was done). Second irrigation was applied at 30 DAT followed by weeding. Fields were irrigated at 45 DAT after applying urea at root zone 15kg N/ha. At 40 DAT plant can be provided with 20 kg K/ha along with weeding with the help of a weeder. Reproductive stage is very susceptible for pest attack, especially aphid, to avoid its attack crops were sown in the 2nd fortnight of October.

A total number of 36 SMI demonstration with adjacent plot of local practices were conducted by Krishi Vigyan Kendra, Mandla (Zone-III, Northern hill of Chhattisgarh) in the 14 villages in an area of 15 ha. The mustard growers were selected for cultivation of improves variety of RP-09 grown with transplanting method under different micro farming situation in the district. Present investigation was carried out to study the performance of mustard with SMI at farmer's field.

Seed Priming and Seed treatment

Seed was primed in a mixture of lukewarm water, cow urine, jaggery and vermicompost. Amount of water was just double the number of seed and the other ingredients were just half of the seed. After 6-8 hours of priming seed was mixed with *Trichoderma* @ 20 g, *Rhizobium* 20g and Phosphorus solubilizing bacteria (PSB) 20g /kg of seed was mixed. The nursery raising programme was started in last week of September for *Rabi* season of2012-13, 2013-14 and 2014-15.

The observations were taken from 10 randomly selected plants in each plot on different aspects. Field days and group meetings were also organized to provide the opportunities for surrounding farmers to witness the benefits of demonstrated technologies. Data were collected by KVK, scientists. The crops were harvested after 100 -120 DAT at maturity stage. The following parameters viz, Technological gap between the potential yield and demonstrated yield, extension gap between demonstrated yield and farmers yield, technological index and seed yield under existing practices were calculated with the help of formulas [3].

Per cent increase in yield over F.P. = [(Demonstration yield-Farmer practice yield) / Farmer practice yield] × 100

Technological gap = Potential Yield-Demonstration Yield

Extension gap = Demonstration yield- Yield under farmer practice

Technological index = [Technology gap / Potential yield] X 100

Cost benefit (B:C) ratio= Grass return/ Grass cost

Results and Discussion

Gap analysis between SMI and farmers practices

Based on recommended/ farmers practice mustard cultivation data were collected from the farmers were analyzed and presented in [Table-1]. It reveals that out of nine parameters, full gap was found in six parameters *i.e*., using of traditional varieties and degenerated seeds, higher seed rate more than 5 times (very dense plant population), no seed treatment, no plant protection measures and without use of inoculation. Whereas, partial gap was found in two parameters *i.e*., Manures & Fertilizers and method of sowing & spacing. No gap was found in land preparation.

Yield attributing Characters

Yield attributing characters is given in [Table-2] revealed that average plant height was observed 185, 176 and 166 cm./year during 2012-13, 2013-14 and 2014-15 in SMI technology whereas in traditional method it was 122,134 and 126 cm. respectively. Pooled height of three years was 176 cm. in SMI technique as against 127 cm. in traditional practice/ farmer's practice. Number of branches/plants 8,11 and13 in SMI technique as against 03, 05and 04 branches in traditional practice. Mean of three years no. of branches indicate that11 branches in SMI and 04 branches in farmer's practice. Numbers of siliqua/plant was632, 780 and868 siliqua/plant in SMI technique while 55,75and 62 siliqua/plant in farmer's practice. Mean of three years revealed that760 siliqua/plant was observed in SMI technique as against 64 in farmer's practice. Weighing of yield/ plant was found 470, 487and 498 gm./plant in SMI technique whereas 86, 83 and 89 gm./plant in farmer's practice. SMI technique showed better response in yield attributing characters in all respect. The result in pigeon pea where Doni planting with scooping gave the higher values for growth and yield attributing characters.

Productivity, extension gap, technology gap and technology index of mustard as grown under SMI and traditional practice is given in [Table.3] revealed that average yield of 36 SMI demonstration shows 32.86, 33.98 and 32.32 q/ha were higher as compare to 9.78, 8.56 and 9.08 q/h in traditional/ farmers practice in each year. Pooled mean of three years shows 33.05 q/ha as against 8.08 q/ha *i.e*., higher 265% over farmer's practice. The yield enhancement due to SMI intervention was 235.99%, 296.96% and 263.55% superior over farmers practice (FP) in respective years. SMI was found to be superior in all the manners in all the years as compare to farmer's practices under demonstrated plot. Authors supported the result in rice variety MTU-1081 planted with SRI method gave significantly higher yield [4] and [5]. The cumulative effect of the technological intervention over three years, revealed that on an average yield of 33.05 q/ha was recorded which was265.50 % higher over FP. Extension gap q/h indicates that 23.08, 25.42 and 23.43 average of three years shows 23.98 q/ha. Technological gap revealed that +12.86,+ 13.98 and+ 12.12 q/ha higher from potential yield of the variety. Average of technology gap + 12.99 q/ha indicate that technology proved more beneficial to explore higher yield than potential yield. Percent yield index was also higher 64.30, 66.90 and 60.60 over farmers practice, mean of three years indicate 63.93% over farmers' practice.

Profitability of SMI Over Traditional practice of Mustard

Average cost of cultivation, average gross return, average net return and B:C ratio was worked out as above-mentioned formulae.

Cost of cultivation

Cost of cultivation of SMI technique and traditional practice is mentioned in [Table-4] revealed that Rs.25200,26500 and 26800/- ha^{-1}. in SMI technique as compare to farmers practice Rs.13200/-, 13600/- and 14200/-ha^{-1}. in traditional practice Pooled mean indicate that higher cost Rs.26166 ha^{-1} in SMI Technique and 13667/- ha^{-1} in traditional practice.

Average gross Return Rs./ha

The average gross return Rs. 167586/- 173298/- 164832/- ha^{-1} in SMI as against RS.49878/- 43656/- and 43339/- ha^{-1} in farmer's practice. Pooled mean of three years indicates that Rs.168572/- per ha in SMI and Rs.46291/- per ha in farmers practice was just one fourth of SMI technique.

Net Return and B:C ratio

The yield performance and economic indicators are presented in [Table-4]. The data revealed that net return Rs.142386/-, 146798/- and 138032/- per ha was found in SMI while Rs.36678/- 30056/- and 31139/- per ha in farmers practice, yield of all SMI demonstrated plots of mustard was found to be higher in all the manners in all the years. The SMI package of practices was higher as compare to farmer's practices. Under demonstrated plot, the performance of mustard yield was found to be just four times higher to farmer's practices during three consecutive years. The B:C ratio of SMI was found 6.65, 6.54 and 6.15 where as in farmer's practice it was 3.78, 3.21 and 3.19. Pooled mean of three years revealed that 6.45 in SMI and 3.39 in farmers practices. Yield of mustard variety RP-9 was recorded, 32.86, 33.98 and32.32 q/ha respectively during2012-13, 2013-14 and 2014-15.

Conclusion

Mustard is one of the most important oilseed crops of India sharing 91% of world production. There is a huge gap between production and consumption for which nation must import from other countries. It is observed that it is very sensitive crop against pests and diseases. Hence to harvest the bumper production of mustard, demonstration on large scale (15 hectors) were carried out on farmers field in three consecutive years (2012-13, 2013-14 and 2014-15). System of Mustard Intensification (SMI) with the variety RP-9 was demonstrated and it showed good result *i.e*., average plant height 176 cm., No. of branches 11, No. of siliqua760 and finally 485 g./plant yield as comparison to traditional practice *i.e*., plant height 127 cm., 04 branches/plant ,64 siliqua/plant and 86 g. yield/plant.

Average yield 33.05q/ha in SMI as against 9.08 q/ha in farmers practice, it is higher 265.50 % over farmers' practice. Pooled mean of extension gap, technological gap and yield index was 23.98(q/ha), +12.99 (q/ha) and 63.93 % respectively. Average cost of cultivation was Rs.26166/-ha in SMI while Rs.13667/- in farmer's practice. Average gross return, Net return, and B:C ratio was Rs. 168572/- ha, Rs., 142405/- ha and 6.45 in demonstrated practice as against Rs.46291/- ha, Rs. 32624/- ha and 3.39 in farmer's practice

Application of research: Field operated and farmers may use the technology of SMI for enhancement of their crop yield.

Research Category: Agriculture Extension

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Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Umariya district

Cultivar / Variety / Breed name: *Brassica rapa* L. var. brown sarson, *Brassica rapa*. var. toria, Black mustard (*Brassica nigra*), *Brassica rapa* L. var. yellow sarson, Indian mustard (*Brassica juncea*), Taramira (*Eruca sativa/vesicaria*), Gobhi sarson (*Brassica napus*), Ethiopian mustard or Karan rai (*Brassica carinata*)

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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