

Relay seeding of berseem

in mustard crop influences system productivity and economics

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In the semi-arid tropics, mustard-based cropping systems grown in monocropping resulted in declined soil fertility, system productivity and profitability. It was observed that by growing the relay crop of berseem in mustard, soil fertility, system productivity and profitability can be improved. The relay cropping of berseem in mustard was introduced in 2018–19 in 32 ha in Farmer First Programme (FFP) project adopted villages of Morena district of Madhya Pradesh and its adoption has expanded to 11,800 ha. Compared with existing system of without relay cropping, the relay legume crop of berseem enhanced the productivity of rainy (kharif) season crops- pearl millet, paddy and greengram and winter (rabi) season mustard. Like-wise system-based mustard equivalent yield (MEY) in relay cropping system increased from 35–62% with additional net profit from ₹29,000-46,300/ha as compared to without relay cropping. The water productivity was also increased from 6–19% with relay cropping as compared to without relay system. Thus, the relay cropping of berseem in mustard gained popularity among farmers as an appropriate farm adequate, knowledge-intensive, eco-friendly, profitable and socially acceptable technology.

Keywords: Adaptability, Berseem, Mustard-based system, Relay cropping, System productivity

In oilseed crops, Indian mustard (*Brassica juncea*) is second most important crop grown with pearl millet/greengram/blackgram/maize/paddy-based cropping systems. These cropping systems are grown in limited irrigated areas as monocropping under intensive tillage, improper crop establishing and imbalanced use of chemical fertilizers. The cultivation practice of mustard has been showing signs of fatigue and stagnating productivity. Reasons behind are deteriorating soil health and resources due to monocropping, mechanized intensive and repeated tillage, and burning of crop residues. To improve system productivity, it is necessary to diversify the existing system through legume crop-based relay cropping system. The present innovative study on legume crop of berseem (*Trifolium alexandrinum*) relayed in mustard in pearl millet/

paddy/greengram cropping systems was conducted in FFP project adopted villages of Morena district of Madhya Pradesh.

Methodology adopted

A field study was carried out at selected farmer fields at Barauli, Santa and Hadbansi adopted villages under the FFP project in Morena district for 3 years (2018–19 to 2020–21). An innovative relay cropping of berseem was established in standing mustard crop grown in rotation with pearl millet/paddy and greengram cropping systems. As per treatments, pearl millet (var.-NHB 4903), paddy (var.-Pusa 1509) and greengram (var.-Shikha) were raised during rainy (*kharif*) season followed by succeeding crop of mustard (var.- Giriraj) raised in winter (*rabi*) season. After the establishment of 30–35 days of mustard, berseem (var.- Warden) seeds were sown by uniform broadcasting @20 kg/ha just

before first irrigation of mustard. The seed treatment of berseem was done with captan (2 g/kg seed) followed by *Rhizobium trifoli* and *Pseudomonas fluorescens*. The recommended agronomical packages practices were followed. As per FFP project's general standards, demonstration plots size was 4,000 m².

The relay crop of berseem was grown in residual soil fertility of mustard. After harvest of mustard (March), 3 irrigations at tillering, head formation and seed filling stages of berseem were given. Pod borer (*Helicoverpa armigera*) is a serious polyphagous sporadic pest in berseem seed production, which damages the berseem head by common pod borer. This pest was controlled by using spinosad @150 ml/ha at the economic threshold level. The berseem crop was harvested during 3 to 4th week of May. The seed and straw yields of



Berseem crop at early growth stage in mustard crop

individual crops were recorded.

Technology adoption measurement

rainy season crops: The grain yield of rainy season crops (pearl millet, paddy and greengram) increased from 9.4–10.8% and stover yield from 7.3–12.2% with relay berseem as compared with without relay cropping (Table 1). The relay cropping berseem improved grain yield of paddy with maximum (10.8%), followed by pearl millet (10.1%) and least with greengram (9.4%). Among rainy season crops, higher production cost of paddy varied from ₹33,200–34,100/ha followed by pearl millet (₹23,600–24,100/ha) and least with greengram

(₹21,400–22,900/ha). The higher yield of rainy season crops grown in relay cropping fields increased additional returns from ₹3,300–6,600/ha as compared without relay cropping. The trend of NRs was maximum (₹54,400/ha) with paddy followed by pearl millet (₹47,400/ha) and lowest with greengram crop (₹33,600/ha) in relay cropping system. Relaying legume berseem residues improves soil properties resulting in greater productivity of crops, system and net profit. The B:C ratio was higher with relay cropping (2.6–3.1) as compared to without relay cropping (2.3–2.8).

Winter season crop (mustard): Results of relay cropping technology led to an improvement in seed yield of winter crop mustard from 8.5–11.3% and straw yield from 6.6–8.8% as compared without relay cropping (Table 1). Among rainy season crops, greater output of mustard crop was when grown in relay cropping system after greengram followed by pearl millet and lowest with paddy-based cropping systems. By adoption of relay cropping systems, a slightly higher production cost was (₹600–900/ha) found compared with total cultivation cost without relay cropping (₹27,600–30,600/

ha) of mustard. The maximum additional NRs was with mustard (₹8,900/ha) grown after pearl millet followed by greengram (₹8,200/ha) and least with paddy (₹6,400/ha). The B:C ratio ranged from 3.1–3.3 with relay cropping, whereas it was 2.9–3.1 without relay cropping.

System productivity

The mustard equivalent yield (MEY) of system productivity increased from 35.0–60.6% with relay cropping as compared to without relay cropping (Table 2). Among cropping systems, the paddy - mustard + berseem system gave the highest MEY (4.86 t/ha) followed by greengram - mustard + berseem (4.57 t/ha), pearl millet - mustard + berseem (4.28 t/ha) and lowest was with fallow - mustard + berseem (3.28 t/ha). Legume crop berseem is known to improve soil fertility over years contributing to increased productivity.

System economics

The system-based NRs were greater with relay cropping berseem compared to without relay cropping systems (Table 2). The cultivation cost slightly increased from ₹15,300–15,800/ha of relay cropping berseem

Table 1. Effect of relay cropping berseem in mustard-based cropping systems on productivity and profitability (3-years pooled data)

Cropping system		No. of farmer	Grain yield (tonne/ha)		Stover yield (tonne/ha)	Production cost	Net returns	B:C ratio
System	Crop		Range	Mean				
F-Mustard	Mustard	24	1.78-2.64	2.03	3.64	30.6	63.0	3.1
F-Mustard + Berseem	Mustard	24	1.82-2.95	2.26	4.15	31.4	73.1	3.3
	Berseem		0.36-0.58	0.45	1.92	14.5	30.7	3.1
Pearlmillet - Mustard	Pearl millet	21	2.40-3.45	2.87	5.41	23.6	44.1	2.8
	Mustard		1.77-2.67	1.88	3.01	29.6	56.3	2.9
Pearlmillet - Mustard + Berseem	Pearl millet	21	2.67-3.84	3.05	5.62	24.1	47.4	3.0
	Mustard		1.84-2.81	2.09	3.16	29.9	65.2	3.2
	Berseem		0.32-0.51	0.40	2.01	15.0	25.4	2.7
Paddy - Mustard	Paddy-	16	4.12-5.16	4.46	5.46	33.2	50.8	2.5
	Mustard		1.71-2.52	1.76	3.15	27.8	53.4	2.9
Paddy - Mustard + Berseem	Paddy	16	4.30-5.46	4.67	5.86	33.8	54.4	2.6
	Mustard		1.86-2.72	1.91	3.38	28.2	59.8	3.1
	Berseem		0.40-0.61	0.46	1.85	14.8	31.2	3.1
Greengram - Mustard	Greengram-	21	0.51-1.12	0.71	1.64	21.4	27.0	2.3
	Mustard		1.84-2.81	1.99	3.20	29.4	61.5	3.1
Greengram - Mustard + Berseem	Greengram-	21	0.61-1.18	0.82	1.74	22.1	33.6	2.5
	Mustard		2.07-3.09	2.19	3.42	30.2	69.7	3.3
	Berseem		0.39-0.64	0.49	1.92	14.4	34.6	3.4

Table 2. Effect of relay cropping berseem in mustard-based systems on system-based productivity, economics and water productivity (3-years pooled data)

Cropping system	System productivity (tonne/ha)	Cultivation cost (000' ₹/ha)	Net profit	B:C ratio	Total water-use (mm/ha)	Water productivity (kg seed/mm-ha)
Fallow - Mustard	2.03	30.6	63.0	3.1	182	11.2
Fallow - Mustard + Berseem	3.28	45.9	92.0	3.0	362	9.1
Pearlmillet - Mustard	3.10	53.2	77.3	2.5	565	5.4
Pearlmillet - Mustard + Berseem	4.28	69.0	111.6	2.6	770	5.7
Paddy - Mustard	3.60	61.0	90.3	2.5	961	3.8
Paddy - Mustard + Berseem	4.86	76.8	128.2	2.7	1141	4.3
Greengram - Mustard	3.09	50.8	79.3	2.6	495	6.2
Greengram-Mustard + Berseem	4.57	66.7	125.6	2.9	703	6.5

F-Fallow, B:C ratio- Benefit cost ratio, Minimum support price of seed in Rupees (₹) for year 2018–19, 2019–20 and 2020–21 for pearl millet @ ₹14250, 19500 and 20000/t; mustard ₹40000, 42000 and 44250/t; paddy ₹15,900, 17,700 and 18350/t; greengram ₹55750, 69750 and 70500/t and berseem (local market) ₹90,000, 95,000 and 100,000/t; stover in local market @ ₹2500, 3000 and 3500/t for pearl millet; ₹2,000, 2,250 and 2,500/t for mustard; ₹1000, 1250 and 1500/t for paddy and greengram and berseem, respectively.

in mustard crop grown in systems. Among the system, the maximum additional net returns was received with greengram - mustard + berseem (₹46,300/ha) followed by paddy - mustard + berseem (₹37,900/ha), pearl millet - mustard + berseem (₹34,300/ha) and lowest with fallow - mustard + berseem (₹29,000/ha). Higher net returns with relay berseem was owing to improve soil fertility and ability of the soil to absorb rainwater and supply it to crops. Also the higher B:C ratio was received with pearl millet, paddy and greengram based mustard relayed berseem compared to without relayed berseem.

Total water-use

The TWU in all cropping systems was higher with relay cropping than without relay cropping (Table 2). The maximum TWU with relay cropping was recorded with paddy - mustard + berseem (1141 mm/ha) followed by paddy - mustard (961 mm/ha), pearl millet - mustard + berseem (770 mm/ha), greengram - mustard + berseem (703 mm/ha), pearl millet - mustard (565 mm/ha), greengram - mustard (495 mm/ha), fallow - mustard + berseem (362 mm/ha) and least with fallow-mustard (182 mm/ha).

Water productivity

The rainy season crop-based mustard relayed berseem cropping system increased WP from 5.5 to 13.2% as compared to without relay cropping (Table 2). The variations of WP due to higher yield advantage of relay cropping were due to constant soil moisture availability which supports the concept of better soil moisture environment. Overall WP of the system was maximum increased by 13.2% with paddy - mustard + berseem followed by greengram - mustard + berseem (6.5%) and lowest by pearl millet - mustard + berseem (5.5%), whereas decreased by 18.8% with fallow-mustard + berseem as compared without relay cropping.

Table 3 Effect of relay cropping berseem in mustard-based systems on soil physicochemical properties after 3rd harvest of berseem

Cropping system	EC (dS/m)	pH	OC (g/kg)	Available nutrients (kg/ha)			
				N	P	K	S
Fallow - Mustard	0.49	7.98	0.38	182	10.4	224	11.4
Fallow - Mustard + Berseem	0.36	7.81	0.42	218	12.2	314	13.6
Pearlmillet - Mustard	0.52	7.84	0.32	172	9.4	210	10.6
Pearlmillet - Mustard + Berseem	0.42	7.70	0.41	204	11.3	221	12.8
Paddy - Mustard	0.41	7.75	0.40	191	8.7	195	10.6
Paddy - Mustard + Berseem	0.32	7.62	0.46	221	10.6	209	12.4
Greengram - Mustard	0.42	7.80	0.36	210	10.1	213	12.1
Greengram - Mustard + Berseem	0.30	7.64	0.42	234	12.0	230	14.2

Physicochemical properties

The positive changes in soil organic carbon (OC) and available macronutrients (N, P, K, and S) were observed, while electrical conductivity (EC) and pH were decreased with relay cropping as compared to without relay cropping showed systems (Table 3). The crop establishment with relay cropping showed slight decrease in EC (0.09–0.13 dS/m) and pH by 0.13–0.17 as compared with without relay cropping systems. The maximum additions of available macro-nutrients were 24–36 kg N, 1.8–2.1 kg P, 17–24 kg K and 1.8–2.2 kg S/ha as compared to without relay cropping. The nutrients accumulated due to retention of higher amounts of berseem residue (1.85–2.01 tonne residue/ha/year) rich in plant nutrients.

Impact on technology adoption

The results presented in Table 4 indicate that the diversification of mustard-based cropping with relay cropping berseem in mustard crop improved soil fertility resulting in improvement in grain yield and additional benefits. The berseem seed production increased income of farmers and also acted as flora for honey bees. This practice is supporting dairying and beekeeping enterprises. The beneficial impact on total adopted area, additional total seed production and net returns were 11,800 ha, 2242-tonne mustard and 5310-tonne berseem, and ₹7415 lakh/year with innovative relay berseem in mustard crop, respectively (Table 4).

Table 4. Estimated impact of relay cropping in standing mustard crop on area coverage, total yield and net benefits

Intervention	Area coverage (ha)	Total grain production (tonnes)		Total cultivation cost (lakh ₹)		Net income (lakh ₹/year)		Additional net income (lakh ₹/year)
		Mustard	Ber-seem	Mustard	Ber-seem	Mustard	Ber-seem	
FP (2018–19)		61	-	9.3	-	24.4	-	-
IP	32	68	14.4	9.6	4.7	27.2	13.0	15.8
FP (2020–21)		22656	-	3446	-	10535	-	-
IP	11,800	24898	5310	3540	1735	11578	6372	7415

FP, Farmers' practice; IP, Relay cropping berseem in standing mustard; technology impact based on sample survey during 2020–21 in Morena district, minimum support price of grain in INR(₹) for year 2018–19 and 2020–21 for mustard @ ₹40,000 and 46,500/tonne and berseem (local market) ₹90,000 and 120,000/tonne, respectively.



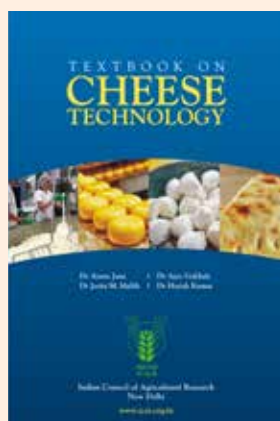
Relay crop berseem after harvest of mustard

SUMMARY

The crop production under monocropping systems is declining soil fertility, system productivity, profitability and water productivity over time. In these conditions, relay cropping reformed soil properties and improved system productivity, economic profitability and WP. The yield of crops, MEY, NRs and WP with relay cropping legume crop berseem were enhanced compared without relay cropping. Likewise, MEY and NRs were greater with paddy-mustard followed by greengram-mustard, pearl millet-mustard and lowest with fallow-mustard grown in berseem as relay cropping in mustard; thus, it is considered the best practice to maintain soil fertility, food security, and profitability. As per our findings, the mustard crop establishment and relay cropping of legume crop berseem in mustard have overall beneficial and wide scope for its adoption in similar agro-ecologies.

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