Received: 25 July 2024 | Accepted: 27 December 2024 | Published online: 22 February 2025

DOI: 10.59797/ijsc.v52.i3.180

ORIGINAL ARTICLE

Indian Journal of Soil Conservation

Relay sowing of berseem (*Trifolium alexandrinum*) in mustard (*Brassica juncea*) improves system productivity, economics and soil fertility

Y.P. Singh | Sandeep S. Tomar | Sushma Tiwari | Ravi S. Yadav | S.K. Dubey*

Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India.

***Corresponding Author :**
E-mail: skdubeyagara@gmail.com

Handling Editor :
Dr Dinesh Jinger

ABSTRACT

Mustard-based mono-cropping systems have been experiencing a decline in productivity, economic profitability and soil quality in India's arid and semi-arid climate. An on-farm research study was conducted from 2017-18 to 2021-22 to address these issues. This study focused on the relay cropping of the legume fodder crop berseem (*Trifolium alexandrinum* L.) alongside standing mustard, which was grown after fallow, pearl millet, paddy and green gram-based cropping systems. Including berseem as a relay crop in mustard cultivation, significantly greater soil organic carbon and its stock, macro- and micronutrient availability in soil and use-efficiency of land. Enhancements physicochemical properties of soil led to an increase in seed yields of pearl millet, paddy and green gram by 10-15%, followed by a 9-14% increase in mustard yield as compared to the existing cropping systems. Notably, the highest seed yield of berseem occurred when it was relay seeded in a fallow-mustard cropping system, followed by green gram-mustard and pearl millet-mustard. The lowest yield was observed in paddy-mustard cropping systems. The studies revealed that the mustard equivalent yield (MEY) in the legume-based relayed berseem cropping systems increased by 33-66%, resulting in an additional net profit ranging from ₹ 40,000-51,000 ha^{-1} as compared to traditional cropping systems. Water productivity was significantly enhanced by 5-14% when relay cropping berseem in mustard-based systems. However, it declined by 15% when berseem was relayed after mustard was grown in the fallow *kharif* season. Overall, the trend for MEY and net returns under the relay cropping of berseem in mustard-based systems was ranked as follows: paddy-mustard > pearl millet-mustard > green gram-mustard > fallow-mustard. This study demonstrated that relay cropping of berseem within mustard-based cropping systems can improve crop productivity, increase net profitability, enhance water productivity and positively affect soil physicochemical properties.

Key words:
Berseem
Mustard-based cropping system
Relay cropping
Soil physicochemical properties
System productivity

1 | INTRODUCTION

Among oilseed crops, Indian mustard (*Brassica juncea*) is a major oilseed crop. It is grown in mono-crop or rotation with pearl millet, green gram, black gram, maize or paddy under irrigated and rainfed conditions in 7.99 M ha areas. In recent decades, mustard-based cropping systems have shown signs of fatigue and stagnating productivity. Intensive tillage, improper time and methods of crop sowing, crop residues burning, and imbalanced utilisation of chemical fertilizers resulted in deteriorating soil quality and resources are some of the factors contributing to the declining performance of mustard crop (Fustec *et al*., 2010; Singh *et al*., 2020a).

The fallow-mustard system is followed in major mustard-grown areas of India's Central and Western parts (Gupta *et al*., 2019). However, studies showed that the *kharif* season crops incorporated in a mustard-based system impact better resource utilization and high remuneration (Shekhawat *et al*., 2012). Soil quality is directly linked to land utilisation, cropping, land management practices (Singh *et al.,* 2021), and crop and water productivity (Singh *et al*., 2023). Intensive cropping without legume crops fosters high nutrient extraction levels from soils without natural replenishment. Scanty practices of green manure and legume-based cropping patterns have led to the declining content of soil organic matter and soil fertility (Acharya *et al*., 2019; Singh *et al*., 2023). The

relay sowing of legume crop berseem in mustard crops could help restore crop productivity (Singh *et al*., 2020b). To improve productivity and make it profitable, reduced tillage, minimal soil disturbance, use of crop residues of the previous crops as mulch and practising a legume-based relay cropping system are among the viable alternatives to conventional agricultural practices (Singh *et al.,* 2020b). In this context, the current study aims to investigate the impact of relay cropping of legume crop berseem in mustard within mustard-based cropping systems grown as fallow-mustard, pearl millet-mustard, paddy-mustard and green gram-mustard on the productivity of different crops and systems, economics, water productivity and soil physicochemical properties of Alluvial soils.

2 | MATERIALS AND METHODS

A 5 yr field trials were initiated from 2017-18 to 2021-22 at on-farm locations under the Farmer First Programme (FFP) project in the Morena district of Madhya Pradesh. The study location has a semi-arid climate, severely cold from Dec to Jan (1.0 °C minimum temp.), and hot from May to June (49 °C maximum temp.). The weekly mean of the minimum and maximum relative humidity ranges from 23.3-88.0% and 38.1-90.4%, respectively. The annual rainfall mean of 40 yrs is 650 mm, mainly received in July and Aug month. At the time of the 5 yr study, the minimum and maximum temp. were 0°C and 48°C, respectively. The total annual rainfall received was 396, 606, 628, 514 and 684 mm during 2017-18, 2018-19, 2019-20, 2020-21 and 2021-22, respectively. The soils of selected fields were sandy loam with the texture of an old alluvial plain. The samples of soil were assembled randomly with 0-15 cm upper soil layer after the harvest of the fifth relay cycle of berseem in mustard-based cropping systems from different locations. Three plot samples were thoroughly mixed before making a composite soil sample. Soil samples were ground in a wooden mortar, passed through a 2 mm sieve, and stored in plastic bags for analysis following standard procedures described by Jackson (1973). The soils of the selected locations were neutral to alkaline and deficient in organic carbon content, available N, P, S, and Zn, while medium in available K.

The spacing between row to row for pearl millet, paddy, green gram, and mustard were 45, 25, 30 and 30 cm while using 4, 20, 20 and 4 kg seed ha^{-1} for sowing, respectively. At 35-40 days after sowing (DAS) mustard, berseem (Var.-*Wardan*) were sown uniformly with broadcasting @ 20 kg ha^{-1} just prior to the first irrigation of mustard. The seed treatment of berseem was done with *captan* (2 g kg^{-1} seed) followed by *Rhizobium trifoli* and *Pseudomonas fluorescens*. A recommended agronomical package of practices was adhered to raise the experimental crops. The total plot area of 4,000 m^2 was divided into two equal parts. Each intervention had five locations, and four cropping systems with and without relayed berseem were established. The twenty experimental plots were organised in a randomized block design. The least significant difference test was applied for the treatment mean comprised of 5% critical differences (Panse and Sukhatme, 1954).

HIGHLIGHTS

- Higher productivity of pearl millet, green gram, paddy and mustard with relay cropping of berseem.
- Improved water productivity with relay cropping berseem in mustard based systems.
- Increased productivity and net gains from relay crop berseem in mustard based system.
- Relay cropping of berseem crop in mustard improved soil physicochemical properties.

As per recommendations for pearl millet, full recommended doses of P, K, and Zn were 18, 17, 5 kg ha^{-1}, and 40 kg ha^{-1} N was given at the sowing time, and the rest 40 kg ha^{-1} used at 30 to 40 DAS in two splits. For paddy, full suggested doses of P, K, and Zn were 26, 33, and 5 kg ha^{-1} and 20 kg N were mixed at the time of puddling as basal application, and the remaining 100 kg N ha^{-1} was used in three equal splits at tillering, panicle initiation and heading stage. Full recommended N, P, K, S, and Zn doses were 20, 22, 25, 30 and 5 kg ha^{-1} applied to green gram at sowing. In the mustard crop, the full recommended dose of P, K, S and Zn was 26, 33, 40 and 5 kg ha^{-1} was applied at sowing, while N was applied in two splits of 50 kg ha^{-1} at sowing time and the remaining 50 kg ha^{-1} at flowering initiation (about 40 DAS). The berseem was grown in residual nutrition of mustard. The mustard crop was harvested in the first week of March each year. After the harvesting of mustard, three irrigations were given during the berseem crop's tillering, head formation and seed filling stages. To control pod borer (*Helicoverpa armigera*), *spinosad* @ 150 ml ha^{-1} at the economic threshold level was applied in berseem. The berseem crop was harvested during 3rd to 4th week of May. The crop yield was recorded for individuals grown in the systems.

Seed and straw yield, gross and net returns and benefit-cost ratio were calculated. The economics of the crops and the systems between the sowing and harvest of crops were examined. The total water use (TWU) was calculated with the formula used by Singh *et al*. (2021). The water productivity was calculated by seed yield (kg ha^{-1}) divided by TWU (mm water-ha). The system productivity of different crops was calculated with the yields of non-mustard crops converted into mustard equivalent yield (MEY) for pearl millet, as shown by Singh *et al.* (2020a).

$$\text{MEY (t ha}^{-1}\text{)} = \frac{\text{Pearlmillet seed yield (t ha}^{-1}\text{)} \times \text{Minimum support price of pearlmillet (₹ t}^{-1}\text{)}}{\text{The minimum support price of mustard (₹ t}^{-1}\text{)}}$$

The land use efficiency was estimated using equation given below:

$$\text{Land use efficiency (\%)} = \frac{\text{The total duration of crops}}{365} \times 100$$

3 | RESULTS AND DISCUSSION

3.1 | Crop Productivity and Production Cost

Relay sowing of berseem in mustard significantly increased the seed yield of pearl millet, paddy and green gram from 10-15% and straw yield from 7-16% grown in mustard-based systems as compared to without relay cropping (Table 1). The maximum seed yield improved in paddy was 15%, followed by pearl millet at 12%, and the least was recorded with green gram (10%) under the relay cropping with legume crop berseem. The retention of berseem residue and nitrogen fixation with microsymbiont of legume crop berseem grown as a relay crop resulted in a congenial impact on soil quality and crop yield over the years (Singh *et al*., 2021). Among *kharif* season crops, the production cost of paddy varied from ₹ 34,100-34,600 ha^{-1}, followed by pearl millet (₹ 24,300-25,000 ha^{-1}) and the least with green gram (₹ 22,100-23,000 ha^{-1}). The higher yields of pearl millet, paddy and green gram crops grown in mustard-based relay cropping of Berseem resulted in the maximum additional gain in net returns with paddy (₹ 8,300 ha^{-1}) followed by pearl millet (₹ 6,300 ha^{-1}) and the lowest with green gram (₹ 5,500 ha^{-1}) as compared to without relay cropping. Relaying legume berseem residues improved soil quality, resulting in greater productivity of crops and, in turn, increased net returns.

Relay cropping of berseem significantly improved the seed yield of mustard from 8-14% and its straw yield from 9-15% as compared to without relay cropping (Table 1). Mustard grown after the fallow *kharif* season gave the significantly highest yield. At the same time, in the various cropping systems, the maximum seed yield of mustard was observed when grown after green gram, pursued to pearl millet, and lowest with paddy crop. Legume crop berseem is known to enhance soil physicochemical properties (Singh *et al.,* 2020b), rendering it tremendously influenced crop yield over the years. Compared to various cropping systems, the berseem seed yield was significantly greater when grown into fallow-mustard, followed by green gram-mustard, pearl millet-mustard and lowest with paddy-mustard cropping systems.

The establishment of relay cropping systems incurred additional production costs on mustard, which was higher (2.4-3.0%) than the total cultivation cost without relay cropping (₹ 28,300-34,200 ha^{-1}). However, it resulted in the highest additional net return of mustard (₹ 15,500 ha^{-1}) with relay cropping of berseem grown in fallow *kharif* season plots followed by pearl millet (₹ 9,000 ha^{-1}), green gram (₹ 8,300 ha^{-1}) and least with paddy (₹ 6,600 ha^{-1}) plots as compared with without relay cropping. Singh *et al*. (2020b) reported that the relay berseem crop in mustard had

TABLE 1 Relay cropping of berseem in mustard-based cropping systems affects on crop yield and economics (5 yr pooled data)

Treatments	Seed yield (t ha^{-1})			Production cost (000 ₹ ha^{-1})		
	Kharif	*Rabi*	Relay crop	*Kharif*	*Rabi*	Relay crop
Fallow-Mustard	-	2.14 (3.72)*	-	-	34.0	- (61.1)**
Fallow-Mustard+Berseem	-	2.41 (4.28)	0.52 (2.06)*	-	34.8 (76.6)	14.8 (39.6)**
Pearlmillet-Mustard	2.87 (5.26)*	1.93 (3.11)	-	24.3 (45.5)**	30.1 (58.1)	-
Pearl millet-Mustard+Berseem	3.21 (5.68)	2.19 (3.39)	0.45 (1.91)	25.0 (51.8)	30.9 (67.1)	15.6 (27.6)
Paddy-Mustard	4.33 (4.43)	1.80 (3.02)	-	34.1 (50.4)	28.3 (55.3)	-
Paddy-Mustard+Berseem	4.96 (4.96)	1.96 (3.36)	0.41 (1.81)	34.6 (58.7)	29.0 (61.9)	15.5 (33.4)
Greengram-Mustard	0.74 (1.64)	2.09 (3.21)	-	22.1 (30.2)	30.2 (63.6)	-
Greengram-Mustard+Berseem	0.81 (1.89)	2.28 (3.56)	0.47 (1.93)	23.0 (35.7)	31.1 (71.9)	15.1 (36.8)
S Em±	0.02 (0.07)	0.02 (0.04)	0.01 (0.02)	0.5 (0.9)	0.5 (1.1)	0.6 (0.8)
CD (p = 0.05)	0.07 (0.21)	0.05 (0.12)	0.03 (0.06)	NS (2.8)	NS (3.4)	NS (2.3)

**Figure parenthesis indicates straw yield, **Net returns.*

significantly improved the net returns due to higher yield than without relay cropping.

3.2 | System Productivity

The relay berseem-based cultivation cost cropping produced significantly higher MEY of all the cropping systems than without relay cropping (Fig. 1). The system productivity increased from 33-66% with relay cropping compared to without relay cropping. Among the different mustard-based cropping systems, the paddy-mustard + berseem system recorded the highest MEY (4.84 t ha^{-1}), followed by green gram-mustard+berseem (4.63 t ha^{-1}), pearl millet-mustard+berseem (4.57 t ha^{-1}) and lowest with fallow-mustard+berseem (3.56 t ha^{-1}). Leguminous crop berseem is known to ameliorate soil quality over the years, contributing to system productivity. Similarly, Singh *et al.* (2020b) reported that the relay berseem in mustard significantly enhanced the soil quality and system productivity.

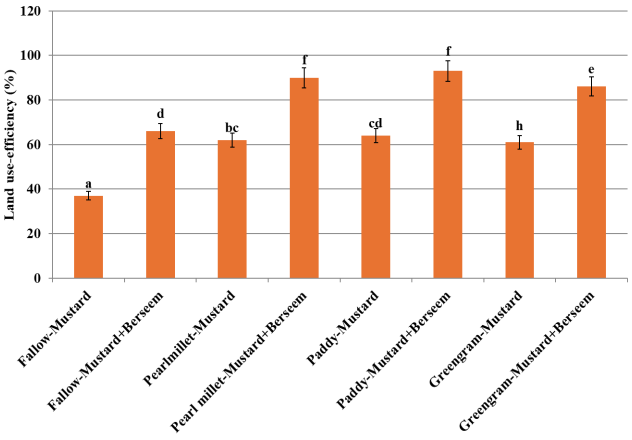
Land use efficiency was also significantly higher in relay cropping than without relay cropping (Fig. 2). Among relay cropping systems, land use efficiency was higher with paddy-mustard+berseem (93%), followed by pearl millet (90%) and green gram (86%), and lowest with fallow-mustard+berseem (60%).

3.3 | System Economics

The system-based cultivation cost and net return significantly increased with relay sowing of berseem crops in mustard-based cropping systems compared to those without relay cropping systems (Fig. 3). The cultivation cost is slightly higher, from ₹ 15,700-16,900 ha^{-1} in relay cropping of berseem with mustard compared to without relay berseem crop in the mustard crop. Among the relay cropping systems, the maximum net returns fetched under the paddy-mustard+berseem system (₹ 1,52,000 ha^{-1}) followed by pearl millet-mustard+berseem (₹ 1,45,000 ha^{-1}), green gram-mustard+berseem (₹ 1,44,000 ha^{-1}) and the least with fallow-mustard+berseem system (₹ 1,04,000 ha^{-1}). The higher net returns with Berseem relay cropping in mustard due to improved soil fertility resulted in a higher yield of crops and additional net income.

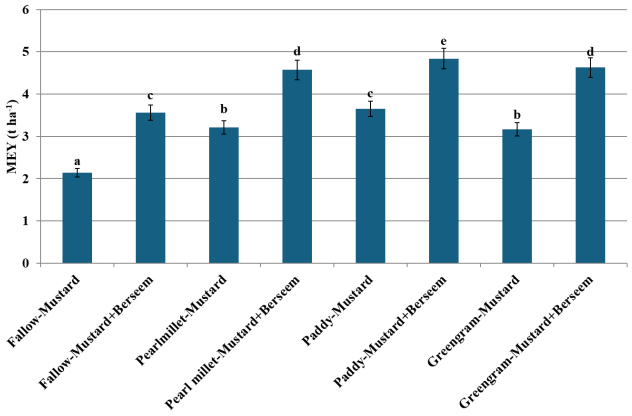
3.4 | Total Water Use (TWU)

Total water use in all cropping systems was significantly higher with relay cropping as compared to without relay cropping (Fig. 4). Among different cropping systems higher water use was recorded with paddy-mustard+berseem system (116 cm ha^{-1}) followed by paddy-mustard (97 cm ha^{-1}), pearl millet-mustard+berseem (76 cm ha^{-1}), greengram-mustard+



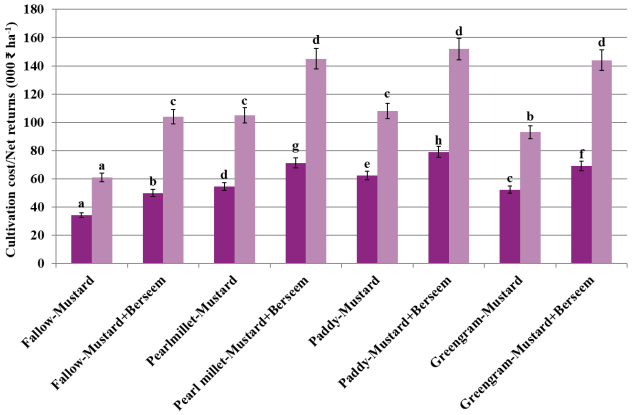
Different letters within treatments indicate significant differences (P<0.05).

FIGURE 2 Relay cropping of berseem in mustard-based cropping systems effect on land use efficiency (5 yr pooled data)



Different letters within treatments indicate significant differences and similar letters are not significant (P<0.05).

FIGURE 1 Relay cropping of berseem in mustard-based cropping systems effect on MEY (5 yr pooled data)



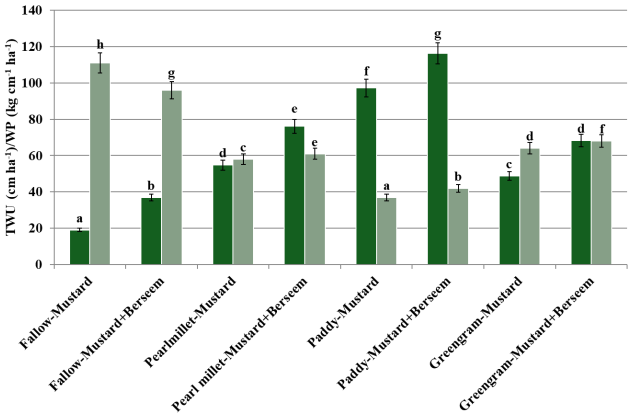
Different letters within treatments indicate significant differences and similar letters are not significant (P<0.05).

FIGURE 3 Relay cropping of berseem in mustard-based cropping systems effect on economics (5 yr pooled data)

berseem (68 cm ha^{-1}), pearlmillet-mustard (55 cm ha^{-1}), greengram-mustard (49 cm ha^{-1}), fallow-mustard + berseem (37 cm ha^{-1}) and least with fallow-mustard (19 cm ha^{-1}). The TWU was significantly greater with relayed berseem in mustard crops than without a relay cropping system because of a maximum number of crops harvested in a year. The consistent results were reported by Singh *et al.* (2020b).

3.5 | Water Productivity (WP)

The *rabi* season mustard crop combined with berseem as relay cropping in mustard increased water productivity from 5-14% compared to without relay cropping treatment (Fig. 4). The significant increase in water productivity was because of yield maximisations with relay cropping and constant soil moisture availability supports of previous crop mustard. The water productivity was increased by 14% under the paddy-mustard+berseem system, followed by a 6% increase under the green gram-mustard+berseem system, and the lowest increase of 5% in water productivity was under the pearl millet-mustard+berseem system, whereas declined by 14% with fallow-mustard+berseem as compared without relay cropping systems. The higher water productivity of crops under relay sowing of berseem in mustard-based cropping systems was due to improved soil physicochemical properties, reduced evaporation losses and soil moisture storage due to soil cover with the residues of previous crop berseem. Das *et al.* (2014) and Singh *et al*. (2020b) also examined that the greater yield and thrift TWU with relay crop resulted in enhanced water productivity.



Different letters within treatments indicate significant differences (P<0.05).

FIGURE 4 Relay cropping of berseem in mustard-based cropping systems effect on TWU and WP (5 yr pooled data)

3.6 | Physicochemical Properties

Significant positive changes in soil organic carbon, available macro (N, P, K and S) and micronutrients (Zn, Fe, Cu and Mn), reduced electrical conductivity (EC), and pH were observed due to mustard crop-grown in relayed legume crop berseem as compared to without relay cropping systems (Table 2). Cropping systems with relay cropping of berseem reduced EC by 0.07-0.12 dS m^{-1} and pH by 0.09-0.15 units as compared to cropping systems without relay cropping.

The available macro-nutrients were increased by 37-53 kg N, 3.0-5.0 kg P, 20-32 kg K and 2.9-3.5 kg S ha^{-1}, whereas available micronutrients were increased from 0.07-0.11 mg Zn, 0.6-0.9 mg Fe, 0.04-0.06 mg Cu and 0.4-0.7 mg Mn ha^{-1} as compared to the values of without relay cropping. It should be due to the retention of substantial amounts of berseem residues (1.8-2.2 t dry residue ha^{-1} yr^{-1}) rich in plant nutrients (Singh *et al*., 2020b). Similarly, Parmar *et al.* (2023) reported that the 90% residue retention improved nutrient recycling and soil properties.

TABLE 2 Effect of relay cropping of berseem in mustard-based systems on soil physicochemical properties after 5th harvest of berseem crop

Treatments	EC (dS m^{-1})	pH	OC (g kg^{-1})	SOC stock (mg ha^{-1})	Available macro-nutrients (kg ha^{-1})				Available micro-nutrients (mg ha^{-1})			
					N	P	K	S	Zn	Fe	Cu	Mn
Initial value	0.54	7.83	3.9	-	193	11.6	223	13.2	0.43	5.3	0.30	2.9
Fallow-Mustard	0.47	7.88	3.8	4.89	181	10.2	214	11.2	0.46	5.1	0.28	2.8
Fallow-Mustard+Berseem	0.35	7.79	4.9	6.27	234	13.2	234	14.6	0.57	5.7	0.32	3.4
Pearlmillet-Mustard	0.51	7.82	4.1	5.35	173	9.3	206	10.1	0.49	4.9	0.26	3.0
Pearl millet-Mustard+Berseem	0.44	7.68	5.3	6.82	224	14.3	228	13.6	0.57	5.5	0.31	3.4
Paddy-Mustard	0.40	7.73	4.4	5.78	190	8.8	192	10.5	0.47	5.2	0.25	2.9
Paddy-Mustard+Berseem	0.33	7.61	5.6	7.21	232	12.6	219	13.4	0.54	5.9	0.29	3.3
Greengram-Mustard	0.44	7.78	4.0	5.19	218	9.8	210	11.4	0.50	5.0	0.27	3.1
Greengram-Mustard+Berseem	0.35	7.63	5.2	6.65	285	14.0	242	14.9	0.61	5.9	0.33	3.7
S Em±	0.01	0.01	0.1	0.09	5	0.3	2	0.2	0.01	0.1	0.003	0.03
CD (P = 0.05)	0.03	0.04	0.3	0.28	16	0.8	7	0.7	0.02	0.2	0.01	0.1

EC - Electrical conductivity, OC - Organic carbon, SOC - Soil organic carbon

4 | CONCLUSIONS

In various mustard-cultivated areas in India, farmers grow mustard as a mono-cropping system, negatively impacting soil properties, productivity, profitability and water productivity. Results showed that the relay cropping with berseem can reverse these trends. The yield of crops and system productivity, net economic returns, and water productivity with relay sowing of berseem were significantly enhanced compared to those without relay cropping systems. Among different cropping systems, the crop yield and net economic returns were significantly greater with relay seeded berseem in the paddy-mustard system, followed by pearl millet-mustard, green gram-mustard cropping system, and the least with fallow-mustard. Relay cropping berseem in mustard crops is the best practice for maintaining soil fertility, food-feed security and economic profitability. Therefore, retractions of berseem residues relayed in mustard prove to be profitable and can be used at a large scale at the farm level.

ACKNOWLEDGEMENTS

The authors sincerely thank the Farmers First Programme project staff in Morena for the experimental work. They are also grateful to all the laboratory staff of AICRP on Irrigation Water Management, ZARS (RVSKVV), Morena, Madhya Pradesh, for conducting laboratory work on the experiment.

DATA AVAILABILITY STATEMENT

The datasets used or analysed during the current study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

The authors declare no competing interests.

AUTHOR'S CONTRIBUTION

YPS: methodology, investigation, original draft, formal analysis, review; SST and ST: conceptualization, funding acquisition, analytical works; RSY: formal analysis, original draft, review and editing; SKD: conceptualization, review, editing and corresponding.

FUNDING

This work was supported by the Farmer First Programme project of ICAR, New Delhi.

REFERENCES

Acharya, B.S., Dodla, S., Gaston, L.A., Darapuneni, M., Wang, J.J., Sepat, S. and Bohara, H. 2019. Winter cover crops effect on soil moisture and soybean growth and yield under different tillage systems. *Soil Till. Res.,* 195: 104-430.

Das, T.K., Bhattacharyya, R. and Sudhishri, S. 2014. Conservation agriculture in an irrigated cotton-wheat system of the western Indo-Gangetic Plains: crop and water productivity and economic profitability. *Field Crops Res.,* 158: 24-33.

Fustec, J., Lesuffleur, F., Mahieu, S. and Cliquet, J.B. 2010. Nitrogen rhizodeposition of legumes. A review. *Agron. Sust. Deve.,* 30: 57-66.

Gupta, Raj, Kumar, Nirmal, Singh, S.K., Sahoo, R.N. and Abrol, I.P. 2019. Resource Management Domains of *kharif* and *rabi* season fallows in Central plateau region of India: A strategy for accelerated agricultural development *J. Agron. Res*., 2(1): 47-67.

Jackson, M.L. 1973. Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi, 498p.

Panse, V.G. and Sukhatme, P.V. 1954. Statistical method for agriculture workers. In Public. ICAR, New Delhi, pp 97-151.

Parmar, B., Vishwakarma, A.K., Gupta, V., Jha, P., Biswas, A.K., Hati, K.M. and Patra, A.K. 2023. Ganesh Malgaya Effect of crop residue retention and nutrient application rates on soil health dynamics: A study on Vertisols of central India. *Indian J. Soil Cons.,* 51(1): 11-17.

Shekhawat, Kapila, Rathore, S.S., Premi, O.P., Kandpal, B.K. and Chauhan, J.S. 2012. Advances in agronomic management of Indian mustard (*Brassica juncea* (L.) Czernj. Cosson): An overview. *Int. Jou. Agron.,* 1-14.

Singh, Y.P. and Tomar, Sandeep, S. 2023. Effect of tillage and water management practices on pearl millet-wheat cropping system productivity, water - balance and soil properties of alluvial soil. *Indian J. Soil Cons.,* 51(2): 144-153.

Singh, Y.P., Tomar, Sandeep, S. Singh, S. and Nanda, P. 2020a. Effect of precise levelling and crop establishment options for wheat-based systems on soil quality, system - and water productivity in scarce irrigated areas. *Arch. Agron. Soil Sci.,* 67(10): 1327-1340.

Singh, Y.P., Tomar, Sandeep, S., Singh, S., Singh, A.K. and Gupta, Raj, K. 2020b. Influence of tillage and relay cropping of berseem in mustard-pearl millet system on soil quality, productivity of crops and water. *Agric. Res.,* 10: 645-655.

Singh, Y.P., Tomar, Sandeep, S. and Singh, S. 2021. Effect of precise levelling, tillage and seed sowing methods of pearl millet-based cropping systems on productivity and soil quality in dryland area. *Soil Till. Res.,* 212:105069.

How to cite this article: Singh, Y.P., Tomar, S.S., Tiwari, S., Yadav, R.S. and Dubey, S.K. 2024. Relay sowing of berseem (*Trifolium alexandrinum*) in mustard (*Brassica juncea*) improves system productivity, economics and soil fertility. *Indian J. Soil Cons.,* 52(3): 261-266.