



# Effect of Mustard Based Intercropping Systems on Yield and Profitability under Organic Management in Bundelkhand Region

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**Abstract:** A field experiment was conducted at the Institute of Agricultural Sciences Bundelkhand University Jhansi to study the effect of mustard-based intercropping systems using skip-row method under organic management during *Rabi* 2021 - 2022. Nine treatments comprising of mustard, *kabuli* chickpea, field pea, fenugreek and desi chickpea as sole crops, mustard + *kabuli* chickpea, mustard + field pea, mustard + fenugreek and mustard + desi chickpea (1:2 ratio) in intercropping system skipping one row of mustard were evaluated. The mustard intercropping with other crops considerably affected the yield parameters compared to their comparable sole crops, but all intercropping methods provided greater equivalent yields and land equivalent ratio. The cost and return analysis showed that the highest net return (Rs. 110552 ha<sup>-1</sup>) and benefit-cost ratio (3.8) was obtained when mustard intercropped with desi chickpea compared to sole crop of mustard while it was minimum (2.7) in mustard alone. Significantly highest profitability (Rs 888 ha<sup>-1</sup> day<sup>-1</sup>) was observed when mustard intercropped with desi chickpea compared to sole crop of mustard but it was statistically at par with rest of the treatments.

**Keywords:** Biological yield, LER, Intercropping with mustard, Profitability

Successful intercropping systems provide more diversified crops and yield higher monetary returns per unit area than producing a single crop with greater resource use efficiency (Bhuiyan et al 2013). Intercropping is an essential multiple cropping technique that has been employed extensively in underdeveloped and developing countries. Inter-cropping is preferable to monoculture since it enhances productivity by effectively utilizing resources like water, nutrients and solar energy. Out of the seven edible oilseeds grown in India, rapeseed and mustard produce 28.6% of the total amount of oilseeds. The most important pulse crops / legumes grown in India during *Rabi* season are Desi chickpea, Kabuli or White Gram, Field Pea as pulse crop while Fenugreek (Methi) is mostly grown for seeds as spice and condiments, green and dry leaves to enhance the flavour and nutritional content of dishes. In fact, Bundelkhand is considered a bowl of pulses in the U.P. Mustard is also very important crop for improving the farmer's income. The information on intercropping of mustard with pulses in organic management is not available. Therefore, present attempt was made to identify the most suitable mustard-based intercropping system for obtaining higher yield, profitability, and resource-saving in the Bundelkhand region.

## MATERIAL AND METHODS

A field experiment was conducted during the *Rabi* season of 2021-22 at the Institute of Agricultural Sciences, Bundelkhand University, Jhansi, Uttar Pradesh involving nine treatments comprising of five crops and four intercropping systems in a Randomised block design with three replications as detailed in Table 2. The experiment was carried out on a silt loam soil having pH of 8.2, low in organic carbon, medium nitrogen, phosphorus and potash availability. Field pea (Prakash), *Kabuli* chickpea (L-552), Fenugreek (Pusa Early Bold) and Desi chickpea (RVG202) were intercropped according to row proportion with the primary crop mustard variety NRCHB 101. In all

intercropping plots, Indian mustard was sown in replacement series skipping one row of mustard. The experiment was planted on October 29, 2021 and harvested on March 24, 2022. Data were analysed using OPSTAT. The intercropping systems were assessed in terms of land equivalent ratio (LER), harvest index, seed yield, biological yield, mustard equivalent yield (MEY), gross return, net return, benefit cost ratio and profitability considering based on prevailing market rates.

**Grain yield (q ha<sup>-1</sup>):** After threshing and winnowing the produce of individual plot, the seed yield/ plot was finally converted in to q/ha.

**Biological yield (qha<sup>-1</sup>):** Each net plot's crop was harvested, left to dry in the field and then weighed separately. It had both straw and grain. In the end, the biological yield per plot was converted to q/ha.

**Harvest index (%):** The harvest index was calculated in percentage by the following formula.

$$HI (\%) = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

**Mustard equivalent yield:** Based on the prices of mustard and Desi chickpea, *Kabuli* chickpea, fenugreek and Field pea, the grain yields as obtained under various treatments were converted into mustard yield equivalent as per Katyal and Gangwar (2014).

$$MEY = \frac{\text{Yield of intercrop (q/ha)} \times \text{Price of intercrop (Rs/q)}}{\text{Price of mustard crop (Rs/q)}}$$

**Land equivalent ratio (LER):** It denotes relative land area under sole crop required to give the same yield as obtained under a mixed or an intercropping system at the same level of management which was calculated (Willey 1979).

$$LER = La + Lb = Ya/Sa + Yb/Sb$$

Where:

La = LER of crop a, Lb = LER of crop b, Ya & Yb = Yield of individual crop a & b, respectively in mixture, Sa & Sb = Yield of individual crop a & b, respectively in pure stand

**Economics of treatments:** The gross returns were calculated by multiplying quantity of product with market price at the time of harvest. The net returns were computed by subtracting cost of cultivation from gross returns. The benefit-cost ratio was determined by dividing the value of net returns by the value of cost of cultivation. The profitability of various treatment combinations was determined by dividing the net return per hectare by the total number of days the field remained occupied.

## RESULTS AND DISCUSSION

### Yield and Yield Attributes

**Number of siliqua plant<sup>-1</sup>:** The number of siliqua plant<sup>-1</sup> was highest (184) when mustard was grown alone but decreased in intercropping treatments up to 144, 149, 163 and 135 when grown with *kabuli* chickpea, field pea, fenugreek, and desi chickpea respectively (Table 2). It may be due to better use of nutrients and space which results in a greater number of branches and increase in number of siliqua/plants. Similar findings were also reported by Gokhale et al (2008) and Abraham et al (2010).

**Number of seed siliqua<sup>-1</sup>:** The number of seed siliqua<sup>-1</sup> of mustard was recorded higher when mustard was grown with *desi* chickpea (18), fenugreek (17), *Kabuli* chickpea (15) (Table 2) in intercropping system compared to sole crop of mustard (14). It may be due to better utilization of nutrients and space. Similar findings were also reported by Kumar and Singh et al (2006).

**Seed yield (qha<sup>-1</sup>):** The yield of mustard decreased by 19.7, 15.3, 8.7, and 1.4% when intercropped with *kabuli* chickpea, fenugreek, field pea and *desi* chickpea respectively whereas the highest grain yield of 13.7 q ha<sup>-1</sup> (Table 2) was obtained when grown alone. The intercropping of mustard with *Kabuli* chickpea and fenugreek demonstrates that there was resource competition. However, when *desi* chickpea was intercropped with mustard, the yield rose by 8.7%, indicating a favourable interaction between the two crops. The result of this investigation also supported by Kumar et al (2006).

**Straw Yield (q ha<sup>-1</sup>):** The mustard intercropped with *desi* chickpea produced the maximum straw yield of 44.9 q ha<sup>-1</sup> (Table 2), but the yield decreased up to 47.6, 20.0, and 10.9% when intercropped with fenugreek, field pea, and *Kabuli* chickpea, respectively. It shows that there was competition for resources when mustard was intercropped with fenugreek, field pea, and *kabuli* chickpea. But, when mustard and *desi* chickpea were grown together, yield increased by 16.5%. The higher straw yield was mainly due to higher dry matter accumulation and also more translocation of photosynthates towards sink. Similar findings were also reported by Chand et al (2004).

**Mustard equivalent yield (q ha<sup>-1</sup>):** In comparison to mustard cultivated as a single crop with field pea and *desi* chickpea, the intercropped mustard yield (26.7q ha<sup>-1</sup>) was significantly higher, but statistically comparable to other treatments (Table-2). These results are supported by Islam et al (2011) and Yadav et al (2018).

**Biological yield (q ha<sup>-1</sup>):** The biological yield of mustard crop was

**Table 1.** Meteorological data during cropping period 2021-22

Month	SW	Temperature (°C)		Humidity (%)		Wind velocity (km/hr)	Rainfall (mm)	Rainy days	Evaporation (mm)
		Maximum	Minimum	Morning	Evening				
October	43	31.6	16.7	80	53	3.2	0	0	4.8
	44	30.5	12.6	82	52	3.4	0	0	4.8
November	45	30.8	9.9	81	46	3.1	0	0	4.6
	46	27.9	10.6	84	50	3.1	0	0	4.0
	47	28.1	12.0	85	49	3.2	0	0	3.6
December	48	27.5	9.3	85	57	2.8	0	0	3.3
	49	24.7	11.2	88	56	3.2	0	0	2.8
	50	23.4	7.8	89	60	3.0	0	0	2.5
	51	22.9	4.4	88	61	2.8	0	0	2.4
January	52	22.3	8.4	90	65	3.2	12	1	2.3
	1	20.9	7.7	91	71	3.1	18.0	2	2.0
	2	19.2	10.4	91	71	2.9	23.8	1	1.7
	3	18.3	5.8	91	72	2.8	0.0	0	1.6
	4	19.9	7.6	91	71	2.6	3.6	1	1.6
February	5	26.4	7.3	89	59	2.9	0.0	0	3.0
	6	24.0	7.5	88	47	3.6	0.0	0	3.2
	7	25.8	8.0	87	46	4.4	0.0	0	3.7
	8	28.0	11.3	84	46	3.7	0.0	0	4.1
March	9	28.5	11.3	84	45	4.8	0.0	0	4.6
	10	30.0	12.6	81	44	5.1	0.4	0	4.7

highest (57.4q ha<sup>-1</sup>) when mustard was grown with desi chickpea in inter-cropping system while reduced when mustard was grown with *kabuli* chickpea, field pea and fenugreek in inter-cropping system compared to sole crop of mustard (Table 2). Similar findings were reported by Abraham and Lal (2002).

**Harvest index (%):** The harvest index of mustard crop was higher when mustard was grown with fenugreek (36.5%), field pea (28.8%) while reduced with *kabuli* chickpea (24.3%) and desi chickpea (21.9%) in intercropping system compared to sole crop of mustard (26.2) (Fig 1). There was the beneficial relationship of desi chickpea with mustard in intercropping system while all other associated crops showed reduced harvest index in intercropping treatments compared to their respective sole crops.

**Land equivalent ratio (LER):** Highest land equivalent ratio of 1.7 (Fig. 1) was obtained when mustard was intercropped with desi chickpea compared to sole crop of mustard. It shows that Mustard +

Desi chickpea intercropping system is beneficial.

#### Economics

**Cost of cultivation:** Significantly highest cost of cultivation (46300Rs ha<sup>-1</sup>) (Table 3) was incurred when mustard was intercropped with fenugreek due to high cost of seed compared to sole crop of mustard and other treatments. Statistically, similar findings were also reported by Prasad et al (2006).

**Gross returns:** Significantly highest gross return of Rs.151,772 ha<sup>-1</sup> (Table 3) was recorded when mustard was intercropped with fenugreek compared to sole crop of mustard, field pea, desi chickpea, fenugreek and *kabuli* chickpea. But it was statistically at par with intercropping treatments. The gross revenue has been universally reported markedly higher under intercropping systems under good management conditions as compared to sole cropping and chick pea + mustard oilseeds have proved to generate high revenues by Tichy et al (2001).

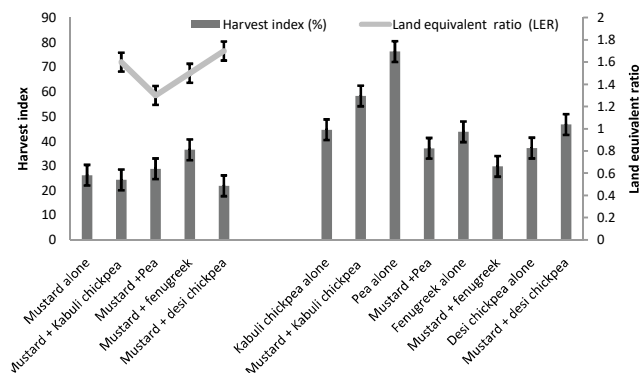
**Table 2.** Effect of mustard-based intercropping systems on yield and yield contributing parameters

Treatments	No. of siliqua or pod plant <sup>-1</sup>		No. of seed siliqua <sup>-1</sup>		Seed yield (q ha <sup>-1</sup> )		Straw yield (q ha <sup>-1</sup> )		Biological yield (q ha <sup>-1</sup> )	Mustard equivalent yield (q ha <sup>-1</sup> )
	Main crops	Associate crops	Main crops	Associate crops	Main crops	Associate crops	Main crops	Associate crops		
T <sub>0</sub> Mustard	184	-	14	-	13.7	-	38.5	-	52.2	13.7
T <sub>1</sub> <i>Kabuli</i> Chickpea alone	29	-	1	-	14.6	-	18.1	-	32.7	18.2
T <sub>2</sub> Pea alone	10	-	5	-	14.5	-	4.5	-	19.5	13.5
T <sub>3</sub> Fenugreek alone	44	-	14	-	10.6	-	13.6	-	24.2	15.6
T <sub>4</sub> Desi chickpea alone	52	-	2	-	12.6	-	21.3	-	33.9	13.5
T <sub>5</sub> Mustard + <i>Kabuli</i> chickpea	144	23	15	1	11.0 (-19.7)	12.6 (-13.7)	34.3 (-10.9)	8.0 (+3.8)	45.3	25.9
T <sub>6</sub> Mustard + Pea	149	4	13	3	12.5 (-8.7)	11.1 (-23.4)	30.8 (-20.0)	8.1 (+80.0)	43.3	22.3
T <sub>7</sub> Mustard + Fenugreek	163	27	17	10	11.6 (-15.3)	8.3 (+43.0)	-21.7 (-47.6)	19.5 (+43.0)	31.7	24.5
T <sub>8</sub> Mustard + Desi chickpea	135	37	18	1	12.6 (-1.4)	13.7 (+8.7)	44.9 (+16.5)	15.6 (-26.7)	57.4	26.7
CD (p=0.05)	-	-	-	-	-	-	-	-	-	8.7

Figures in parenthesis shows percentage of increase or decrease in yield of mustard and associated crops

**Table 3.** Cost of cultivation, gross return, net income, B:C ratio and profitability of mustard-based intercropping systems

Treatments	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net return (Rs/ha)	B:C ratio	Profitability (Rs/ ha /day)
T <sub>0</sub>	34,4267	92,556	58,129	2.7	447.
T <sub>1</sub>	32,934	96,944	64,011	2.9	492.
T <sub>2</sub>	32,434	81,929	49,496	2.5	381
T <sub>3</sub>	33,320	103,337	70,017	3.1	538
T <sub>4</sub>	33,200	84,331	51,131	2.5	393.
T <sub>5</sub>	38,400	145,038	106638	3.7	820.
T <sub>6</sub>	37,134	126,599	89,465	3.4	688.
T <sub>7</sub>	46,300	151,772	105472	3.5	850.
T <sub>8</sub>	39,200	149,752	110552	3.8	888.
CD (p=0.05)	3265	44462	45,626	NS	351



**Fig. 1.** Effect of associated crops on harvest index, and LER of mustard and associate crops

**Net return:** Significantly maximum net return of Rs. 110552 ha<sup>-1</sup> (Table 3) was obtained when mustard was intercropped with desi chickpea compared to sole crop of mustard, field pea and kabuli chickpea, but it was statistically at par with rest of the treatments. Similar findings were also reported by Tichy et al (2001).

**Benefit: cost ratio (B: C Ratio):** The benefit-cost ratio was maximum (3.8) (Table 3) when mustard was intercropped with desi chickpea compared to sole crop of mustard while it was minimum (2.7) in treatment mustard alone. The findings are in conformity with Singh et al (2000) and Abraham et al (2010).

**Profitability (Rs ha<sup>-1</sup> day<sup>-1</sup>):** Significantly highest profitability (888 Rs ha<sup>-1</sup> day<sup>-1</sup>) (Table 3) was obtained when mustard was intercropped with desi chickpea compared to sole crop of mustard, field pea, fenugreek and kabuli chickpea but it was statistically at par with rest of the treatments as also reported by Mandal et al (1996).

### CONCLUSION

It may be concluded that the component crop had an adversely effect on mustard's growth and yield compared to grown alone but intercropping treatments had greater comparable yields. Desi-chickpea was identified to be most suitable companion crop of mustard and Mustard + Desi chick pea intercropping system using skip-row system was found to be most suitable. Therefore, it is advisable to the farmer of Bundelkhand to practice intercropping of mustard with desi chickpea in skip row to sustained production and productivity of both mustard and desi-chickpea and also to ensure higher productivity and profitability in organic farming system.

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