RESEARCH ARTICLE

INTERCROPPING IN MUSTARD (*BRASSICA JUNCEA* L.) WITH CHICKPEA AND FIELD PEA

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Received-02.11.2021, Revised-18.11.2021, Accepted-28.11.2021

Abstract: A field experiment was carried out during the winter (*rabi*) of 2019-20 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar to study the effect of intercropping in mustard (*Brassica juncea* L.) nine treatment combination *viz.*, T_1 : Sole mustard, T_2 : Sole chickpea, T_3 : Sole field pea, T_4 : Mustard + chickpea (1:2), T_5 : Mustard + chickpea (1:3), T_6 : Mustard + chickpea (1:4), T_7 : Mustard + field pea (1:2), T_8 : Mustard + field pea (1:3) and T_9 : Mustard + field pea (1:4) were laid out in randomized block design replicated 3 times. Mustard + chickpea 1:3 ratio (T_5) recorded significantly higher number of primary and secondary branches plant^{-1} and siliquae plant^{-1}. The sole crop of mustard (T_1) produced significantly the highest seed and stover yield in all the treatments. In mustard + chickpea/field pea intercropping system, the number of branches plant^{-1}, number of pods plant^{-1}, grain and straw yield was higher under sole chickpea (T_2)/ field pea (T_3). The higher LER (1.25) was recorded under mustard + chickpea 1:3 ratio intercropping system closely followed by mustard + chickpea 1:4 ratio of intercropping system. Significantly higher mustard equivalent yield was recorded under mustard + chickpea in 1:3 ratio (T_5), which remained at par with mustard + chickpea 1:4 (T_6) and mustard + chickpea 1:2 ratio (T_4). In case of intercropping treatments, mustard + chickpea in 1:3 row proportion recorded the maximum gross returns, net profit and benefit : cost ratio (BCR) of ₹ 1,31,273, ₹ 99,346 ha^{-1} and 4.11, respectively than rest of the treatments.

Keywords: Mustard, Chickpea, Field pea, Land equivalent ratio and Mustard equivalent yield

INTRODUCTION

In India, pulses and oilseeds occupy a pivotal place as far agriculture scenario is concerned. They are the important constituents of Indian dietary system. They play an immense role in the economic upliftment of farmers. Intensive agriculture demands maintenance of soil fertility status, soil health through integrated use of inorganic and organic fertilizers to get higher and sustained level of crop production. Pulses being leguminous crops have the unique ability to fix atmospheric nitrogen and can also bring qualitative changes in soil physical properties. Oilseeds at the same time can be economically remunerative crop.

Mustard belongs to Brassicaceae (*Cruciferae*) family originated from Mediterranean origin and Indian mustard (*Brassica juncea*) belongs to Himalayan origin. Among the seven edible oilseeds cultivated in India Mustard (*Brassica* spp.) contributes 28.6 per cent in the total production of oil seeds. The share of oilseeds is 14.1 per cent out of the total cropped area in India, Mustard accounts for 3 per cent of it. It shares 27.8 per cent in the India's oilseed economy.

Besides, pulses are wonderful gifts of nature having unique ability of biological nitrogen fixation, deep root system, mobilization of insoluble soil nutrients and bringing qualitative favorable changes in soil physical properties. Therefore, pulses have emerged as a viable option to improve soil health, conserve the natural resources and sustain the agricultural productivity.

Chickpea belongs to Fabaceae family originated from South East Turkey. Chickpea is a good source of energy, protein, minerals (especially potassium, phosphorus, calcium, magnesium, copper, iron and zinc), vitamins, fibre and also contains potentially health-beneficial phytochemicals. The salty taste of leaves due to oxalic and malic acid present in it which act as blood purifier and cures scurvy disease. It is a healthy food that is beneficial for the prevention of coronary and cardiovascular diseases. It may also lower blood cholesterol levels due to high content of soluble fibre and vegetable protein.

Pea belongs to the family *leguminoceae* originated from South West Asia. It is an annual plant, grown in cool season in many parts of the world. Pea is one of the most important pulse crops containing about 22.5 per cent protein and 60.4 per cent carbohydrates. It is a high value pulse due to its high nutritional value of grains. Pea is gaining importance due to its hardiness, comparatively more resistance against the pests and diseases and ability to withstand against the drought conditions. Mature seeds of field pea are also used as 'dal.' This type is also used for green manuring. Green seeds are also canned for the use in off season.

The production of pulses and oilseeds can be increased either by bringing more area under pulses and oil seeds cultivation or enhancing their productivity. There is little scope to bring additional area under these crops due to stiff competition from cereals, shrinkage of land holding and use of land for urbanization *etc.* Thus, in the absence of possibilities

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for horizontal expansion, the vertical growth of these crops through intercropping with suitable crops having higher yield potential offering varying competition in spatial and temporal dimension is the need of time. Intercropping is one of the ways to increase the productivity unit^{-1} area of land with limited resources. Intercropping continues to be a prominent system because of various benefits associated with it. So, research on intercropping has been spurred recently to understand the validity of the system by ways of possible increase in yield, efficient use of solar energy and better land use resulting in higher returns (Dhingra *et al.*, 1991). Intercropping provides an insurance against calamities and helps in the profitable production by efficient use of natural resources (Thakur *et al.*, 2000).

MATERIALS AND METHODS

A field experiment was conducted at the Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *rabi* season of the year 2019-20. The soil of the experimental field was loamy sand in texture, low in organic carbon (0.18 %) and available nitrogen (171 kg/ha), medium in available P_2O_5 (37.2 kg/ha) and low in available sulphur (6.8 kg/ha) with soil pH of 7.4. The present experiment comprising of nine treatments combinations *viz.*, T_1 : Sole mustard, T_2 : Sole chickpea, T_3 : Sole field pea, T_4 : Mustard + chickpea (1:2), T_5 : Mustard + chickpea (1:3), T_6 : Mustard + chickpea (1:4), T_7 : Mustard + field pea (1:2), T_8 : Mustard + field pea (1:3) and T_9 : Mustard + field pea (1:4). In the present investigation mustard (Gujarat Mustard 1) was grown with chickpea (Gujarat Gram 3) and field pea (Dantiwada Field Pea 1) in different intercropping proportions on row basis of 1:2, 1:3 and 1:4. This was a replacement series of intercropping system, where in as per row proportion the lines of mustard were replaced by either chickpea or field pea. The main/base crop (mustard) and two intercrops (chickpea and field pea) were planted at 30 × 10 cm spacing. Crops were raised with their recommended package of practices. For chickpea and field pea full dose of nitrogen and phosphorus (20 kg N + 40 kg P_2O_5/ha) were applied as basal, while in case of mustard full dose of phosphorus and half dose of nitrogen was applied as basal in opened furrows. The remaining half dose of nitrogen was top dressed at 50 DAS. Urea and DAP were used as a source for nitrogen and phosphorus, respectively. Total nine treatment combinations were tested in Randomized Block Design (RBD) with three replications. The seeds of mustard, chickpea and field pea were treated with thiram @ 2 g kg^{-1} seed in all treatments and mid formulation of *Azospirillum* (for mustard), *rhizobium* (for chickpea and field pea) and phosphate solubilizing bacteria (PSB) were inoculated with seed at 5 ml kg^{-1} seed just before sowing of the seeds and dried in the shed. The observation on plant growth, yield attributes and yield were recorded as per standard procedure. Economics was worked out on the basis of prevailing market prices of inputs and output obtained from each treatment. The data were statistically analyzed for various characters as described by (Panse and Sukhatme, 1967).

RESULTS AND DISCUSSION

Effect of intercrops on mustard

Growth attributes

An appraisal of data presented in Table 1.0 showed that growth attributes, *viz.* number of primary and secondary branches plant^{-1} indicated that the mustard + chickpea 1:3 ratio (T_5) recorded significantly higher number of primary and secondary branches plant^{-1} and among which primary branches plant^{-1} it remained at par with mustard + chickpea 1:2 ratio (T_4), mustard + chickpea 1:4 ratio (T_6), mustard + field pea 1:3 ratio (T_8) and mustard + field pea 1:4 ratio (T_9). Where in case of secondary branches plant^{-1} a it was at par with mustard + chickpea 1:4 ratio (T_6) and mustard + field pea 1:3 ratio (T_8). Irrespective of the treatments, number of branches plant^{-1} increased with advancement in the age and there after remained constant up to the harvest. Though, differences in the number of primary and secondary branches plant^{-1} were significant due to various treatments with the advancement of crop growth. This indicated that with increase in proportion of intercrops, there was more interception of light which made the mustard plant to grow faster as a result of enhanced photosynthetic activities and accumulation of dry matter during vegetative and reproductive stage. These results corroborated the finding of Meena (1985).

Yield and yield attributes

An appraisal of data presented in Table 1 showed that mustard + chickpea ratio 1:3 (T_5) produced significantly higher number of siliquae plant^{-1}. However, it remained at par with the mustard + chickpea 1:2 ratio (T_4), mustard + chickpea 1:4 ratio (T_6), mustard + field pea 1:3 ratio (T_8) and mustard + field pea 1:4 ratio (T_9). This indicated that with increase in proportion of intercrops, there was more interception of light which made the mustard plant to grow faster as a result of enhanced photosynthetic activities and accumulation of dry matter during vegetative and reproductive stage. Due to this higher number of siliquae plant^{-1} under mustard + chickpea ratio 1:3 (T_5) is achieved on the other hand, it might be due to better resource utilization and better sink of photosynthetic produce which reflected into better yield contributing character. These results are in conformity with the results reported by Bandyopadhyay and De (1986), Jat and Ahlawat

(2009), Mehta (2010), Choudhuri and Jana (2015) and Singh *et al*. (2019).

Mustard + chickpea 1:3 ratio at flowering stage

Mustard + chickpea 1:4 ratio at flowering stage

An appraisal of data presented in Table 2 showed that the sole crop of mustard (T_1) produced significantly the highest seed and stover yield over all other treatments. Among all intercropping treatments, mustard + chickpea 1:2 ratio (T_4) recorded higher seed & stover yield and where in case mustard + field pea 1:4 (T_9) recorded lower seed & stover yield. Irrespective of crop grown in intercropping system with mustard, the seed and stover yield reduced with increasing in proportion of intercrops and the order of significance in terms of row proportions was 1:2 > 1:3 ≥ 1:4. In general, within the intercropping systems, when mustard was grown with chickpea, yield performance of mustard was better, followed by mustard + field pea.

Similarly, with increase in the proportion of mustard, mustard yield showed increasing trend. Higher production of seed yield in sole mustard was recorded due to presence of mustard population while, it was interesting to note that with increase in the population of pulses in the intercropping system the mutual benefit in terms of resource availability particularly nitrogen economy and production of yield was more in mustard. Similar type of results has also been reported by Singh *et al*. (2008), Yadav *et al*. (2009), Choudhuri and Jana (2015), Das *et al*. (2017), Lal *et al*. (2019) and Singh *et al*. (2019).

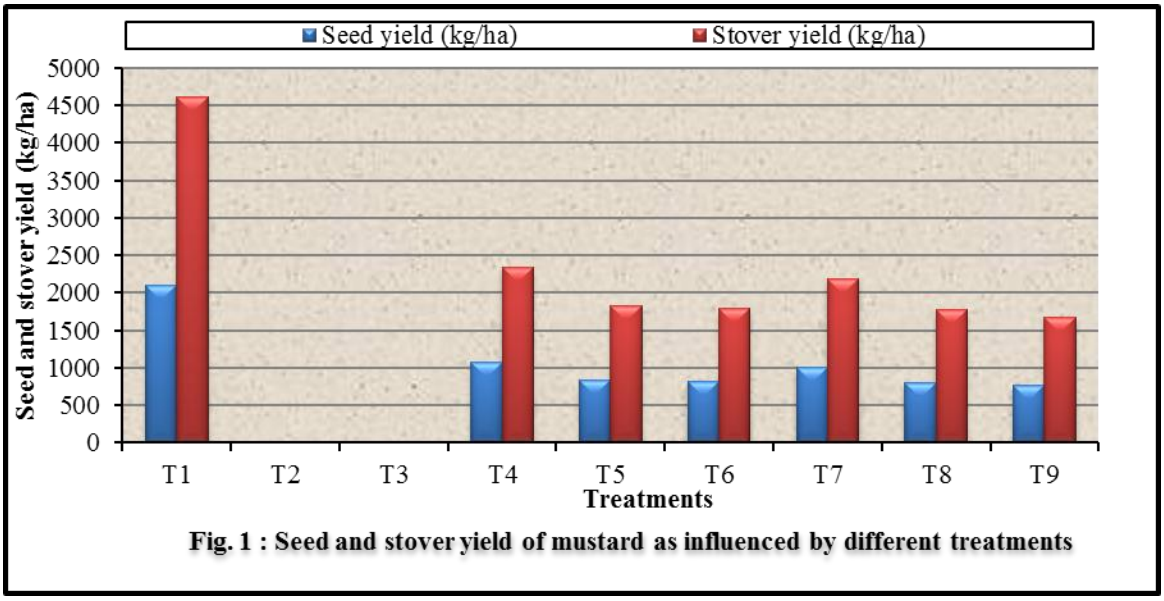

Fig. 1 : Seed and stover yield of mustard as influenced by different treatments

Oil content (%)

Perusal of data presented in Table 2 indicated the oil content of mustard was not significantly influenced by any of the treatments. When the comparison was made among the intercrops, none of the intercrops could influence the oil content of mustard.

Effect of mustard on intercrops

Growth parameters

The data regarding growth parameters of chickpea and field pea are presented in Table 3 and 4, respectively. The data were not analysed statistically hence, the inferences were drawn from the mean values.

Plant height/vine length of intercrops was increased with advancement in age and was maximum at harvest for chickpea and field pea. The plant height/vine length of sole crops was higher than that of all intercropping treatments and it was lower recorded under the 1:2 ratio of mustard with both the intercrops.

Yield and yield attributes

The data regarding yield attributes and yield of chickpea and field pea are presented in Table 3 and 4, respectively. The data were not analysed statistically hence, the inferences were drawn from the mean values.

In mustard + chickpea intercropping system, the number of pods plant^{-1}, grain and straw yield was higher under sole chickpea (T_2). The mustard + chickpea 1:2 ratio (T_4) recorded lower number of pods plant^{-1}, grain and straw yield. In mustard + field pea intercropping system, the number of pods plant^{-1}, grain and straw yield was higher under sole field pea (T_3). The mustard + chickpea 1:2 ratio (T_4) recorded lower number of pods plant^{-1}, grain and straw yield.

Data with respect to pods plant^{-1}, grain and straw yield of intercrops indicated that the overall yield of intercrops were higher in case of their respective sole crops followed by inclusion of these intercrops in 1:4, 1:3 and 1:2 proportion. It indicated that with increase in the population of mustard in the intercropping system, adverse effect of shading increased. Similar trend was observed by Kumar and Singh (1987), Varshney and Arya (2004), Ahlawat *et al*. (2005), Tripathi *et al*. (2005), Kumar and Singh (2006), Yadav *et al*. (2009), Das *et al*. (2017) and Lal *et al*. (2019).

Study of main crop + intercrops

The data regarding LER and mustard equivalent yield are presented in Table 5. Mustard + chickpea 1:3 ratio recorded the highest LER than all other intercropping treatments. In different planting patterns, 1:3 ratio recorded more LER followed by 1:4 and 1:2 ratios. In mustard + field pea intercropping system land equivalent ratio (LER) values was less than < 1 which indicated that sole cropping of mustard and field pea is beneficial then intercropping. The land equivalent ratio (LER) values in different systems were greater than unity, indicating the yield advantage was achieved from intercropping system. The higher LER (1.25) was recorded under 1:3 mustard + chickpea intercropping system, closely followed by 1:4 mustard + chickpea intercropping system. There was considerable increase in the yield of companion crops, therefore, higher LER values were recorded in above referred treatment combinations. These results are in line with those of Kumar and Singh (1987), Singh *et al*. (1998) and Das *et al*. (2017).

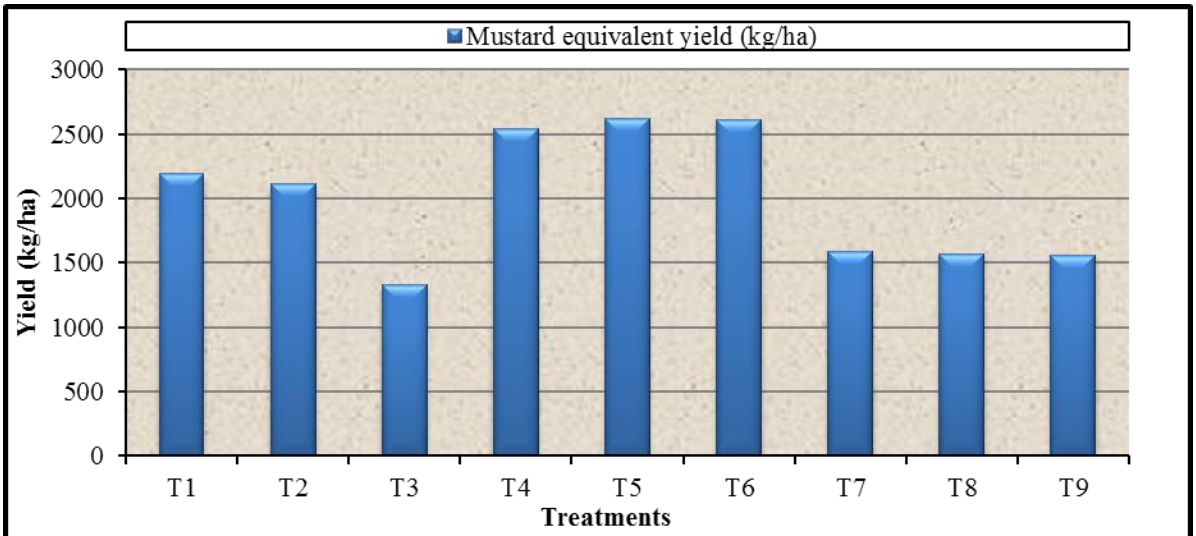

Fig. 2 : Mustard equivalent yield of the cropping system

Under almost all intercropping treatments, significantly higher equivalent yield was recorded under mustard + chickpea in 1:3 ratio (T_5). However, it remained at par with mustard + chickpea 1:4 ratio (T_6) and mustard + chickpea 1:2 ratio (T_4). The mustard + field pea 1:4 ratio (T_9) recorded lower mustard equivalent yield among all treatments. Higher MEY (2624 kg/ha) was registered under mustard + chickpea in 1:3 row ratio (T_5). This was due to higher production of chickpea compare to field pea because of that coupled with better utilization of resources of the component crop in intercropping system. Singh and Pal (1993) also reported similar type of results.

Economics

It is clear from the data presented in Table 6 that there was considerable difference among total cost of cultivation of different treatments under study. In

case of mustard + chickpea and mustard + field pea intercropping systems, mustard + chickpea in 1:3 row proportion recorded the maximum gross return, net return and Benefit: Cost Ratio (BCR) of ₹ 1,31,273, ₹ 99,346 ha^{-1} and 4.11, respectively. These results are in line with those of Kumar and Singh (1987), Patel *et al*. (1991), Singh *et al*. (1998), Punia *et al*. (1999), Singh and Pal (2011) and Kour (2013).

Table 1. Number of primary and secondary branches plant^{-1}, number of siliquae plant^{-1}, number of seeds siliqua^{-1} and test weight of mustard as influenced by various treatments

Treatments			Number of primary branches plant^{-1}	Number of secondary branches plant^{-1}	Number of siliquae Plant	Number of seeds siliqua^{-1}	Test weight (g)
T_1	:	Sole mustard	222.95	14.19	222.95	10.66	4.09
T_4	:	Mustard + chickpea (1:2)	256.15	14.50	256.15	11.77	4.41
T_5	:	Mustard + chickpea (1:3)	285.35	16.72	285.35	12.02	4.68
T_6	:	Mustard + chickpea (1:4)	283.66	15.21	283.66	11.68	4.45
T_7	:	Mustard + field pea (1:2)	236.42	14.34	236.42	11.00	4.08
T_8	:	Mustard + field pea (1:3)	252.90	16.66	252.90	10.83	4.35
T_9	:	Mustard + field pea (1:4)	246.83	14.78	246.83	10.69	4.25
S.Em.±			0.25	0.53	12.88	0.40	0.16
C.D. (P = 0.05)			0.78	1.64	39.68	NS	NS
C.V. (%)			8.88	6.06	8.75	6.17	6.23

Table 2. Seed and stover yield (kg/ha), harvest index and oil content of mustard as influenced by various treatments

Treatments			Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest Index (%)	Oil content (%)
T_1	:	Sole mustard	2103	4615	31.30	34.42
T_4	:	Mustard + chickpea (1:2)	1069	2347	31.29	35.22
T_5	:	Mustard + chickpea (1:3)	840	1829	31.45	36.00
T_6	:	Mustard + chickpea (1:4)	819	1788	31.41	35.86
T_7	:	Mustard + field pea (1:2)	999	2189	31.28	34.89
T_8	:	Mustard + field pea (1:3)	807	1775	31.23	35.15
T_9	:	Mustard + field pea (1:4)	760	1677	31.12	35.06
S.Em.±			77.33	155.86	-	0.36
C.D. (P = 0.05)			238.29	480.29	-	NS
C.V. (%)			12.68	11.65	-	1.77

Table 3. Growth parameters, yield and yield attributes of intercrop chickpea as influenced by various treatments

Treatments			Plant height (cm)		Number of branches plant^{-1}	Number of pods plant^{-1}	Number of grains pod^{-1}	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
			60 DAS	At harvest						
T_2	:	Sole chickpea	28.99	38.76	4.01	31.02	1.32	1729	1895	47.76
T_4	:	Mustard + chickpea (1:2)	26.43	36.27	2.84	23.03	1.26	1168	1282	47.71
T_5	:	Mustard + chickpea (1:3)	26.48	37.95	3.27	26.83	1.29	1431	1584	47.39
T_6	:	Mustard + chickpea (1:4)	27.23	38.35	3.87	29.86	1.30	1439	1587	47.45

*The data were not analysed statistically hence, the inferences were drawn from the mean values.

Table 4. Growth parameters, yield and yield attributes of intercrop field pea as influenced by various treatments

Treatments			Vine length (cm)		Number of branches plant^{-1}	Number of pods plant^{-1}	Number of grains pod^{-1}	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
			60 DAS	At harvest						
T_3	:	Sole field pea	18.27	24.77	2.63	13.04	3.18	728	968	42.92
T_7	:	Mustard + field pea (1:2)	16.70	21.24	2.00	10.22	2.85	301	429	41.23
T_8	:	Mustard + field pea (1:3)	17.33	21.92	2.13	10.98	3.06	398	554	41.81
T_9	:	Mustard + field pea (1:4)	17.73	23.22	2.40	11.25	3.15	419	565	42.58

*The data were not analysed statistically hence, the inferences were drawn from the mean values.

Table 5. Relative yield and LER of the cropping system

Treatments			Relative Yield (RY)		Land Equivalent Ratio	Mustard equivalent yield (kg ha^{-1})
			Mustard	Intercrop		
T_1	:	Sole mustard	1.00	-	1.00	2195
T_2	:	Sole chickpea	-	1.00	1.00	2113
T_3	:	Sole field pea	-	1.00	1.00	1330
T_4	:	Mustard + chickpea (1:2)	0.51	0.68	1.19	2543
T_5	:	Mustard + chickpea (1:3)	0.40	0.85	1.25	2624
T_6	:	Mustard + chickpea (1:4)	0.39	0.85	1.24	2614
T_7	:	Mustard + field pea (1:2)	0.48	0.41	0.89	1593
T_8	:	Mustard + field pea (1:3)	0.39	0.55	0.94	1570
T_9	:	Mustard + field pea (1:4)	0.36	0.58	0.94	1559
S.Em.±			-	-	-	106.58
C.D. (P = 0.05)			-	-	-	319.55
C.V. (%)			-	-	-	9.16

Table 6. Total cost of cultivation, gross return, net return and Benefit: Cost Ratio (CBR) as influenced by various treatments

Treatments			Total cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	Benefit: Cost Ratio (BCR)
T_1	:	Sole mustard	30455	109765	79310	3.60
T_2	:	Sole chickpea	32421	105635	73214	3.26
T_3	:	Sole field pea	31821	66488	34667	2.09
T_4	:	Mustard + chickpea (1:2)	31828	127159	95331	4.00
T_5	:	Mustard + chickpea (1:3)	31927	131273	99346	4.11
T_6	:	Mustard + chickpea (1:4)	32066	130665	98599	4.07
T_7	:	Mustard + field pea (1:2)	31428	79658	48230	2.53
T_8	:	Mustard + field pea (1:3)	31477	78499	47022	2.49
T_9	:	Mustard + field pea (1:4)	31586	77952	46366	2.47

CONCLUSION

The overall findings of the present investigation indicated that mustard + chickpea intercropping system (1:3) was found to be the best for getting potential mustard equivalent yield with higher net profit. While, mustard + chickpea intercropping system with row ratios of 1:2 and 1:4 can be followed for getting higher and profitable equivalent yield than mustard + field pea intercropping system and sole crops.

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