RESEARCH ARTICLE Indian Journal of Agricultural Research, Volume 59 Issue 9: 1436-1440 (September 2025)

Effect of Mustard-based Intercropping Systems on Efficiency Indices under Organic Management

Umesh Kumar Singh[1], B. Gangwar[1], Sourabh Kumar[2], Rajiv Kumar[3]

10.18805/IJARe.A-6209

ABSTRACT

Background: Intercropping has potential to increase land productivity by leveraging species complementarities and a means to achieve sustainable agricultural intensification. The mustard intercropping with other crops significantly modified the competition parameters when compared to their comparable sole crops.

Methods: An experiment was carried out at Organic Research Farm, Karguaji, Institute of Agricultural Sciences, Bundelkhand University, Jhansi, during *Rabi* 2021-22 to investigate the effect of mustard-based intercropping systems utilizing the skip-row method on efficiency indices under organic management. Nine treatments were investigated, including 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 an intercropping system omitting one row of mustard.

Result: Intercropping of mustard with desi chickpea showed positive trends in terms of efficiency indices with higher CGR (17.8 g.day^{-1}cm^{-2}), RGR (17.90 g.g^{-1}.day^{-1}), LER (1.64), MEY (26.7qha^{-1}), CEY (25.87 qha^{-1}) and ATER (1.64) which ultimately resulted in highest profitability (Rs 888 ha^{-1} day^{-1}).

Key words: Efficiency indices, Intercropping systems, Mustard, Organic management.

INTRODUCTION

India has only 2% of the world's land area but 16% of the world's population, making it populous country in the world. The global food requirements, particularly those of India, have recently increased rapidly, but the cultivated land has been decreasing day by day due to rapid urbanization. Thus, there is an immediate need to improve cropping intensity and productivity several folds. Rainfed agriculture accounts for 67% of India's net sown area, supplying 44% of food grains and supporting 40% of the population (Economic Survey, 2023-24).

However, numerous obstacles affect the rainfed condition, such as poor and irregular rainfall distribution and land degradation, which causes low efficiency of various inputs and technology. As a result, these elements cause issues for resource-poor farmers in their year-round food production or subsistence existence (Singh *et al*., 2025). In this situation, intercropping plays a vital role to full fill the demands of people. Intercropping systems that are successful to grow more diverse crops and higher monetary returns per unit area and per unit time than sole crop production (Bhuiyan *et al.,* 2013) and gives improved resource usage efficiency.

Intercropping is an important multiple-cropping technique that has been widely used in developing countries. Increasing food production on the same land area in a sustainable manner may be the only way to tackle poverty and malnutrition, respectively. Intercropping, or the simultaneous growth of two or more crop species in the same field in a specific row arrangement during a growing season (Ofori and Stern, 1987), could play a critical role in ensuring food security while maintaining environmental quality. Intercropping boosts yield and resource use efficiency due to improved temporal and geographical resource use efficiency, in which all above-ground and below ground crop portions play an important role (Midega *et al.,* 2014). It may be preferred to monoculture because it increases output by making better use of resources such as water, fertilizer and solar energy. Mustard, the world's third-largest oilseed crop after soybean and oilpalm. Mustard account for 28.6% of the total amount of edible oilseeds cultivated in India. The Government has been implementing a National Food Security Mission-Oilseeds and Oil Palm (NFSM OS and OP), from 2018-19 to augment the availability of vegetable oils through improved productivity and increase in acreage under cultivation.

[1]Department of Agronomy, Institute of Agricultural Sciences, Bundelkhand University, Jhansi-284 128, Uttar Pradesh, India.
[2]Department of Agronomy, VKS College of Agriculture, Bihar Agriculture University, Sabour, Dumraon-802 136, Bihar, India.
[3]Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara-144 411, Punjab, India.

Corresponding Author: Umesh Kumar Singh, Department of Agronomy, Institute of Agricultural Sciences, Bundelkhand University, Jhansi-284 128, Uttar Pradesh, India.
Email: 1999umesh8@gmail.com

How to cite this article: Singh, U.K., Gangwar, B., Kumar, S. and Kumar, R. (2025). Effect of Mustard-based Intercropping Systems on Efficiency Indices under Organic Management. *Indian Journal of Agricultural Research*. **59(9):** 1436-1440. doi: 10.18805/IJARe.A-6209.

Submitted: 22-01-2024 **Accepted:** 25-12-2024 **Online:** 14-02-2025

The total area coverage of all oilseeds has expanded significantly, increasing from 25.60 million hectares in 2014-15 to 30.08 million hectares in 2023-24 (17.5 per cent growth). The domestic availability of edible oil has risen from 86.30 lakh tonnes in 2015-16 to 121.33 lakh tonnes in 2023-24. This has reduced the percentage share of imported edible oil, from 63.2 per cent in 2015-16 to 57.3 per cent in 2022-23, despite rising domestic demand and consumption patterns. A remunerative minimum support price for rapeseed and mustard (which was at 98 per cent over cost in 2022-23) is also providing the incentive to farmers to diversify production (Economic Survey, 2023-24), while most significant pulse crop is Bengal gram, sometimes known as "chickpea". Fenugreek is an annual plant grown mostly for its seeds and leaves (fresh Abrahamor dried). The seeds are used as a spice and condiment to enhance the flavour and nutritional content of foods. All these crops were associated in mustard based intercropping systems and efficiencies compared to identify most efficient system for organic farming in Bundelkhand region.

The domestic availability of edible oil has risen from 86.30 lakh tonnes in 2015-16 to 121.33 lakh tonnes in 2023-24. The total area coverage of all oilseeds has increased from 25.60 million hectares in 2014-15 to 30.08 million hectares in 2023-24 (17.5 per cent growth). This has reduced the percentage share of imported edible oil, from 63.2 per cent in 2015-16 to 57.3 per cent in 2022-23, despite rising domestic demand and consumption patterns (Economic Survey, 2023-24). The objective of this study was to find out the most suitable mustard based intercropping system for obtaining higher yield, returns and resource saving in Bundelkhand region.

MATERIALS AND METHODS

A field experiment was conducted at the Organic Research Farm of the Institute of Agricultural Sciences, Bundelkhand University, Jhansi, Uttar Pradesh, during the *Rabi* season of 2021-2022. The treatments involving 09 combinations of a single crop from each of the five groups *viz* (T_1) Mustard, (T_2) *kabuli* chickpea, (T_3) field pea, (T_4) fenugreek, (T_5) Desi chickpea and four intercropping systems *viz*. (T_6) Mustard + *kabuli* chickpea (1:2), (T_7) Mustard + Field pea (1:2), (T_8) Mustard + fenugreek (1:2) and (T_9) Mustard + Desi chickpea (1:2) using skip row method of sowing were set in a randomised block design and replicated thrice. The soil of experimental site was silt loam with pH of 8.2, low organic carbon, medium nitrogen, phosphorus and potash availability. With the exception of sole crops, all intercropping treatments, the Indian mustard was planted in replacement series and three rows of intercrops were sown. Recommended dose of fertilizer (RDF) was applied through well rotten farm yard manure before 15 days of sowing of crops. The crops were sown on October 29, 2021 and harvested on March 24, 2022. Standard statistical tools were used to collect and assess data on growth and yield characteristics.

To assess the efficiency of the intercropping systems, growth parameters such as crop growth rate (Watson, 1956), relative growth rate (de Wit and Bergh, 1965), land equivalent ratio (Willey, 1979), chickpea equivalent yield (Verma and Modgal,1983), area time equivalent ratio (Hiebsch,1980), seed yield, relative yield, relative crowding coefficient (Wit,1960 and Hall,1974), aggressivity (Willey and Rao, 1980), competition ratio advantage (Willey and Rao,1980), mustard equivalent yield (Umesh *et al.,* 2024) and profitability were assessed. The data obtained from various characters under study were analysed by the method of analysis of variance as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of various cropping systems on growth of mustard

Crop growth rate

It is clear of the data (Fig 1), when mustard was sown alone, the CGR was (6.9) and (8.3) $g.day^{-1}cm^{-2}$ at 30 and 60 intervals, but in intercropping treatments the values were 9.84 and 10.5, 8.1 and 14.3,7.92 and 12.1 when grown with *kabuli* chickpea, field pea and fenugreek respectively. While, highest values were recorded (10.91 and 17.8 g. day^{-1} cm^{-2}) when mustard was sown with desi chickpea. It could be owing to greater utilisation of nutrients and space, which results in an increase crop growth rate as also reported by Gokhale *et al*. (2008) and Abraham *et al*. (2010).

Relative growth rate

The highest relative growth rate was recorded when it was grown with desi chickpea (10.92 and 17.90 $g.g^{-1}.day^{-1}$) at 30 to 60 days and 60 to 90 days interval. But, in intercropping treatments the values of RGR were 9.86 and 14.21, 8.96 and 10.5,7.93 and 12.17 $g.g^{-1}.day^{-1}$ recoded when mustard was grown with *kabuli* chickpea, field pea and fenugreek respectively. This could be due to better utilization of nutrients and space as also reported by Kumar and Singh (2006).

Effect of intercropping systems on the land equivalent ratio (LER)

Fig 2 shows that LER was considerably altered by different intercropping systems. When mustard was intercropped with Desi chickpea, the values of land equivalent ratio were much higher (1.64) than other intercropping treatments as the values of 1.37, 1.5,1.43 and 1.64 were recoded when mustard was grown with *kabuli* chickpea, field pea and fenugreek respectively. It shows that Mustard + Desi chickpea intercropping system is beneficial. Similar findings were also reported by Singh *et al*. (2023).

Effect of various cropping systems on aggressivity

The competitive potential of the component crops in an intercropping system is determined by the value of aggressivity. It was significantly greater in the main crop

than in the four intercrops. The data in Fig 2 is clearly show that, the highest (1.9) aggressivity was recorded when mustard sown with pea while, lowest aggressivity (1.4) was recorded when mustard was sown with Desi chickpea. This shows that, field pea is more aggressive than chickpea in intercropping system.

Mustard and chickpea equivalent yield

The mustard equivalent yield was significantly influenced by legume crops in a mustard-based intercropping system using the skip row method under organic conditions (Table 1). The highest mustard equivalent yield (26.7 q ha^{-1}) was recorded when mustard was intercropped with desi chick pea compared to mustard alone and other intercropping treatments, with non-significant differences among the other intercropping treatments. In terms of chickpea equivalent yield, the highest desi chickpea equivalent yield was recorded (25.87 q ha^{-1}) when it was grown with mustard.

Competition ratio (CR)

The competitive ratio was higher when mustard was grown with chickpea (Fig 2) compare to other intercrops field pea Desi chickpea, fenugreek and field pea. The values of competitive ratio for mustard intercropped with *kabuli* chickpea, field pea, fenugreek and Desi chickpea were 0.99, 1.5,1.49 and 1.13 respectively. From this result it can be noticed that field pea was more competitive crop when it was intercropped with Mustard compared to other legumes.

Relative crowding coefficient (RCC) and relative yield total

Relative crowding coefficient of mustard and field pea was recorded (1.34) which is more than 1, indicating greater non-competitive interference. RCC is the measure of relative dominance of one species over the other in intercropping. It was followed by mustard intercropped with desi chickpea (1.1). The relative yield total (RYT) index is a measure of the extent to which various crop component shared common resources, rather than as a direct measure of yield advantage. The highest RYT (1.7) was found when desi chickpea and *kabuli* chick pea intercropped with mustard while it was at par with fenugreek (1.5) and field pea (1.3) when intercropped with mustard.

Effect of intercropping systems on ATER

The values of area time equivalent ratio varied slightly among the intercrops namely *kabuli* chickpea, Field pea, fenugreek and Desi chickpea when anyone was intercropped with Mustard (Fig 2) while, highest area time equivalent ratio (1.64) was recorded when mustard was grown with desi chickpea. while lowest ATER were recorded when mustard was grown with fenugreek.

Profitability (Rs ha^{-1} day^{-1})

Significantly highest profitability of Rs 888 ha^{-1} day^{-1}, was obtained when mustard was intercropped with desi

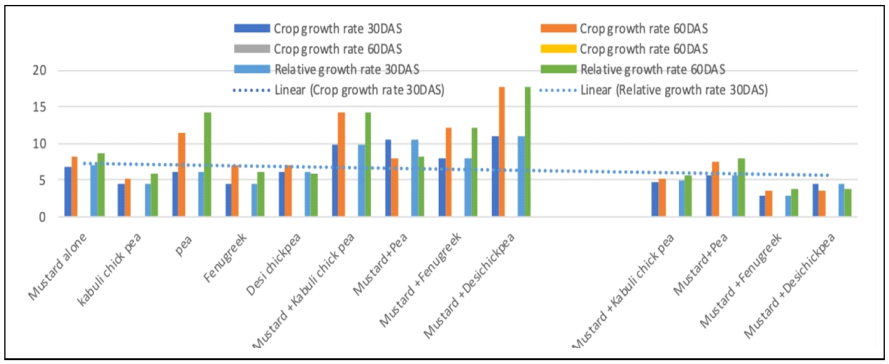


Fig 1: Effect of associated crops on CGR and RGR of mustard crop and effects of mustard on CGR and RGR of associate crops.

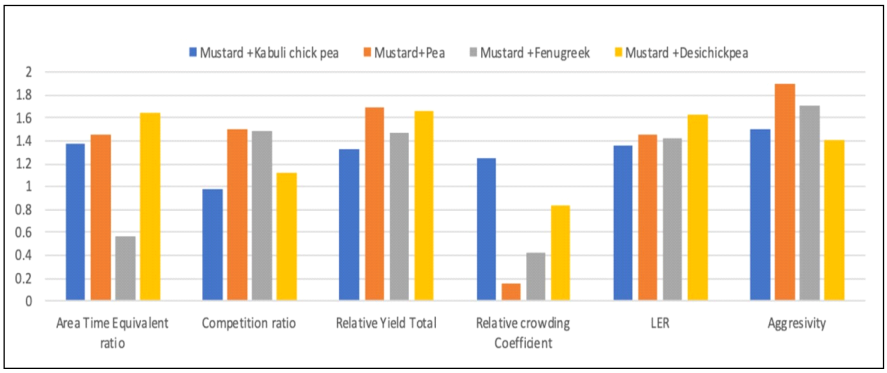


Fig 2: Effect of associated crop on ATER, CR, RYT, LER and Aggressivity of mustard crop.

Table 1: Effects of mustard-based intercropping on MEY, profitability of mustard and CEY of chickpea.

Treatment	Mustard equivalent yield (MEY) (q ha^{-1})	Chickpea equivalent yield (CEY) (q ha^{-1})	Profitability (Rs. ha^{-1} day^{-1})
T0 - Mustard alone	13.7	13.22	447
T1 - *Kabuli* chickpea alone	18.2	16.74	492
T2 - Pea alone	13.5	12.47	381
T3 - Fenugreek alone	15.6	14.18	538
T4 - Desi chickpea alone	13.5	12.6	393
T5 - Mustard + *kabuli* chickpea	25.9	23.18	820
T6 – Mustard + Pea	22.3	21.53	688
T7- Mustard + Fenugreek	24.5	22.47	850
T8 - Mustard + Desi chickpea	26.7	25.82	888
Sem (±)	2.8	3.6	116
C.D (P≤0.05)	8.7	9.5	351

*Significant at P≤0.05; NS- Non-significant at P>0.05.

chickpea (Table 1) compared to sole crop of mustard, field pea, fenugreek and *kabuli* chickpea but it was statistically at par with rest of the intercropping treatments. Similar results also reported by Mandal *et al.* (1996) and Singh *et al*. (2023a).

CONCLUSION

Mustard + Desi chickpea intercropping system using skip-row system was identified to be most suitable with mustard equivalent yield of 26.7 q ha^{-1} or Desi chickpea equivalent yield of 25.87 q ha^{-1}. The efficiency indices support yield trends and therefore intercropping of mustard with desi chickpea is recommended for sustaining higher production with improved productivity and profitability in organic farming systems in Bundelkhand region of Uttar Pradesh.

Submission declaration

- That the article is original work done within the previous five years of the submission.
- That the work is in no way contravenes the publication ethics of the Journal.
- That while preparing the manuscript copying and or plagiarizing has been avoided.
- That the article, in part of full, has not been previously published and is not under consideration for publication elsewhere.
- That the article has been approved by all authors for submission to the Journal.
- That there is no conflict of interest among the authors or any other individual or organisation *etc*.
- That all persons/establishments who have contributed to the said work in terms of financial/intellectual and other helps have been duly acknowledged.
- That all author(s) has/have given consent for publishing the article in Journal.

Conflict of interest

The author(s) declare(s) no known conflict of interests that could have appeared to influence the work reported in this paper.

REFERENCES

Abraham, T., Sharma, U.C., Thenua, O.V.S. and Shivakumar, B.G. (2010). Effect of levels of irrigation and fertility on yield and economics of chickpea (*Cicer arietinum*) and Indian mustard (*Brassica juncea*) under sole and intercropping systems. *The Indian Journal of Agricultural Sciences*. **80(5)**.

Bhuiyan, M.S., Bhowal, S.K., Farhad, I.S., Chowdhury, M.M.U., Amin, M. (2013). Intercropping soybean with kaon in varying plant population in the coastal area of Noakhali region. *Bangladesh Agronomy Journal*. **16:** 81-86.

De Wit, C.T. and Van den Bergh, J.P. (1965). Competition between herbage plants. *The Journal of Agricultural Science*. **13:** 212-221.

Economic Survey, (2023-24). Press Information Bureau Government of India. doc2024722351601.pdf (pib.gov.in).

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research (2nd Edn.). John Wiley and Sons, New York. pp. 680.

Gokhale, D.N., Wadhvane, S.V., Kalegore,N.K., Khalge, M.L and Shaikh, F.G. (2008). Response of linseed varieties to row spacing and phosphorus levels under irrigated condition. *Journal of Oilseed Research*. **25:** 94-95.

Hall, R.L. (1974). Analysis of the nature of interference between plants of different species. I. Concepts and extension of the de Wit analysis to examine effects. *Australian Journal of Agricultural Research*. **25:** 739-747.

Hiebsch, C.K. (1980). Principles of intercropping: Effects of nitrogen fertilization, plant population and crop duration on equivalency ratios in intercrop versus monoculture comparisons. North Carolina State University.

Kumar, A. and Singh, B.P. (2006). Effect of row ratio and phosphorus level on performance of chickpea (*Cicer arietinum*) + Indian mustard (*Brassica juncea*) intercropping. *Indian Journal of Agronomy*. **51:** 100-102.

Mandal, B.K., Dasgupta, S. and Ray, P.K. (1986). Water use by wheat, chickpea and mustard grown as sole and intercrops. *Indian Journal of Agriculture Science*. **56(3):** 187-193.

Midega, C.A.O., Salifu, D., Bruce, T.J., Pittchar, J., Pickett, J.A., Khan, Z.R. (2014). Cumulative effects and economic benefits of intercropping maize with food legumes on *Striga hermonthicain festation*. *Field Crops Research*. **155:** 144-152.

Ofori, F., Stern, W.R. (1987). Cereal-legumes intercropping. *Advances in Agronomy*. **41:** 41-90.

Singh, U.K., Gangwar, B. and Srivastava, H. (2023a). Effect of mustard based intercropping systems on yield and profitability under organic management in Bundelkhand Region. *Indian Journal of Ecology*. **50:** 627-630.

Singh, U.K., Gangwar, B. and Srivastava, H. (2023). Evaluation of mustard based intercropping systems under organic management in Bundelkhand region. *Journal of Crop and Weed*. **19:** 66-72.

Singh, U.K., Korav, S., Kumar, S. and Sujatha, H.T. (2025). Influence of planting systems and nutrient management on maize growth, yield and light interception in a maize-soybean intercropping system. *Indian Journal of Agricultural Research*. 1-6. doi: 10.18805/IJARe.A-6286.

Umesh, S.K., Santhosh, K., Paramesh, V. and Biswajyoti, B. (2024). Impact of planting systems and nutrient management on growth and yield of maize and soybean in a maize + soybean cropping system. *Plant Science Today*. **11(4).** Available from: https://horizonepublishing.com/journals/index.php/PST/article/view/4451.

Verma, S.P. and Modgal, S.C. (1983). Production potential and economics of fertilizer application as resource constraints in maize-wheat crop sequences. *Himachal Journal of Agricultural Research.* **9:** 89-92.

Watson, D.J. (1956). Comparative physiological studies on the growth of field crops. I. Variation in net assimilation rate and leaf area between species and varieties and within and between years. *Annals of Botany*. **11:** 41-46.

Willey, G.R., Leventhal, R.M. and Hammond, N. (1979). Prehistoric settlement at Copan. *Maya Archaeology and Ethnohistory.* pp 75-102.

Willey, R.W. and Rao, R.M. (1980). A competitive ratio for quantifying competition between intercropping. *Experimental Agriculture*. **16:** 17-125.

Wit, De, C.T. (1960). On competition. *Verslagen van Landboukundige Onderzoekingen*. **66:** 1-82.