Environment and Ecology 42 (1) : 43—48, January—March 2024
Article DOI: https://doi.org/10.60151/envec/PUPX3862
ISSN 0970-0420

Effect of Diverse Production Systems on Growth, Yield and Economics of Indian Mustard (*Brassica juncea* (L.) Czern and Coss) Varieties

Shashank Patel, S. S. Rathore, Kapila Shekhawat, R. K. Singh, Subhash Babu, Supriya, Anamika Burman

Received 8 August 2023, Accepted 9 November 2023, Published on 31 January 2024

ABSTRACT

An agronomic experiment to study the effect of diverse production systems on growth, yield and economics of Indian mustard varieties was conducted in the research farm of Division of Agronomy, ICAR–Indian Agricultural Research Institute (IARI), New Delhi, India during *rabi* season of 2021. The field experiment was laid-out in split-plot design in fixed layout with three replications. The field experiment comprised four main plot treatments (Production systems: Organic Management System (OMS), Integrated Crop Management (ICM), Conventional System (CS) and Conservation Agriculture (CA) and three sub-plot treatments (Mustard varieties-PM 26, PM 28 and PDZ 1). The results revealed that the plant height (cm), Dry matter accumulation (DMA), Leaf area index (LAI) of different varieties of Indian mustard under diversified production scenarios was significantly ($p<0.05$) influenced at 30, 60 90 days after sowing (DAS). There was almost 14% increase in seed yield was recorded under ICM compared to CS. Among the mustard varieties, PM 26 resulted in maximum seed yield (2206 kg/ha), closely followed by PM 28 (2123 kg/ha), while least seed yield was recorded under PDZ-1. Under OMS and ICM higher harvest index i.e., 0.23 and 0.24 respectively was observed which was higher than CS (0.22) and CA (0.20). The maximum net return (NR) was obtained under ICM (Rs 76583/ha) and among the varieties, PM 26 gave maximum NR of Rs 76060/ha. ICM and CA resulted in higher B:C ratio (2.87 and 2.97 respectively) compared to CS and OMS, while among the varieties maximum B:C ratio was from PM 26 (2.87) and least was from PDZ-1 (2.18).

Keywords B:C ratio, Diverse production system, Harvest index, Net return, Split plot design.

INTRODUCTION

Oilseeds are the second most important agricultural economy in India next to cereals growing at a pace of 4.1% per annum in the last three decades (Jat *et al.* 2019). Indian mustard is an economically important oilseed crop widely cultivated in various agro-climatic regions of the world, particularly in South Asia. Its high oil content and nutritional value have contributed to its significance in the edible oil indus-

Shashank Patel[1]*, S. S. Rathore[2], Kapila Shekhawat[3], R.K. Singh[4], Subhash Babu[5], Supriya[6], Anamika Burman[7]

[2, 4]Principal Scientist, [3]Scientist, [5]Senior Scientist
[1, 2, 3, 4, 5, 7]Division of Agronomy, ICAR-IARI, New Delhi 110012, India

[6]Section of Agronomy, ICAR-NDRI, Karnal, Haryana 132001, India

Email : shashankpatel996@gmail.com
*Corresponding author

try and as a potential source of biodiesel. However, the productivity and profitability of Indian mustard cultivation are influenced by a multitude of factors, including the choice of production system. Oilseed brassica achieved significant growth in India in the past, however, the productivity levels are still low owing to large cultivation under rainfed situation, biotic and abiotic stresses, and resources crunch. It is also facing the challenges of low genotypic potential, climate change and price fluctuation. In this regard, the crop diversification is one of the potential practices which can minimize the effect of different types of biotic and abiotic stresses (Rathore *et al.* 2019, Baishya *et al.* 2019). During the last two decades, the domestic consumption of vegetable oils increased at a CAGR of 4.3% and is expected to continue increasing with the growing population, changing demographic pattern and rising per capita consumption due to increased GDP (Rathore *et al*. 2020). Indian mustard is the largest contributor of domestic oil production in India, still huge gap exists in present and potential productivity. It gives immense scope to increase the production in traditional and non-traditional areas in India with proper inputs, technological interventions, and suitable policy framework. Amongst the agronomic factors which can augment the crop production, fertilizer stands in first position and is considered one of the most productive inputs in agriculture. The nutrient requirement of Indian mustard, in general is high and inadequate nutrient use often leads to low productivity in *Brassica juncea* (Tripathi *et al.* 2010). The traditional agricultural practices have often relied on conventional chemical-intensive methods, utilizing synthetic fertilizers and pesticides. While these methods initially led to increased crop yields, they have also resulted in various ecological and economic challenges, such as soil degradation, water pollution, and escalating input costs. As a result, there has been a growing interest in exploring more sustainable and eco-friendly production systems that can maintain or enhance crop productivity while promoting environmental stewardship. In recent years, research efforts have been directed towards adopting diverse production systems that incorporate both organic and inorganic sources of nutrients, conservation tillage practices, crop rotations, and integrated pest management strategies. These systems aim to optimize resource use efficiency, conserve soil health and reduce the environmental footprint of agriculture. This study encompasses a systematic evaluation of various production approaches, such as organic farming, integrated nutrient management and sustainable crop management, among others. Through meticulous experimentation and data analysis, the study aims to unravel the potential benefits and challenges associated with each production system and identify the most promising strategies to enhance Indian mustard cultivation.

MATERIALS AND METHODS

Field experiment was conducted at ICAR-IARI, New Delhi during *rabi* 2020–21. The experiment was conducted at research farm of the division of Agronomy, Indian Agricultural Research Institute, New Delhi (28.63°N latitude, 77.15°E longitude, 228.6 m above mean sea level). Meteorological data recorded during cropping season, showed that the mean maximum temperature varies from 17.9 to 32.8ºC and the minimum temperature varies from 3.3 to 14.4ºC. Relative humidity ranged from 28.7 to 95.1% during the cropping period. During the period of experimentation total 76.8 mm rainfall received. The field has an even topography and good drainage system. Soil of the experimental field belongs to the order Inceptisol having sandy loam texture in top 30 cm layer. Composite soil sampling was accomplished from 0–15 cm depth randomly before sowing of the crop and were analyzed for major plant nutrients and also for the physico-chemical properties of soil. From the analysis, it was revealed that the soil of the experimental site was sandy loam in texture, medium in organic carbon concentration in OMS (0.67%), ICM (0.64%), CS (0.55%) and CA (0.59%) plots, low in available nitrogen and medium in available P and K in all plots. The field experiment was laid-out in split-plot design in fixed layout with three replications. The field experiment comprised four main plot treatments (Production systems: Organic Management System, Integrated Crop Management, Conventional System and Conservation agriculture) and three sub-plot treatments (Mustard varieties-PM 26, PM 28 and PDZ 1). In OMS, nutrients were applied from the organic sources only. Application of well decomposed FYM @10 kg/ha along with vermicompost was done 10 days before sowing of crop. Seed treatment with Phosphorus solubilizing bacteria was done. In ICM, nutrients were applied @ 50% of recommended dose of nutrients along with well decomposed FYM and vermicompost. Seed treatment with phosphorus solubilizing bacteria was also done. In CS, application of nutrients viz. NPK and S was done on the recommended dose of nutrients i.e., @ 80:40:40:30 kg/ha respectively. Nitrogen was applied with Urea, Phosphorus with SSP, Potassium with MOP and sulfur with bentonite. In conservation system there is no any tillage practices were performed before sowing of crop. Crop was sown in zero tillage condition using maize residue for the covering of the soil and nutrients were applied on the basis of recommendation. Sowing was done on 22[nd] October, 2020 using 'happy seeder' after application of 60 mm irrigation. A seed rate of 4 kg/ha was used under planting density of 45 cm for row to row and 4-5 cm for plant to plant. The experimental crop was harvested on 6[th] March 2021. Observations were recorded on growth and yield periodically. Economics of different treatments were worked out by taking into account the cost of inputs and income and price of output (seed and stover yield). Various growth and yield indices were estimated with the formulae as per mentioned below:

$$\text{LAI} = \frac{\text{Total leaf area (sq cm)}}{\text{Total ground area (sq cm)}}$$

$$\text{HI (\%)} = \frac{\text{Economic yield (t/ha)}}{\text{Biological yield (t/ha)}} \times 100$$

$$\text{Benefit-cost ratio (B:C)} = \frac{\text{Net returns}}{\text{Total cost of cultivation}}$$

The data collected from the experimental field as well as laboratory were compiled and properly tabulated. These were subjected to statistical analysis by using the standard technique of analysis of variance (ANOVA), and their significance was tested using F-test (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Effect of different production systems on growth and physiological parameters of mustard crop

The growth attributes of different varieties of Indian mustard under diversified production systems was significantly ($p<0.05$) influenced at 30, 60 90 days after sowing (DAS) and remained so even at harvest (Table 1). PDZ-1 was recorded with least plant height (9.95 cm) and maximum was in PM 26 (11.45 cm) at 30 DAS, this trend remained same even at 60 DAS. But at 90 DAS maximum plant height was noticed in PDZ-1 (167.6 cm) and least in PM 26 (157.6 cm) and the plant height persisted in similar pattern between 90 DAS and at harvest where maximum plant height was in PDZ-1 (170.29) and least was in PM 26 (160.70). The availability of nutrient becomes regular due to slow release under organic and ICM system, which also enhance the plant height and other growth parameters (Premi *et al*. 2012, Shekhawat *et al.* 2016, Rathore *et al.* 2015, Kansotia *et al.* 2013). This was the reason for the maximum plant height being under ICM and least was under CA at 30 DAS, however at 60 DAS the maximum height was remained under ICM, mainly due to better nutrient acquisition (Murali *et al.* 2018). Dry matter accumulation (DMA) per plant was also influenced significantly where PM 26 and PM 28 accumulated more amount of dry matter (biomass) at 90 DAS and also at harvesting stage. (Table 1). The inoculants of organic manure in soil plants, promote seed germination and initial vigour of plants by producing growth promoting substances. These do add-on for chemical fertilizers for meeting the integrated nutrient demand of the crops (Nagdive *et al.* 2007, Kumar *et al.* 2018 and Singh *et al.* 2018). The variation in Leaf area index at different stages was significantly observed. The maximum value of LAI was observed at 60 DAS which remained >4.0 among most of the treatments, however under ICM maximum LAI (4.37) was recorded and among varieties PM 26 and PM 28 were recorded with almost similar but higher LAI (4.29 and 4.27) compared to PDZ 1. Almost all 3 varieties performed better in terms of enhanced LAI under ICM (Table 1). Premi *et al.* (2005) and Singh *et al.* (2018) also reported that conjunctive use of *Azotobacter* + PSB seed treatment + 100% ($N + P_2O_5$) recorded same results mainly due to better supply of nutrients.

Effects of diversified production systems on grain, biological yield and harvest index of mustard crop

The seed yield of mustard crop was significantly high-

Table 1. Effect of diverse production systems on growth and physiological parameters of mustard crop.

Treatments	Plant height (cm)				Dry matter accumulation (g/plant)				Leaf area index		
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS
Production systems											
Organic management system	11.04	102.36	155.03	158.6	0.676	10.674	31.74	41.34	0.28	4.25	3.49
Integrated crop management	11.44	105.08	162.36	164.92	0.403	10.153	44.94	54.44	0.20	4.37	3.69
Conventional system	10.73	86.12	154.32	157.98	0.232	7.633	32.5	38.40	0.14	4.15	3.11
Conservation agriculture	10.27	96.94	174.36	176.25	0.302	8.038	35.44	44.4	0.17	4.22	3.15
SE (m) +	0.21	1.76	3.41	2.94	0.042	0.486	0.731	0.93	0.02	0.02	0.083
LSD (p<0.05)	0.74	6.21	12.04	10.17	0.148	1.715	2.58	3.25	0.05	0.091	0.28
Varieties											
Pusa mustard 26	11.45	105.18	157.61	160.70	0.47	10.598	38.63	47.06	0.24	4.29	3.53
Pusa mustard 28	11.20	103.85	159.32	162.32	0.403	8.993	37.52	47.81	0.19	4.27	3.40
Pusa double zero-1	9.95	83.85	167.62	170.29	0.337	7.782	29.76	40.4	0.16	4.19	3.15
SE (m)+	0.11	1.91	2.84	2.50	0.054	0.456	1.50	1.226	0.01	0.019	0.078
LSD (p<0.05)	0.34	5.78	8.52	7.51	NS	1.379	4.54	3.678	NS	0.058	0.23

Table 2. Effects of diversified production systems on grain, biological yield and harvest index of mustard crop.

Treatments	Seed yield	Stover yield	Biological yield	Harvest index
Production systems				
Organic management system	1934	6906	8840	0.23
Integrated crop management	2259	6985	9244	0.24
Conventional system	1986	6920	8928	0.22
Conservation agriculture	2008	7950	9936	0.20
SE (m) +	72.3	434.2	478.8	0.00
LSD (p<0.05)	250.2	1502.5	1656.8	0.02
Varieties				
Pusa mustard 26	2206	8505	10711	0.21
Pusa mustard 28	2123	6536	8659	0.24
Pusa double Zero-1	1810	6530	8341	0.21
SE (m)+	40.7	310.5	334.9	0.0089
LSD (p<0.05)	122.1	930.8	1003.9	0.02

er under ICM (2259 kg/ha), which was significantly higher than seed yield under remaining production systems (Table 2). There was almost 14% increase in seed yield was recorded under ICM compared to CS (1986 kg/ha), but lower seed yield was recorded under OMS (1934 kg/ha) than obtained under CS. Chand (2007) and Singh and Kumar (2009) revealed that continuous application of FYM for long term helped in maintaining and improving physical properties

Table 3. Economics (Rs/ha) of varietal diversification under diverse production systems in mustard crop.

Treatments	Cost of cultivation	Gross return	Net return	B:C ratio	Profitability index Rs/ha/day
Production systems					
Organic management system	28900	89914	61014	2.11	508.44
Integrated crop management	27115.2	105051	77935.8	2.87	649.46
Conventional system	26317.9	92337	66019.1	2.50	550.15
Conservation agriculture	23517.9	93367	69849.1	2.97	582.07
SE (m) +	-	3362	3362	0.12	27
LSD (p<0.05)	-	11633	11633	0.43	93
Varieties					
Pusa mustard 26	26462.8	102581	76118.3	2.87	634.31
Pusa mustard 28	26462.8	98735	72272.3	2.73	602.26
Pusa double Zero-1	26462.8	84186	57723.3	2.18	481.02
SE (m)+		1894	1894	0.07	16
LSD (p<0.05)		5677	56770	0.21	47

of eroded alluvial soil and gave higher crop yield as compared to application of chemical fertilizers alone in a permanent manurial trial. However, under CA (2008 kg/ha), higher seed yield was harvested than it was under CS. It was mainly due to better soil health, moisture retention, thermal regulation and nutrient release in conservation agriculture (Shekhawat *et al*

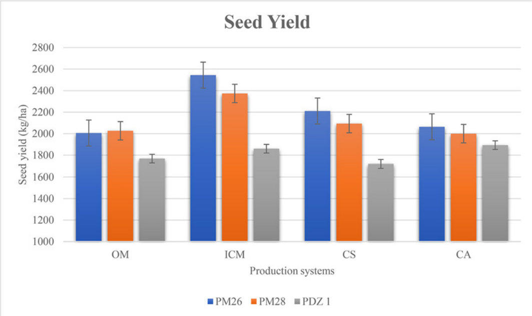

Fig. 1. Seed yield of Indian mustard varieties under diverse production systems.

2016, Shekhawat *et al.* 2012, Rathore *et al.* 2019). Among the mustard varieties, PM 26 resulted in maximum seed yield (2206 kg/ha), closely followed by PM 28 (2123 kg/ha), while least seed yield was recorded under PDZ-1 (1810 kg/ha) (Table 2). Interestingly higher stover yield (7950 kg/ha) was recorded under CA and remaining production system received almost similar stover yield, while biological yield again remained higher under CA (9936 kg/ha), followed by biological yield under ICM (9244 kg/ha). All the varieties resulted in higher seed yield under ICM except PDZ-1, which yielded maximum seed output under CA (Fig. 1). Harvest index was significantly influenced by production scenario in different varieties. Under OMS and ICM higher harvest index (0.23 and 0.24 respectively) was observed which was higher than HI under CS (0.22) and CA (0.20). Singh *et al.* (2014), Singh *et al.* (2018), Murali *et al.* (2018), Nurhidayati *et al.* (2018) and Shekhawat *et al.* (2012) also reported enhanced seed yield of Indian mustard under ICM due to better plant growth and yield attributes.

Economics of varietal diversification under diverse production systems in mustard crop

The effect of diverse production systems on mustard varieties were quantified under the parameters of cost of cultivation, gross and net return, B:C ratio and profitability (Table 3). The gross return was maximum under ICM (Rs 10,5051/ha), while least was under OMS (Rs 89,914/ha) which was lesser than gross return under conventional system (92,337 Rs/ha). The gross return from mustard under CA (ZT+RR) was higher (93367 Rs/ha) than CS and OMS. The gross return from PM 26, PM 28 and PDZ-1 was Rs 102581, 98735 and 84186 /ha respectively. The trend in net return was also same as it was in gross return. The maximum NR was obtained under ICM (Rs 77935.8/ha) and among the varieties, PM 26 gave maximum NR of Rs 76118.3/ha B:C ratio was significantly influenced, it ranged from 2.11–2.97, ICM and CA resulted in higher B : C ratio (2.87 and 2.97 respectively) compared to CS and OMS, while among the varieties maximum B : C ratio was from PM 26 (2.87) and least was from PDZ-1 (2.18). The profitability was noticed from 508-649 Rs/ha/day, the maximum was under ICM (649.46 Rs/ha/day) and among the varieties PM26 resulted in higher profitability 634 Rs/ha/day (Table 3).

CONCLUSION

From the present investigation it can be concluded that, the varietal diversification of Pusa mustard 26 and Pusa mustard 28 Indian mustard varieties gave maximum productivity, profitability under integrated crop management system. In summary, integrating inorganic and organic sources of nutrients is a sustainable and effective approach to enhance soil health and crop productivity. The different production systems under different mustard varieties showed the significant impact on growth, yield and economics. Integration of inorganic and organic sources of nutrients has proven to be beneficial for soil health and crop growth. It improved the soil organic carbon (SOC) content, availability of soil nutrient status (N, P and K) and microbial biomass carbon (MBC) in soil. These factors contribute to enhanced plant growth attributes and yield of mustard crop.

REFERENCES

Baishya LK, Rathore SS, Sarkar D, Jamir T, Rajkhowa DJ (2019) Crop and varietal diversification for enhancing productivity and profitability of rice fallow system in eastern Himalayan region. *Ind J Agric Sci* 89 (5) : 800—805.

Chand S (2007) Effect of integrated nutrient management on yield and nutrient use efficiency in Mustard (*Brassica juncea* L.). *Saarc J Agric* 5 (2) : 93—100.

Gomez KA, Gomez AA (1984) Statistical procedures for agricultural research. Second Edition. An International Rice Research Institute Book. A Wiley-inter-science Publication, John Wiley and Sons, New York, pp 680.

Jat RS, Singh VV, Sharma P, Rai PK (2019) Oilseed brassica in

India: Demand, supply, policy perspective and future potential. *OCL* 26 : 8.

Kansotia Bhagchand, Meena, Swaroop Ram, Meena, Singh Vijay (2013) Effect of vermicompost and inorganic fertilizers on Indian mustard (*Brassica juncea* L.). *Asian J Soil Sci* 8 (1) : 136—139.

Kumar S, Yadav KG, Goyal G, Kumar R, Kumar A (2018) Effect of organic and inorganic sources of nutrients on growth and yield attributing characters of mustard crop (*Brassica juncea* L.). *IJCS* 6 (2) : 2306—2309.

Murali M, Umrao R, Kumar H (2018) Effect of different levels of organic manure on the growth and yield of mustard (*Brassica juncea* L.). under Jatropha (*Jatropha circus* L.) based agroforestry system. *J Pharmacog Phytochem* 7 (4) : 955—958.

Nagdive SJ, Bhalerao PD, Dongarwar UR, Goud VV (2007) Effect of irrigation and nutrient management on yield, quality and uptake of nutrients by mustard (*Brassica juncea* L.). *J Soils Crops* 17 (1) : 128—132.

Nurhidayati N, Machfudz M, Murwani I (2018) Direct and residual effect of various vermicompost on soil nutrient and nutrient uptake dynamics and productivity of four mustard Pak-Coi (*Brassica rapa* L.) sequences in organic farming system. *Int J Recycling Organic Waste Agric* 7 (2) 173—181.

Premi OP, Kumar M, Kumar A, Sinsinwar BS (2005) Influence of organics and inorganics on yield and quality of Indian mustard (*Brassica juncea* L. Czern and Coss) in semi-arid region of Rajasthan. *J Oilseeds Res* 22 (1) : 45—46.

Premi OP, Rathore SS, Shekhawat Kapila, Kandpal BK, Chauhan JS (2012) Sustainability of fallow-Indian mustard (*Brassica juncea*) system as influenced by green manure, mustard straw cycling and fertilizer application. *Ind J Agron* 57 (3) : 229—234.

Rathore SS, Shekhawat Kapila, Premi OP, Kandpal BK, Singh Dhiraj (2015) Improved agronomic practices for cultivation of rapeseed-mustard in India ICAR-Directorate of Rapeseed-Mustard Research Sewar, Bharatpur Rajasthan India, pp 26 : 321—303.

Rathore SS, Shekhawat Kapila, Singh RK, Upadhyay PK, Singh VK (2019) Best management practices for doubling oilseed productivity: Aiming India for self-reliance in edible oil. *Ind J Agric Sci* 89 (8) : 1225—1231.

Rathore Sanjay Singh, Shekhawat Kapila, Babu Subhash, Singh VK (2020) Mitigating moisture stress in *Brassica juncea* through deficit irrigation scheduling and hydrogel in ustocherpts soils of semi-arid India. *Heliyon* 6 (12) : In press. https://doi.org/10.1016/j. heliyon. 2020.e05786.

Shekhawat K, Rathore SS, Kandpal BK, Premi OP, Singh D, Chauhan BS (2016) Crop establishment techniques affect productivity, sustainability and soil health under mustard based cropping systems of Indian semi-arid regions. *Soil Tillage Res* 158 : 137—146.

Shekhawat K, Rathore SS, Premi OP, Kandpal BK, Chauhan JS (2012) Advances in agronomic management of Indian mustard (*Brassica juncea* (L.) Czernj. Cosson) : An overview. *Int J Agron* 2012.

Singh AK, Kumar P (2009) Nutrient management in rainfed dryland agro ecosystem in the impending climate change scenario. *Agric Situ Ind* 66 (5) : 265—270.

Singh R, Singh AK, Kumar P (2014) Performance of Indian Mustard (*Brassica juncia* L.) in Response to Integrated Nutrient Management. *J Agric Res* 1 (1) : 9—12.

Singh H, Singh RP, Meena BP, Lal B, Dotaniya ML, Shirale AO, Kumar K (2018) Effect of integrated nutrient management (INM) modules on late sown Indian mustard (*B juncea* (L.) Cernj. Cosson) and soil properties. *J Cereals Oilseeds* 9 (4) : 37—44.

Tripathi MK, Chaturvedi Sumit, Shukla DK, Mahapatra BS (2010) Yield performance and quality in Indian mustard (*Brassica juncea*) as influenced by integrated nutrient management. *Ind J Agron* 55 : 138—142.