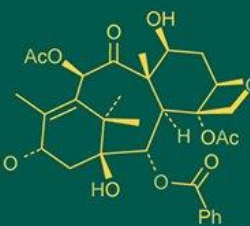
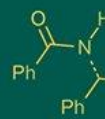
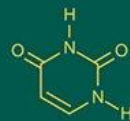


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Productivity and intercropping indices of wheat (*Triticum aestivum* L.) and Indian mustard (*Brassica juncea* L.) Intercropping system as influenced by different row ratio and nitrogen management

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Abstract

A field experiment was carried during *Rabi* seasons of (2024-25) at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.), India. The present experiment consist of three intercropping systems viz., Wheat + Indian Mustard (4:1), Wheat + Indian Mustard (6:1), Wheat + Indian Mustard (8:1), row ratios in replacement series and five nitrogen management viz., RDF to both Wheat + Indian mustard, 75% N to both Wheat + Indian Mustard + 1 Spray of Nano Urea Plus at 30 DAS, 75% N to both Wheat + Indian Mustard + 25% N through P.M., 75% N to both Wheat + Indian Mustard + 25% N through FYM and 50% N to both Wheat + Indian Mustard + 2 Spray of Nano Urea Plus at 30 and 45 DAS and two sole crops viz., wheat + Indian mustard. Results revealed that among the row arrangements, the maximum grain and straw yield of wheat, as well as the seed and stover yield of Indian mustard, along with the highest Land Equivalent Ratio and Wheat Equivalent Yield, were recorded under the wheat + Indian mustard 8:1 row ratio. Whereas, among 50% N to both Wheat + Indian Mustard + 2 Spray of Nano Urea Plus at 30 and 45 DAS found to be superior over rest of the nitrogen levels tried. In case of yield parameter of wheat and Indian mustard treatment combination of wheat + Indian mustard (8:1) + 50% N to both wheat + Indian mustard + 2 spray of Nano Urea Plus at 30 and 45 DAS found best among all treatment combinations tried.

Keywords: Row ratio, nitrogen management, wheat, Indian mustard, land equivalent ratio and wheat equivalent yield

Introduction

Agriculture is facing several challenges, including stagnating production, declining factor productivity, soil degradation, resource scarcity, rising cultivation costs and low farm returns. These issues are largely attributed to the adverse effects of the Green Revolution, which emphasized higher production over input-use efficiency. Declining per capita land availability and climate change have further increased pressure on agricultural systems. Since expansion of cultivable land is limited, enhancing productivity per unit area has become essential, and intercropping offers an effective approach to achieve this goal (Kumar *et al.* 2024) [6].

In India, intercropping of wheat (*Triticum aestivum* L.) and Indian mustard (*Brassica juncea* L.) is a traditional and widely adopted cropping system under both irrigated and rainfed conditions. The cultivation of cereals with oilseed crops having different rooting patterns and growth habits facilitates efficient utilization of soil moisture and nutrients from various soil layers (Singh *et al.* 2018) [13].

Wheat is a major cereal crop, which plays an important role in food and nutritional security. It contains carbohydrate (70-72%) with considerable amount of protein (10-13%), fiber (11%), fat (3%). It occupies about 220 million hectares with a total production of 798.97 million tonnes and an average productivity of 3.62 t/ha globally (FAOSTAT, 2023) [4]. In India, wheat was grown on 32.80 million hectares, producing 117.94 million tonnes with an average productivity of 3,595 kg/ha during 2024-25. Uttar Pradesh remained the leading wheat-producing state, accounting for 9.60 million hectares of area and 35.65 million tonnes of production with a productivity of 3,714 kg/ha (Anonymous, 2025) [2]. Owing to its vital

role in global food security, increasing wheat productivity has become essential. In India, where scope for horizontal expansion is limited, a production target of 140 million tonnes has been projected by 2050 to meet the growing food demand (Pal *et al.* 2023) ^[8].

Indian mustard (*Brassica juncea* L.) belongs to *Cruciferae* family and genus *Brassica*. Indian mustard is the third foremost edible oil seed crop after soybean and groundnut in India in terms of oil production. A number of elements, such as the 37-49% oil content, 38-57% eruric acid, 27% oleic acid, 17-25% proteins, 8-10% fibres, 6-10% moisture, and 10-12% extractable chemicals, all contribute to the high nutritional value of mustard seeds (Pandey *et al.*, 2013). India is fourth largest vegetable oil economy in the world next to USA, China and Brazil. Globally, rapeseed-mustard is cultivated over an area of about 40-42 million hectares, with a production of approximately 85-88 million tonnes and an average productivity of about 2.0-2.1 t/ha (FAOSTAT, 2023) ^[4]. In India, the crop covers about 8.66 million hectares with a production of 12.67 million tonnes and an average productivity of 1,463 kg/ha during 2024-25. Uttar Pradesh is among the major mustard-producing states, accounting for about 1.63 million hectares of area and 2.41 million tonnes of production, with a productivity of 1,474 kg/ha during the same period (Anonymous, 2025) ^[2].

The choice of a suitable intercropping system is complex, as its success depends on the interaction among component crops, management practices and prevailing environmental conditions. Intercropping provides better ground cover for a longer duration, thereby reducing soil desiccation and erosion. The cultivation of more than one crop simultaneously in the same field improves water-use efficiency, helps maintain soil fertility and minimizes soil erosion compared to mono cropping systems (Tiwari *et al.* 2024) ^[16].

Nitrogen is the most important nutrient influencing the growth and productivity of wheat and mustard. Organic sources such as FYM, poultry manure and Nano urea serve as supplementary sources of nitrogen, thereby supporting crop growth in intercropping systems. Row proportion plays a crucial role in determining light interception by component crops. In recent years, row intercropping has been found more productive than mixed cropping. Variations in row ratio influence the growth and development of both crops, which ultimately affect yield attributes and final yield (Shyamsunder *et al.* 2024) ^[11].

Keeping the above facts in mind, the present experiment was conducted at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) India.

Materials and methods

The field experiment was conducted during the Rabi season of 2024-2025 at the Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India. Present study carried out with 17 treatment combinations, which consisted of three intercropping systems viz., wheat + Indian mustard (4:1) (I₁), wheat + Indian mustard (6:1) (I₂), wheat + Indian mustard (8:1) (I₃), row ratios in replacement series and five nitrogen management viz., RDF to both Wheat + Indian Mustard (N₁), 75% N to both Wheat + Indian Mustard + 1 Spray of Nano Urea (N₂), 75% N to both Wheat + Indian Mustard + 25% N through P.M. (N₃), 75% N to both Wheat + Indian Mustard + 25% N through FYM (N₄) and 50% N to both Wheat + Indian Mustard + 2 Spray of Nano Urea (N₅) and two sole crops viz., wheat and Indian

mustard. A total of 17 treatment combinations were evaluated in a split-plot design with three replications. Intercropping systems were assigned to the main plots, while nitrogen management treatments were allocated to the sub-plots, resulting in a total of 51 experimental plots. The experimental soil was sandy loam in texture with pH values of 7.7 and 7.2, and low organic carbon content (0.46 and 0.47%). The gross plot size was 4.5 m × 3.0 m (13.5 m²). The field was prepared by one deep ploughing followed by two cross harrowing and planking. Wheat and Indian mustard were sown using seed rates of 120 kg/ha and 5 kg/ha, respectively. The crops were sown on 05 November 2024 using K-1317 for wheat and Rohini for Indian mustard. Spacing of 22.5 cm × 15 cm for wheat and 45 cm × 15 cm for Indian mustard was maintained. The recommended dose of fertilizer for wheat is 120 kg N, 60 kg P₂O₅ and 60 kg K₂O for Indian mustard 90 kg N, 45 kg P₂O₅ and 45 kg K₂O per hectare were applied through urea, DAP and MOP in sole crop only. Under intercropping treatments, seed rate and fertilizer quantities were adjusted according to the row arrangement. Nano Urea Plus was applied as a foliar spray at 30 and 45 DAS on both crops. The experiment was conducted under irrigated conditions, and five irrigations were provided at 20, 40, 60, 80 and 100 DAS. Necessary plant protection measures were adopted as required during the crop growth period. Both wheat and Indian mustard were harvested manually at about 10 cm above the ground surface, sun-dried in the field and subsequently threshed, cleaned, dried and weighed. The recorded data were analyzed using analysis of variance (ANOVA) appropriate for a split-plot design as described by Gomez and Gomez (1984) ^[5]. Treatment means were compared at the 5% level of significance (P = 0.05), and critical difference (CD) values were computed for testing treatment effects.

Results and discussion

Effect of row ratio and nitrogen management

The study revealed that significantly higher grain yield and straw yield of wheat, as well as seed yield and stover yield of Indian mustard, were recorded under wheat + mustard intercropping at 8:1 row proportion, which was followed by 6:1 and 4:1 row proportions.

This could be ascribed to the inter-generic competition between the component crops for possible under and above ground resources, viz., space, nutrients and moisture. These results corroborated the findings of Singh *et al.* (2018) ^[13] and Srivastava *et al.* (2007) ^[15].

Among the nitrogen management, significantly higher grain yield and straw yield of wheat, and seed yield and stover yield of Indian mustard were recorded under 50% N to both wheat + Indian mustard + 2 sprays of Nano urea.

This may be due the application of Nano fertilizer in conjugation with traditional nitrogen fertilizers improves nutrient absorption efficiency, enhanced photosynthesis, increases nutrient translocation and ultimately increases the economic and biological yield. When growth and yield parameters are increasing by Nano urea spray, overall yield will also increase. These results are close with results of Rani *et al.* (2024) ^[10].

The increase in yield might be directly associated with concomitant increase in growth and yield attributes of mustard plant, because of improved nutritional environment in the plant metabolic system leading to higher plant metabolism and photosynthetic activity due to Nano Urea. Similar finding was close vicinity of those reported by Bhadela *et al.* (2024) Pandav *et al.* (2022) ^[9].

Table 1: Effect of row ratio and nitrogen management on yield of wheat and Indian mustard

Treatments	Wheat		Indian Mustard	
	Grain yield (t/ha)	Straw yield (t/ha)	Seed yield (t/ha)	Stover yield (t/ha)
Sole Wheat	4.73	7.51	-	-
Sole Indian Mustard	-	-	1.976	6.152
Row ratio (Intercropping system)				
Wheat + Indian Mustard (4:1)	3.28	4.60	0.655	2.567
Wheat + Indian Mustard (6:1)	3.68	6.27	0.825	2.862
Wheat + Indian Mustard (8:1)	4.35	7.29	1.047	3.384
F-test	S	S	S	S
SEm±	0.14	0.28	0.025	0.121
CD (p=0.05)	0.54	1.08	0.099	0.474
Nitrogen Management				
RDF to both Wheat + Indian Mustard	3.62	5.83	0.738	2.061
75% N to both Wheat + Indian Mustard + 1 Spray of Nano Urea Plus at 30 DAS	3.85	6.17	0.915	3.663
75% N to both Wheat + Indian Mustard + 25% N through P.M.	3.75	6.08	0.825	2.788
75% N to both Wheat + Indian Mustard + 25% N through FYM	3.66	5.95	0.794	2.430
50% N to both Wheat + Indian Mustard + 2 Spray of Nano Urea Plus at 30 and 45 DAS	3.98	6.25	0.941	3.746
F-test	S	S	S	S
SEm±	0.08	0.01	0.032	0.010
CD (P=0.05)	0.24	0.03	0.094	0.028

Land Equivalent Ratio (LER)

Land equivalent data are presented in table 2. Among row ratio, significant difference was noticed. Among the row ratio, a significant difference in land equivalent ratio (LER) was observed. Significantly higher LER was recorded under wheat + Indian mustard (8:1) (1.45), which was significantly superior to all other intercropping systems and none of the treatments was found to be statistically at par.

This might be due to efficient effect of light, moisture and nutrients, besides reduced competition from taller component (Indian mustard) on shorter component (wheat). Singh *et al.* (2016) ^[14] and Singh *et al.* (2014) ^[12] also reported higher yield advantage under wider row ratios of 8:1 in wheat + Indian mustard intercropping.

As regard nitrogen management, land equivalent ratio significantly affected among different treatments. Significantly higher land equivalent ratio was recorded through 50% N to both wheat + Indian Mustard + 2 spray of Nano urea (1.32) which was at par with 75% N to both Wheat + Indian Mustard + 1 Spray of Nano Urea.

Wheat Equivalent Yield (WEY)

The wheat grain equivalent yield as computed from grain yield of wheat combined with that of intercrops (q/ha). Data

pertaining to wheat equivalent yield was recorded and presented in table 2. Significant variation in wheat equivalent yield (WEY) was observed among different row ratio. Significantly higher WEY was recorded under wheat + Indian mustard (8:1) (4996.12 kg/ha), which was significantly superior to all other intercropping treatments and none of the treatments was found to be statistically at par. These attributed to higher yield of both the crop due to good compatibility of system and enable to utilize nutrient, moisture, space and light efficiently by the crop. This could result in favourable influence on growth and yield components of mustard. Higher price of mustard in the market was also one of the factors for recording higher WEY, the higher yield of both the component crops. Similar results were reported Wheat Equivalent Yield (WEY) was significantly influenced by different nitrogen management treatments. Significantly higher WEY was recorded with 50% N to both wheat + Indian mustard + 2 sprays of Nano Urea Plus at 30 and 45 DAS (4554.00kg/ha), whereas the wheat equivalent yield recorded under 75% N to both wheat + Indian mustard + 1 spray of Nano Urea Plus at 30 DAS (4394.71 kg/ha) was found to be statistically at par to that recorded under 50% N to both wheat + Indian mustard + 2 sprays of Nano Urea Plus at 30 and 45 DAS.

Table 2: Effect of row ratio and nitrogen management on land equivalent ratio and wheat equivalent yield

Treatments	Land equivalent ratio (LER)	Wheat equivalent yield (WEY)
Sole Wheat		
Sole Indian Mustard	-	-
Row Ratio (Intercropping System)		
Wheat + Indian Mustard (4:1)	1.03	3937.53
Wheat + Indian Mustard (6:1)	1.20	4509.77
Wheat + Indian Mustard (8:1)	1.45	5397.91
F-test	S	S
SEm±	0.03	139.204
CD (p=0.05)	0.12	547.282
Nitrogen Management		
RDF to both Wheat + Indian Mustard	1.13	4311.51
75% N to both Wheat + Indian Mustard + 1 Spray of Nano Urea Plus at 30 DAS	1.28	4762.64
75% N to both Wheat + Indian Mustard + 25% N through P.M.	1.22	4603.71
75% N to both Wheat + Indian Mustard + 25% N through FYM	1.18	4473.60
50% N to both Wheat + Indian Mustard + 2 Spray of Nano Urea Plus at 30 and 45 DAS	1.32	4923.88
F-test	S	S
SEm±	0.03	89.76
CD (P=0.05)	0.07	262.003

Conclusion

Based on the findings of the present investigation, it is concluded that wheat intercropped with Indian mustard in 8:1 row ratio along with 50% N to both wheat + Indian Mustard + 2 sprays of Nano Urea Plus at 30 and 45 DAS was found to be the most productive treatment with higher Wheat Equivalent Yield (WEY) and Land Equivalent Ratio (LER).

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