



# **Effect of Row Ratio on Growth and Yield of Wheat (*Triticum aestivum*) and Mustard (*Brassica nigra*) Intercropping System**

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## **Authors' contributions**

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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## **ABSTRACT**

A field experiment was conducted during *Rabi* 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) on the topic "Effect of row ratio on growth and yield of wheat and mustard intercropping system". To study treatments consisting with row Proportions with wheat and mustard intercropping. The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 8.0), low in organic carbon (0.28 %), available N (225 kg/ha), available P (19.50 kg/ha) and available K (92 kg/ha). There were 8 treatments each being replicated thrice and laid out in Randomized Block Design. The results revealed that treatment 1 (Sole wheat cropping) recorded significantly higher Plant height (89.4 cm), plant dry weight (16.15 g), number of effective tillers/m<sup>2</sup> (634.01), number of grains/spike (52.80), grain yield (4.02 t/ha), straw yield (6.73 t/ha) of wheat and treatment 2 (Sole mustard cropping) recorded significant and higher Plant height (120.50 cm), plant

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dry weight (34.18 g), number of siliqua/plant (210.47), number of seeds/siliqua (22.90), test weight (3.66 g), seed yield (1.27 t/ha), stover yield (2.65 t/ha) and Harvest index (32.33 %) in mustard.

*Keywords: Wheat; mustard; intercropping; sole cropping.*

## 1. INTRODUCTION

“Agriculture land is shrinking day by day as it is used for non-agricultural purposes. It is rather inevitable to accommodate production in existing crops/cropping systems. The food requirement of the country by 2030 is expected to be around 300 million tonnes” [1]. “This additional production has to come from existing land of cultivated area (143.8 million ha) and water resources. Increasing the resource use efficiency and vertical intensification of cropping system is the need of the hour. This can be achieved through intercropping” [2].

“Wheat crop is the first important and strategic cereal crop for the majority of world’s population. It is the most important staple food for about two billion people (36 % of the world population) and it is responsible up to 70 per cent of daily calorie intake of the population living in rural regions. It is basically a temperate region crop but can also be grown under different sub-tropical and tropical conditions successfully. It is an important winter cereal contributing about 38% of the total food grain production in India. Wheat straw is an important source of fodder for a large Indian animal population. The nutritive value of wheat is also an important component for nearly 35 percent of world population as it contains, 71.2 grams of carbohydrates, 11-12 grams of protein, 1.5 grams of fat, 306 milligrams of phosphorus and 41 milligrams of calcium per 100 g of wheat grain and it is rich in carbohydrate, protein, fat and minerals like zinc, iron and also contains vitamins such as thiamine and vitamin-B” [3].

“On global scale, the crop is grown over an area of 215.48 m ha with annual production of 731.46 mt and productivity of 33.9 q/ha during 2019-20 worldwide. India is the second largest producer of wheat in the world next only to China and the crop has provided the fastest pace of growth to Indian agriculture. Among cereals, wheat is next to rice in area 24.23 million ha and production 75.6 million tonnes. In India, the major States where wheat is cultivated are Haryana, Punjab, Uttar Pradesh, Bihar, Rajasthan, Madhya Pradesh, Maharashtra, Karnataka and highest

productivity of wheat is recorded in Punjab, nearly 29.14 m ha area with annual production of 102.19 m t carrying average productivity of 3506.8 kg/ha in year 2018-19. Uttar Pradesh is the largest state of India with maximum contribution towards national production 35.03% from a large area 35.12%, but with productivity on a lower side of 2.7 tones/ha, the area is 9.2 m ha, with a production of 24.5 m t and productivity of 2.7 t/ha in 2013-14” [4].

“Mustard is one of the important rabi season oilseed crops especially grown widely in northern India. It is popularly known as rai. India is one among the leading oilseed producing countries in the world. Mustard is the second most important edible oilseed crop next to groundnut. Mustard oil is used primarily for cooking and valued for vegetable, fodder, condiments and medicinal purposes. Mustard is nutritionally very rich and its oil content varies from 37 to 49 per cent. The seed and oil of mustard have a peculiar pungency due to a glycoside “Sinigrin” thus making it suitable for condiments and can be used for the preparation of pickles, curries and vegetables. In India, mustard is grown in an area of 6.7 m ha with a production of 7.80 mt (2015) and a productivity of 1,188 kg/ha” [5].

“India, Canada, China, Pakistan, Poland, Bangladesh and Sweden are the important mustard growing countries in the world. In India it is mainly cultivated in states viz., Rajasthan, Madhya Pradesh, Haryana, Punjab, Gujarat, Assam and West Bengal. In Karnataka, it is grown in an area of 2,000 hectare with a production of 1,000 tonne and a productivity of 333 kg/ha” [5]. One of the new vistas in the remunerative cultivation of oilseed brassicas in the non-traditional areas is to select appropriate row ratio suited to particular agro-climatic situations which can yield more per unit of water and nutrients used. Though, mustard is sporadically raised as sprinkle crop or as mixed crop along with rabi crops such as wheat, barley, groundnut, lentil, chickpea, sorghum, coriander etc. to meet the domestic culinary requirements in southern parts of the country, meager attempts have been made in non traditional growing areas of Uttar Pradesh with respect to row ratio and

nutrient management for particular set of environment to achieve potential yield.

Intercropping of wheat and mustard is an age old practice particularly in Northern Indian for sake of yield stability and to cater the needs of both oil and grains. Due to change in demand and price scenario of mustard seed and wheat grains, currently intercropping may be boon to produce higher yield per unit area, in turn generate more income under specific set of conditions particularly row ratio as replacement series in wheat and mustard. Intercropping is an effective and potential means of increasing crop production per unit area and time particularly for small landholders. Winter oilseeds are becoming more prevalent as the alternative crops to wheat. This reflects the awareness of producers about diversification of the cropping system to fulfill their demand and to get the benefits of sound crop rotations on wheat yield. A better understanding of magnitude and mechanism of break-crop effects on wheat yield would allow management to maximize the potential benefits within cropping sequence. In order to feed the world's population, it is imminent to increase productivity per unit area of available land, which seems to be shrinking by the day.

At present, row intercropping has been proved to produce higher yield advantage over mixed intercropping. If recommended row ratio for specific area is adopted then farmers could utilize applied and available resources more efficiently and effectively on sustainable basis. With variation in row combination growth and development of both the component crops are being devated ultimately affects the yield attributes and yield, but at specific combination LER and yield advantage is definitely augmented. For obtaining higher return per unit land area intercropping appears to be one of the important aspect. It increases the efficiency of scarce resources and reduces the risk of failure of a single crop under a fluctuating environment. The major cause of low productivity of wheat and mustard in U.P. is their mixed cropping without proper proportion. Due to the greater competing ability of mustard, proper placement of mustard plant is more important than that of wheat. However, the information on their compatibility as an intercrop with wheat pertaining to optimum row ratio is very meagre. Keeping these issues in view, an experiment has been planned to investigate the feasibility of intercropping of mustard with wheat under varying row ratio for assessment of yield advantage in order to

maximize the productivity and profitability of small and marginal farmers.

## 2. MATERIALS AND METHODS

A field experiment was conducted during *Rabi* 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) on the topic "Effect of row ratio on growth and yield of wheat and mustard intercropping system". To study treatments consisting with row Proportions with wheat and mustard intercropping. There were 8 treatments each being replicated thrice and laid out in Randomized Block Design. The treatment combinations are treatment 1 (Sole wheat cropping), treatment 2 (Sole mustard cropping), treatment 3 (Wheat + mustard in 4:1 rows), treatment 4 (Wheat + mustard in 6:1 rows), treatment 5 (Wheat + mustard in 8:1 rows), treatment 6 (Wheat + mustard in 4:2 rows), treatment 7 (Wheat + mustard in 6:2 rows) and treatment 8 (Wheat + mustard in 8:2 rows).

## 3. RESULTS AND DISCUSSION

### 3.1 Growth Parameters of Wheat

**Plant height (cm):** The data revealed that, significantly higher plant height (89.4 cm) was recorded in treatment 1 (Sole Wheat cropping) as compared to rest of the treatments. However, the treatment 2 (Wheat + Mustard in 4:1 rows) was found to be statistically at par with treatment 1 (Sole Wheat cropping) [Table 1]. Significant and higher plant height was recorded with sole wheat cropping might be due to synthesis accumulation and translocation of photosynthesis which mainly depend upon efficient photosynthetic structure as well as the extent of translocation from source (leaf) to sink (grain) and also the plant growth and development during early stages of crop growth in intercropping system. Similar results was also reported by Agarwal et al. [6]. Further, significant and higher plant height in wheat and mustard intercropping was recorded with (4:1) row proportion might be due to efficient utilization of available resources such as space, nutrients, moisture and light compared to other row proportion in intercropping system. Similar results was also reported by Wasaya et al. [7].

**Plant dry weight (g):** The data revealed that, significant and higher plant dry weight (16.15 g) was recorded in treatment 1 (Sole Wheat cropping) as compared to rest of the treatments. However, the treatment 2 (Wheat + Mustard in

4:1 rows) was found to be statistically at par with treatment 1 (Sole Wheat cropping) [Table 1]. Significant and higher plant dry weight was recorded with sole wheat cropping might be due to higher leaf area of plants that determines the photosynthetic activity and dry matter accumulation. Similar results was also reported by Wasaya et al. [7].

### 3.2 Yield and Yield Attributes of Wheat

#### **Number of effective tillers/running row meter:**

The data revealed that, Significant and maximum number of effective tillers/running row meter ( $634.01/m^2$ ) was recorded with treatment 1 (Sole wheat cropping) as compared to rest of the treatments. However, the treatment 2 (Wheat + Mustard in 4:1 rows) was found to be statistically at par with treatment 1 (Sole Wheat cropping) [Table 2]. Significant and maximum number of effective tillers/running row meter was with sole wheat cropping could be due to reduced competition for nutrient requirement, which enhance better uptake of nutrients from soil in all stages, results in development of effective tillers of crop.

**Number of grains/spike:** The data revealed that, Maximum number of grains/spike (52.80) was recorded with treatment 1 (Sole wheat cropping) as compared to rest of the treatments and there was no significance difference between them [Table 2].

**Test weight (g):** The data revealed that, highest test weight (44.50 g) was recorded with treatment 1 (Sole wheat cropping) as compared to rest of the treatments as compared to rest of the treatments and there was no significance difference between them [Table 2].

**Grain yield (t/ha):** The data revealed that, Significant and higher seed yield (4.02 t/ha) was recorded with treatment 1 (Sole wheat cropping) as compared to rest of the treatments. However, the treatment 2 (Wheat + Mustard in 4:1 rows) was found to be statistically at par with treatment 1 (Sole Wheat cropping) [Table 2]. Significant and higher grain yield was recorded with Sole wheat cropping might be due to efficient utilization of available resources such as space, nutrients and light. Similar findings were also reported by Ali et al. [8]. Further, Significant and higher grain yield was recorded with (4:1) row proportion might be due to utilization of available resources such as space, nutrients, moisture and light and the grain yield of any plant which mainly

depends on the production of photosynthates and its distribution among different plant parts. Similar results was also reported by Agarwal et al. [6].

**Straw yield (t/ha):** The data revealed that, Significant and higher straw yield (6.73 t/ha) was recorded with treatment 1 (Sole wheat cropping) as compared to rest of the treatments. However, the treatment 2 (Wheat + Mustard in 4:1 rows) was found to be statistically at par with treatment 1 (Sole Wheat cropping) [Table 2]. Significant and higher straw yield was recorded with Sole wheat cropping might be due to increase in plant growth and efficient utilization of available resources such as space, nutrients and light. Similar findings were also reported by Ali et al. [8]. Further, Significant and higher straw yield was recorded with (4:1) row proportion might be due to growth and development of plant with available resources and utilization of available resources such as space, nutrients, moisture and light and the grain yield of any plant which mainly depends on the production of photosynthates and its distribution among different plant parts. Similar results was also reported by Agarwal et al. [6].

**Harvest index (%):** The data revealed that, Significant and highest harvest index (44.20 %) was recorded with treatment 7 (Wheat + Mustard in 6:2 rows) as compared to rest of the treatments [Table 2].

### 3.3 Growth Parameters of Mustard

**Plant height (cm):** The data revealed that, significantly higher plant height (120.50 cm) was recorded in treatment 2 (Sole mustard cropping) as compared to rest of the treatments. However, the treatment 3 (Wheat + Mustard in 4:1 rows) was found to be statistically at par with treatment 2 (Sole mustard cropping) [Table 3]. Significant and higher plant height was recorded with sole mustard cropping might be due to better utilization of resources, space availability between the rows of mustard for proper distribution of light, space and nutrients, reduced competition for the same resources which led to increased amount of cellular constituents specially protoplasm along with increased amount of protein which led to the increased turgidity of plant cells leading to expansion of cell wall and area of leaves and stem. Similar results was also reported by [9].

**Plant dry weight (g):** The data revealed that, significantly higher plant dry weight (34.18 g) was

recorded in treatment 2 (Sole mustard cropping) as compared to rest of the treatments. However, the treatment 3 (Wheat + Mustard in 4:1 rows) was found to be statistically at par with treatment 2 (Sole mustard cropping) [Table 3]. Significant and higher plant dry weight was recorded with sole mustard cropping might be due to higher leaf area of plants that determines the photosynthetic activity and dry matter accumulation. Similar results was also reported by Wasaya et al. [7].

### 3.4 Yield and Yield Attributes of Mustard

**Number of siliqua/plant:** The data revealed that, Significant and maximum number of siliqua/plant (210.47) was recorded in treatment 2 (Sole mustard cropping) as compared to rest of the treatments. However, the treatment 3 (Wheat + Mustard in 4:1 rows) was found to be statistically at par with treatment 2 (Sole mustard cropping) [Table 4]. Significant and maximum siliqua/plant was recorded with sole wheat cropping could be due to reduced competition for nutrient requirement, which enhance better uptake of nutrients from soil in all stages, results in formation of maximum siliqua/plant.

**Number of seeds/siliqua:** The data revealed that, Significant and maximum number of seeds/siliqua (22.90) was recorded in treatment 2 (Sole mustard cropping) as compared to rest of the treatments. However, the treatment 3 (Wheat + Mustard in 4:1 rows) was found to be statistically at par with treatment 2 (Sole mustard cropping) [Table 4]. Significant and maximum number seeds/siliqua was recorded with sole mustard cropping could be due to utilization of available resourced and enhance pollen tube formation, pollen viability, starch utilization and chlorophyll biosynthesis, which results in better seed formation.

**Test weight (g):** The data revealed that, Significant and higher test weight (3.66 g) was recorded in treatment 2 (Sole mustard cropping) as compared to rest of the treatments. However, the treatment 3 (Wheat + Mustard in 4:1 rows) was found to be statistically at par with treatment 2 (Sole mustard cropping) [Table 4].

**Seed yield (t/ha):** The data revealed that, Significant and higher seed yield (1.27 t/ha) was

recorded in treatment 2 (Sole mustard cropping) as compared to rest of the treatments. However, the treatment 3 (Wheat + Mustard in 4:1 rows) was found to be statistically at par with treatment 2 (Sole mustard cropping) [Table 4].

Significant and higher grain yield was recorded with Sole mustard cropping might be due to efficient utilization of available resources such as space, nutrients and light. Similar findings were also reported by Ali et al. (2000). Further, Significant and higher grain yield of intercropping of wheat and mustard was recorded with (4:1) row proportion might be due to utilization of available resources such as space, nutrients, moisture and light and the grain yield of any plant which mainly depends on the production of photosynthates and its distribution among different plant parts. Similar results was also reported by Agarwal et al. [6].

**Straw yield (t/ha):** The data revealed that, Significant and higher straw yield (2.65 t/ha) was recorded in treatment 2 (Sole mustard cropping) as compared to rest of the treatments. However, the treatment 3 (Wheat + Mustard in 4:1 rows) was found to be statistically at par with treatment 2 (Sole mustard cropping) [Table 4].

Significant and higher straw yield was recorded with Sole mustard cropping might be due to efficient utilization of available resources such as space, nutrients and light. Similar findings were also reported by Ali et al. [8]. Further, Significant and higher straw yield of intercropping of wheat and mustard was recorded with (4:1) row proportion might be due to utilization of available resources such as space, nutrients, moisture and light and the grain yield of any plant which mainly depends on the production of photosynthates and its distribution among different plant parts. Similar results was also reported by Agarwal et al. [6].

**Harvest index (%):** The data revealed that, Significant and higher harvest index (32.33 %) was recorded in treatment 8 (Wheat + Mustard in 8:2 rows) as compared to rest of the treatments. However, the treatment 4 (Wheat + Mustard in 6:1 rows) and treatment 5 (Wheat + Mustard in 8:1 rows) was found to be statistically at par with treatment 8 (Wheat + Mustard in 8:2 rows) [Table 4] [10-12].

**Table 1. Effect of row ratio on growth parameters of Wheat**

S. No	Treatments Combination	At 80 DAS	
		Plant height (cm)	Plant dry weight (g)
1	Sole Wheat cropping	89.4	16.15
3	Wheat + Mustard in 4:1 rows	88.7	15.60
4	Wheat + Mustard in 6:1 rows	86.8	14.80
5	Wheat + Mustard in 8:1 rows	86.2	14.29
6	Wheat + Mustard in 4:2 rows	87.3	14.96
7	Wheat + Mustard in 6:2 rows	88.0	15.43
8	Wheat + Mustard in 8:2 rows	85.6	13.72
	F- test	S	S
	SEm ( $\pm$ )	0.24	0.21
	CD ( $p = 0.05$ )	0.72	0.65

**Table 2. Effect of row ratio on yield and yield attributes of wheat**

S. No	Treatments Combination	No. of effective tillers/m <sup>2</sup>	No. of grain/spike	Test weight(g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
1	Sole Wheat cropping	634.01	52.80	44.50	4.02	6.73	37.39
3	Wheat + Mustard in 4:1 rows	622.16	51.87	44.23	3.46	4.73	42.28
4	Wheat + Mustard in 6:1 rows	568.83	50.60	43.42	3.56	5.32	40.08
5	Wheat + Mustard in 8:1 rows	551.05	50.47	43.20	3.45	5.13	40.19
6	Wheat + Mustard in 4:2 rows	592.53	51.00	43.63	3.29	4.53	42.05
7	Wheat + Mustard in 6:2 rows	604.38	51.40	44.09	3.35	4.62	44.20
8	Wheat + Mustard in 8:2 rows	539.20	50.13	43.02	3.41	5.04	40.33
	F- test	S	NS	NS	S	S	S
	S E <sub>m</sub> ( $\pm$ )	10.85	0.23	0.10	0.07	0.05	2.58
	CD ( $p = 0.05$ )	32.25	-	-	0.21	0.17	0.86

**Table 3. Effect of row ratio on growth attributes of mustard**

S. No	Treatments Combination	At 80 DAS	
		Plant height (cm)	Plant dry weight (g)
1	Sole Wheat cropping	120.50	34.18
3	Wheat + Mustard in 4:1 rows	116.57	34.01
4	Wheat + Mustard in 6:1 rows	103.80	33.25
5	Wheat + Mustard in 8:1 rows	100.43	33.17
6	Wheat + Mustard in 4:2 rows	105.03	33.48
7	Wheat + Mustard in 6:2 rows	111.33	33.56
8	Wheat + Mustard in 8:2 rows	97.03	33.12
	F- test	S	S
	SEm ( $\pm$ )	4.06	0.18
	CD ( $p = 0.05$ )	1.36	0.55

**Table 4. Effect of row ratio on yield and yield attributes of mustard**

S. No	Treatments Combination	No. of Siliqua/plant	No. of seeds/Siliqua	Test weight(g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
2	Sole mustard cropping	210.47	22.90	3.66	1.27	2.65	32.33
3	Wheat + Mustard in 4:1 rows	205.43	22.23	3.58	0.33	0.85	27.74
4	Wheat + Mustard in 6:1 rows	194.78	21.01	3.27	0.24	0.40	37.16
5	Wheat + Mustard in 8:1 rows	189.86	19.74	3.06	0.23	0.37	37.79
6	Wheat + Mustard in 4:2 rows	197.62	21.15	3.52	0.29	0.77	27.60
7	Wheat + Mustard in 6:2 rows	200.11	21.74	3.52	0.32	0.80	28.36
8	Wheat + Mustard in 8:2 rows	184.05	19.15	2.97	0.22	0.34	39.15
	F- test	S	S	S	S	S	S
	S E <sub>m</sub> ( $\pm$ )	1.24	0.31	0.03	0.01	0.01	0.96
	CD ( $p = 0.05$ )	3.71	0.93	0.11	0.05	0.05	2.87

#### 4. CONCLUSION

Based on the above findings it was concluded that the effect of row ratio under replacement series on growth and yield of wheat and mustard intercropping system. Sole cropping of wheat and Sole cropping of Mustard has recorded higher growth parameters and yield and also Inter cropping with wheat-mustard in (4:1) rows (treatment 3) in wheat and mustard intercropping system recorded higher growth parameters and seed yield.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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