Original Research Article

Effect of Row ratio and Planting methods on Growth, Yield Performance of wheat (*Triticum aestivum* L.) and Mentha (*Mentha arvensis* L.)

ABSTRACT

This study investigates the effects of row ratio and planting methods on the cultivation of wheat and mentha. Japanese mint (*Mentha arvensis* L.) is an important essential oil-bearing plant of the family Lamiaceae. Essential oil obtained from the leaves used in aromatherapy, flavour, and pharmaceutical industries. Hence, a field experiment was conducted to study the effect of Row ratio and Planting methods on Growth, Yield Performance of wheat (*Triticum aestivum* L.) and Mentha (*Mentha arvensis* L.) was conducted during 2016-17 at the Soil Conservation and Water Management Farm to investigate the response of mentha when intercropped with wheat under various row ratio and planting methods. The experiment was laid out in Randomized Block Design (RBD) with three replication keeping one variety of Mentha 'Shivalik'& Wheat 'Halna'. The experiment consisting of nine treatments are T1:Sole Mentha direct sowing (50 cm apart), T2:Sole Mentha transplanting (50 cm apart), T3:Sole Wheat (25 cm apart), T4:Wheat+Mentha (d, 1:1), T5:Wheat+Mentha (t, 1:1), T6:Wheat+Mentha (d 2:2), T7:Wheat+Mentha (t 2:2), T8:Wheat Paired+Mentha (d 2:3), T9: Wheat Paired+Mentha (t, 2:3). The results showed that the highest number of leaves per plant (457 at maturity) and number of branches per plant (80.97 at 90 DAS) were observed in Treatment 9 (T9). Treatment 3 (T3) exhibited the maximum number of tillers per plant in wheat (6.20). T4 had the highest yield attributes for wheat. The maximum herbage yield of mentha (177 q/ha) was found in Treatment 7 (T7). T1 had the highest oil content (0.85%) and oil yield (163.35 l/ha) for mentha. Treatment 8 (T8) recorded the highest equivalent oil yield (189.97 l/ha) and land equivalent ratio (1.50). Treatment 3 (T3) yielded the maximum grain yield (39.80 q/ha), straw yield (74.52 q/ha), and harvesting index (38.95%).

Keyword: *Wheat; Mentha; Growth; Yield; row ratio; planting methods*

INTRODUCTION

Intercropping is an agricultural practice that involves the simultaneous cultivation of two or more crops on the same piece of land. This cropping system offers several advantages, such as maximizing land productivity, efficient resource utilization, and diversification of income sources (Gebru, 2015). One such intercropping system is the combination of wheat (*Triticum aestivum* L.) and mentha (*Mentha arvensis* L.). The intercropping system of wheat and mentha offers several advantages firstly, it maximizes the utilization of resources such as water, sunlight, and nutrients by effectively utilizing different layers of the crop canopy. The vertical structure of

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wheat and the spreading nature of mentha complement each other, allowing for efficient resource capture and utilization. Secondly, intercropping can help in weed suppression, as the dense canopy of both crops can shade out weed growth, reducing the need for herbicides and manual weeding. Moreover, the release of volatile oils from mentha plants can act as a natural deterrent to certain pests and diseases, potentially reducing the need for chemical pesticides (Salem *et al.*, 2017). Intercropping has long been recognized as a potentially beneficial system of crop production. It offers stability in yield during unpredictable weather conditions and the occurrence of pests and diseases, which is vital for subsistence farmers (Brooker *et al.*, 2015). Intercropping enables the harvesting of more energy by producing a higher biomass from the component crops. This not only provides insurance against crop failure but also enhances productivity through the efficient use of land, water, and soil energy in a vertical dimension. Researchers have reported significant advantages in land use efficiency, crop productivity, and monetary returns in intercropping compared to sole cropping under various agro-climatic conditions (Kumar *et al.*, 2012). Intercropping leads to more efficient solar energy use and harnesses the benefits of positive interactions in crop associations. These advantages are generally more pronounced in widespread crops and stressful environments. Overall, mixture densities and relative proportions of component crops are crucial in determining yield and production efficiency of intercropping systems (Reddy, 2004).

Wheat (*Triticum aestivum* L.) is a vital cereal crop for a significant portion of the world's population. It serves as the primary staple food for around two billion people (36% of the world population), providing nearly 55% of global carbohydrates and 20% of food calories (Breiman and Graur, 2016). Wheat exceeds other grain crops in acreage and production, making it the most important cereal grain crop cultivated across a wide range of climatic conditions. Wheat is primarily grown for human consumption, with about 10% reserved for seed and industry uses, such as starch, paste, malt, dextrose, and gluten production. Wheat grain contains essential nutrients, including carbohydrates, proteins, fats, vitamins, and crude fibers. Early biomass production in wheat allows for more efficient use of soil water, particularly in Mediterranean climates (Loss and Siddique, 1994). Spikes in wheat have higher water use efficiency (WUE) than leaves, contributing up to 40% of total carbon fixation under moisture stress (Evans *et al.*, 1972).

Japanese Mint (*Mentha arvensis* L.) is a valuable medicinal and aromatic crop native to Brazil. Commercial production of mint began in Japan around 1870, leading to the name "Japanese mint" (Taneja & Chandra, 2012). Mint production spread to other countries, including China, South America, and India. Major mint-producing states in India include Uttar Pradesh, Uttarakhand, Punjab, and Bihar. Japanese mint is a fast-growing, hairy-leaved herb that can reach up to 1.5 meters in height under favorable conditions. Its oil is widely used in the food, pharmaceutical, and perfumery industries, as well as in balms, cough drops, inhalers, toothpaste, and mouthwash. Kothari and Singh, (1994) found that the production cost of mint oil in India was relatively low compared to other mint-growing countries due to the availability of cheap labor and low input costs. They concluded that mint oil has significant export potential, and the

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future of the mint industry in India is promising, but full potential exploitation depends on the extent to which technological advancements are utilized and remunerative prices are established. With the following objectives; to study the effect of planting methods on the production of Wheat & Mentha; to determine the suitable row ratio of Wheat & Mentha; to study the effects of treatments on resource conservation and to analyze the effects of treatments on economics.

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2. MATERIALS AND METHODS

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2.1 Experimental site: The Kanpur district is situated in sub-tropical region of Uttar Pradesh in part of Gangetic alluvium, lying between the river Ganga and Yamuna. It lies between 25º 26' and 26º 58' North latitude and 79º 31' and 80º 34' East longitude. The elevation of the Kanpur is approximately 125.9 meters above Mean Sea Level. The average annual rainfall of the district is about 800 mm. The major portion of rainfall is received during monson season from first week of July to last week of Septembesr. The region is classified as agro-climatic zone V (Central Plain Zone) of Uttar Pradesh. The experimental field was located in the same area for both years of the study, as shown in Figure 1.

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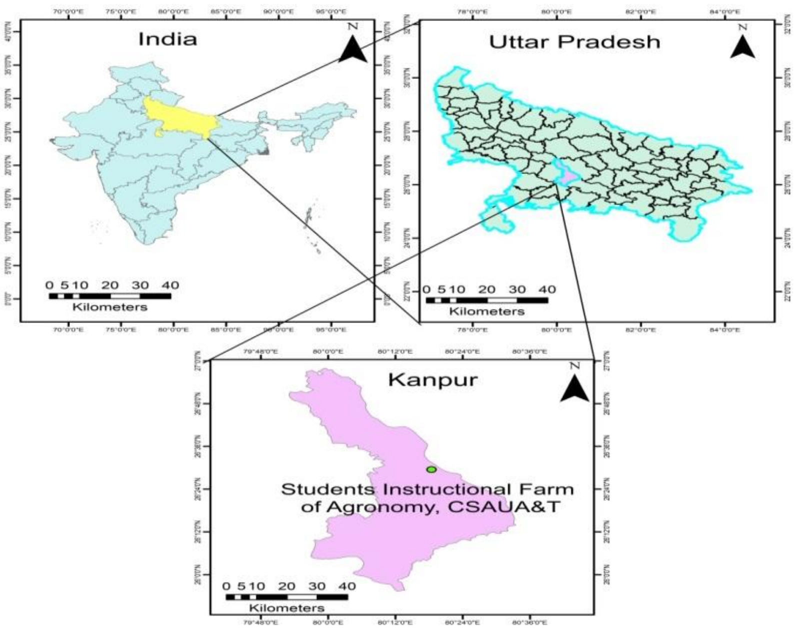

Fig. 1 LOCATION MAP OF THE STUDY AREA

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2.2 Soil Characteristics: The soil of the experimental field was sandy loam in texture with fairly deep. Soil samples were collected from (0-25 cm) depth from all the replications before sowing to determine the status of the soil. The data with respect to mechanical composition and physicochemical characterizations of soil are soil pH (7.3), EC (0.36 dSm^{-1}), Bulk density (1.35 Mg m^{-3}), Particle density (2.60 Mg m^{-3}), Field capacity (18.6 %), Porosity (48.07 %), Organic Carbon (0.33 %), Total N (0.03 %), Available P_2O_5 (17.85 kg ha^{-1}), Available K_2O (131.30 kg ha^{-1}).

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2.3 Experimental Details: The experiment was laid out in Randomized Block Design with three replication keeping one variety of Mentha 'Shivalik'& Wheat 'Halna'.The experiment consisting of nine treatments are T1: Sole Mentha direct sowing (50 cm apart), T2: Sole Mentha transplanting (50 cm apart), T3: Sole Wheat (25 cm apart), T4: Wheat + Mentha (Direct sowing 1:1), T5: Wheat + Mentha (Transplanting 1:1), T6: Wheat + Mentha (Direct sowing 2:2), T7: Wheat + Mentha (Transplanting 2:2), T8: Wheat Paired + Mentha (Direct sowing 2:3), T9: Wheat Paired + Mentha (Transplanting 2:3) . The size of each plot was (18 m^2), 4.5 m long and 4.0 m width.

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2.6 Agronomical Practices Adopted: The field preparation for the experiment involved ploughing with a tractor-drawn disc harrow in the second half of December. Two criss-cross ploughings were performed with a cultivator, followed by planking. The application of nutrients included 120 kg of nitrogen, 60 kg of phosphorus, and 60 kg of potash per hectare for wheat, and the same amounts per hectare were applied for mentha, according to the respective treatments. Half of the nitrogen, along with the full doses of phosphorus and potassium, was applied as a basal application, while the remaining half of the nitrogen was top-dressed 30 days after sowing. The wheat variety used was 'Unnat Halna,' and the mentha variety was 'Shivalick.' Sowing of wheat and mentha was done manually in furrows created by a traditional plough. The spacing for wheat was 25 cm, while for mentha it was 50 cm using both flat and 25:25 cm intercrop treatments. The seed rate was adjusted to maintain the desired plot geometry according to the treatment requirements. Furrows were covered with light single planking immediately after sowing to conserve soil moisture. The seed rate for wheat was 80 kg/ha, while mentha suckers were planted at a rate of 400 kg per hectare. Wheat seeds were presoaked for 4 days, and mentha suckers were cut into small pieces and kept in shade for 3 days to enhance germination. Irrigation was applied based on crop requirements throughout the experiment. Thinning was carried out 15 days after sowing to maintain a proper and uniform plant population. Weeding and hoeing were performed to ensure a weed-free condition in the field and minimize weed-related issues. Crop maturity was determined, and the first cutting was conducted on May 12, 2017, where plants were cut from the ground level, immediately weighed for fresh weight, and then sent to an oil extraction unit. The second cutting took place on July 8, 2017.

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The following parameters were measured and recorded for each treatment:

a. Number of functional leaves per plant: The total number of green leaves was counted from three tagged plants in each plot, and the average number of leaves per plant was calculated.

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b. Number of tillers per plant: The total number of tillers emerging from the main shoot of each tagged plant in each plot was counted.
c. Ear head length (cm): The length of the ear head in the tagged plant of each plot was measured using a meter scale.
d. Grain weight per ear head (g): The weight of grains per ear head in each plot was measured using a balance.
e. 1000-grain weight: A sample of grains was taken from the produce of each plot to determine the 1000-grain weight. A count of 1000 grains was taken, and their weight was measured using an electronic balance.
f. Grain yield (q/ha): The yield of grains per plot was recorded in kilograms after threshing and then converted to quintals per hectare (q/ha) for all treatments.
g. Straw yield (q/ha): The yield of straw per plot was recorded and then converted to quintals per hectare (q/ha) for all treatments.
h. Harvest Index (%): Harvest index was calculated by the following formula (Singh & Stoskopf, 1971).

$$\text{H.I. (\%)} = \frac{\text{Grain yield (q/ha)}}{\text{Biological yield (q/ha)}} \times 100$$

(Biological yield = Grain yield + Straw yield)

i. Land Equivalent Ratio (LER): The Land equivalent ratio is the relative land area under sole crops that is required to produce the yield achieved in intercropping. In the present experiment, the land equivalent ratio was estimated by fallowing equation (Oyejola & Mead, (1982):

$$\text{LER} = \frac{\text{Ya}}{\text{Sa}} + \frac{\text{Yb}}{\text{Sb}}$$

Where,
Ya and Yb= Yield of Intercrops ‘a’ and ‘b’ respectively
Sa and Sb= Yield of individual crops ‘a’ and ‘b’ respectively in pure stand

Statistical analysis: The data collected during the experimental period and after harvest of the experiment was statistically analyzed employing the following statistical techniques given by Fisher's & Yates, (1958).

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RESULT AND DISCUSSION

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3.1 Mentha

The data reveals that the growth and oil yield of mentha (Table 1, 3) significantly affected by different row ratio and planting methods. The maximum number of leaves/plant was observed under row ratio of 2:3 of wheat are mentha followed by 2:2 row ratio and significantly superior over sole treatments of direct sowing methods. The data recorded from the practical site that the No. of branches/plant are more in wheat: mentha (2:3) there after wheat sole and wheat: mentha (2:2), (2:3) and (1:1) have been recorded from the crop, the data indicated that intercropping system were influenced significantly. The fresh herbage yield at harvesting stage of crop significantly affected by intercropping tiller however essential oil content was not significant during experiment. Mentha sole crop (135.82 q ha^{-1}) and essential oil (0.85%) recorded maximum essential oil followed by T8 (0.85%) while minimum was in variety T5 (0.82%). It is evident from Table 4 that highest mentha equivalent oil yield (189.05 l/ha) was recorded under row ratio 2:3 of wheat + mentha as direct sowing followed by row ratio of 2:3 of wheat + mentha (transplanting) which were significantly superior over other treatments however minimum mentha equivalent oil yield (57.74 q/ha) were recorded in sole wheat. The different cropping system was found to exhibit significant variation under mentha equivalent oil yield. The mentha under intercropping gave significantly the highest mentha equivalent oil yield than other cropping system, the improvement in growth parameters of mentha and wheat might have occurred because the crop enjoyed a competition free environment for light, water and nutrients. The similar result observed by Chauhan *et al*. (2012) conducted a field experiment in CIMAP, Lucknow for two years (2007-08 and 2008-09). To study the effect of different dates of planting for three menthol mint cultivars (Saksham, Kushal and Kosi) on herb yield, oil yield and oil quality. Average herb yield increased 85.71, 104.91 and 109.49 per cent. All the groups of intercropping produced more land equivalent ratio over sole wheat and mentha which may be attributed to more yield in intercropping over sole cropping. The maximum LER of 1.50 was found in wheat + mentha (2:3) intercropping. Higher LER value with 2:3 row ratio of mentha with wheat indicate better adoptability of the intercropping system and it might be due to efficient utilization of natural resources viz. space, light as well as applied inputs by the component crop having different characteristics viz. nutrient requirements, root system and canopy structures. The similar results were observed by (Patra *et al*., 2003), (Brar *et al*., 2000), **(Singh *et al*., 2002),** (Sarkar and Pal, 2004), (Pandey *et al*., 2006) and (Singh *et al*., 2018).

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3.2 Wheat

The data pertaining to yield attributes (Table 2) *viz*., number of tillers/plant, length of spike, number of ear/plant, number of grain/plant, 1000-grain weight (g) were significantly affected by row ratio and planting methods. Clearly indicate that intercropping of wheat and mentha significantly affect the length of spike and number of tillers per plot. The maximum length of spike (13.17cm) and number of tillers per plot recorded under row ratio of wheat and mentha (direct sowing) as 1:1 and minimum tiller under sole wheat. The data observed from the experimental site that the number of ear/plant, number of grain/plant and 1000-seed weight (g) was more in wheat: mentha (1:1) row ratio their after wheat: mentha (2:2) and (1:1) have been

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recorded from the crop, the data indicated that cropping system were influenced significantly all the yield attributing characters of crop. The data pertaining to grain yield (Table 4) of the crop is the resultant of growth and yield contributing characters. The significant variation in growth characteristics and yield attributes as a result of differential intercropping treatments further led to marked variation in yield of wheat. Among the intercropping system there were significant variation in grain yield was recorded. As regards of cropping systems maximum grain yield (39.80 q ha^{-1}) recorded under sloe wheat while minimum grain yield (20.90 q ha^{-1}) was obtained with T9 cropping systems (2:3). Similar result was observed by (Kumar *et al.*, 2012), (Kumar *et al.*, 2001). The data of straw yield of wheat was recorded under various treatment combinations and presented in Table 3. Among the intercropping system there were significant variation in straw yield was recorded. As regards of cropping systems maximum straw yield (74.52 q ha^{-1}) recorded under sloe wheat while minimum straw yield (39.38 q ha^{-1}) was obtained with T5 cropping systems. The values calculated for the harvest index in relation to intercropping system and significantly maximum harvest index calculated under sole wheat. The similar results were observed by (Sarkar and Pal, 2004), (Singh *et al.*, 2018) and (Rathi *et al.*, 2014).

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Table-1: Effect of intercropping system on No. of leaves and Branches/plant of mentha under different treatments.

Treatments	No. of leaves/plant				No. branches/plant		
	30DAS	60DAS	90DAS	At maturity	30DAS	60DAS	90DAS
T_1- sole mentha (d)	28.40	62.65	217.80	405.15	14.33	24.35	67.35
T_2- sole mentha (t)	30.04	64.45	234.80	434.90	15.31	26.13	73.88
T_3- sole wheat	-	-	-	-	-	-	-
T_4- w+m (d) 1:1	29.54	67.14	234.35	434.64	13.80	25.20	69.54
T_5- w+m (t) 1:1	29.22	63.54	224.49	415.64	14.56	27.49	73.60
T_6- w+m (d) 2:2	30.45	68.30	239.42	446.15	14.22	25.96	72.66
T_7- w+m (t) 2:2	29.14	67.95	239.21	445.82	16.20	27.74	76.36
T_8- w+m (d) 2:3	30.55	71.75	225.03	454.34	14.75	26.95	73.95
T_9- w+m (t) 2:3	30.86	69.72	247.12	457.72	16.90	29.01	80.97
SE (d)	0.93	1.45	3.50	14.18	0.96	0.95	1.91
C D(P=0.05)	N.S	3.11	7.52	8.97	N.S	2.05	4.09

Table-2: Effect of intercropping system on No. of tillers / and yield Attributes under different treatment in wheat crop.

Treatments		Yield Attributes of Wheat			
	No. of tillers/plant	length of spike	No. of ear/plant	No. of grain/plant	1000-grain weight (g)
T_1- sole mentha (d)	-	-	-	-	-
T_2- sole mentha (t)	-	-	-	-	-

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T_3- sole wheat	6.20	11.13	10.58	43.44	37.56
T_4- w+m (d) 1:1	5.39	13.27	10.80	42.85	38.66
T_5- w+m (t) 1:1	5.30	11.98	10.75	39.73	38.23
T_6- w+m (d) 2:2	6.00	11.84	10.58	44.71	37.56
T_7- w+m (t) 2:2	5.90	11.40	10.45	41.27	35.68
T_8- w+m (d) 2:3	5.40	11.46	10.20	44.22	35.68
T_9- w+m (t) 2:3	5.35	11.98	9.76	43.44	34.35
SE (d)	0.41	0.29	0.36	0.92	0.53
C D(P=0.05)	N.S	0.65	N.S	2.01	1.16

Table-3: Effect of intercropping system on fresh herbage yield and essential oil content at harvesting stage under different treatment in mentha crop.

Treatments	**Fresh herbage Yield of mentha (q/ha)**	**Oil content in Mentha (%)**	**Oil Yield of Mentha (l/ha)**	**Equivalent Oil Yield of Mentha (l/ha)**
T_1- sole mentha (d)	135.82	0.85	163.35	163.35
T_2- sole mentha (t)	134.25	0.84	159.83	159.83
T_3- sole wheat	-	-	-	57.74
T_4- w+m (d) 1:1	100.80	0.82	122.93	160.36
T_5- w+m (t) 1:1	92.91	0.84	110.61	146.03
T_6- w+m (d) 2:2	120.51	0.83	145.20	177.17
T_7- w+m (t) 2:2	177.78	0.82	143.64	175.41
T_8- w+m (d) 2:3	134.72	0.84	158.50	189.05
T_9- w+m (t) 2:3	130.74	0.84	155.65	185.97
SE (d)	7.08	0.01	6.30	5.44
C D(P=0.05)	15.20	NS	13.52	11.53

Table-4: Effect of intercropping system on Yield of wheat and land equivalent ratio of Wheat and Mentha.

Treatments	**Land Equivalent Ratio (LER)**	**Grain Yield (q/ha)**	**Straw yield (q/ha)**	**Harvest index (%)**
T_1- sole mentha (d)	1.0	-	-	-
T_2- sole mentha (t)	1.0	-	-	-
T_3- sole wheat	1.0	39.80	74.52	38.95
T_4- w+m (d) 1:1	1.39	25.80	40.13	37.80
T_5- w+m (t) 1:1	1.30	24.60	39.58	37.45

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T_6- w+m (d) 2:2	1.43	22.04	39.90	37.31
T_7- w+m (t) 2:2	1.44	21.90	39.84	37.79
T_8- w+m (d) 2:3	1.50	21.30	47.79	37.62
T_9- w+m (t) 2:3	1.49	20.90	48.85	38.63
SE (d)	0.08	1.31	2.37	0.38
C D(P=0.05)	0.17	2.85	5.16	NS

4. Conclusion

In conclusion, the study found that Treatment 9 (T9) exhibited the highest number of leaves and branches per plant, Treatment 3 (T3) had the maximum number of tillers per plant in wheat, and Treatment 4 (T4) showed the highest yield attributes for wheat. For mentha, Treatment 7 (T7) had the highest herbage yield, Treatment 1 (T1) had the highest oil content and oil yield, and Treatment 8 (T8) recorded the highest equivalent oil yield and land equivalent ratio. Treatment 3 (T3) yielded the maximum grain yield, straw yield, and harvesting index for wheat. These findings provide valuable insights for optimizing growth and yield performance in wheat and mentha cultivation by selecting appropriate row ratios and planting methods.

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