Int J Seed Spice, 15(1), June, 2025: 96-100 DOI: https://doi.org/10.56093/IJSS.v15i1.9

Enhancing system productivity of transplanted celery (*Apium graveolens* L.) through *Mentha* intercropping

Rajender Kumar[1*]

Reviewed by
Dr. Narendra Chaudhary
ICAR-National Research Centre on Seed Spices Tabiji, Ajmer, Rajasthan
Email: Narendra.Chaudhary@icar.org.in

***Correspondence**
Rajender Kumar
*drajmunjal@pau.edu

Received: 14 January 2026
Revision: 19 January 2026
Accepted: 29 January 2026

Citation
Kumar, R. 2025. Enhancing system productivity of transplanted celery (*Apium graveolens* L.) through *Mentha* intercropping. *Int J Seed Spice*.15 (1): 96-100

DOI
https://doi.org/10.56093/IJSS.v15i1.9

Affiliation
[1]School of Organic and Natural Farming, Punjab Agricultural University, Ludhiana, Punjab 1411004

Abstract

Intercropping medicinal and aromatic plants with seed spices offers a promising approach to enhancing land-use efficiency, system productivity, and farm profitability in intensive agricultural systems. A field experiment entitled 'Enhancing system productivity of transplanted celery (*Apium graveolens* L.) through *Mentha* intercropping' was conducted during 2019–20 and 2020–21 at PAU, Ludhiana. The treatments comprised sole celery and celery intercropped with menthol mint (*Mentha arvensis*) varieties Kosi and CIM Kranti, and peppermint (*Mentha piperita*), both under direct planting and transplanting, in a 1:1 row proportion. Growth parameters of celery, including plant height, number of branches per plant, and umbels per plant, were not significantly affected by intercropping during both years, indicating good compatibility between celery and mentha species. Seed and straw yields of celery under intercropping systems remained statistically at par with the sole crop, confirming that intercropping did not compromise celery productivity. Intercropped mentha produced substantial herb and oil yields, with menthol mint var. CIM Kranti consistently records the highest herb yield and oil yield across both seasons. Equivalent celery yield (ECY) was significantly higher under all intercropping systems compared to sole celery, with increases ranging from 24.7 to 39.3% during 2019–20 and from 15.9 to 29.4% during 2020–21. The results clearly demonstrate that celery intercropped with menthol mint var. CIM Kranti (1:1) is a biologically efficient, stable, and economically viable intercropping system. The study supports the integration of medicinal and aromatic plants into seed spice-based cropping systems to achieve sustainable intensification and higher overall productivity.

Keywords: Celery, *Mentha species*, intercropping, equivalent celery yield, system productivity

Introduction

Celery (*Apium graveolens* L.) is an important seed spice crop cultivated for its seeds and straw, which possess aromatic, medicinal, and culinary value. It is used as an aphrodisiac, anthelmintic, antispasmodic, carminative, diuretic, emmenagogue, laxative, sedative, stimulant , and medicinally it regulates blood pressure, cholesterol, hypertension, etc. Celery is rich in beta-carotene, folic acid, vitamin C, magnesium, potassium, silica, sodium, chlorophyll and fiber (Meena *et al*., 2024). Despite its economic importance, celery productivity in India remains relatively low due to monocropping, inefficient land use, and rising production costs (Singh *et al*., 2018).

Intercropping has emerged as a viable agronomic strategy to enhance crop productivity, resource-use efficiency, and farm profitability while maintaining soil health and sustainability. Intercropping systems are particularly relevant for seed spice crops because of their wider spacing, slow initial growth, and longer duration, which allow the inclusion of short-duration or compatible intercrops (Yadav *et al*., 2019). The integration of medicinal and aromatic plants as intercrops is gaining attention due to their high market value, increasing demand, and export potential.

Among aromatic crops, *Mentha* species such as menthol mint (*Mentha arvensis*) and peppermint (*Mentha piperita*) are economically important for essential oil production. India is the world's leading producer and exporter of menthol mint oil, contributing more than 70% of global supply (FAO, 2021). Mentha crops are fast-growing, have shallow root systems, and show good adaptability under irrigated conditions, making them suitable candidates for intercropping with seed spices (ICAR-DMAPR, 2020).

Previous studies have demonstrated the feasibility of intercropping mentha with fennel, coriander, ajwain, and sugarcane without significantly affecting the yield of the base crop, while substantially improving system productivity and economic returns (Singh *et al*., 2017; Kumar *et al*., 2018; Kumar *et al*., 2015). However, limited systematic information is available on the performance of different *Mentha* species and varieties as intercrops in transplanted celery, particularly under north Indian agro-climatic conditions. Therefore, the present investigation was undertaken to evaluate the effect of intercropping different *Mentha* spp. and varieties on the growth and yield of transplanted celery, mentha productivity, and equivalent celery yield, with the objective of identifying a biologically efficient and economically viable intercropping system.

Materials and Methods

Experimental site and soil characteristics

A field experiment entitled *"Enhancing system productivity of transplanted celery (Apium graveolens L.) through Mentha intercropping"* was conducted during the *rabi* seasons of 2019–20 and 2020–21 at the Research Area of the School of Organic Farming, Punjab Agricultural University, Ludhiana, India. The experimental site is situated in the Trans-Gangetic agro-climatic zone of the Indo-Gangetic alluvial plains at 30°56′ N latitude and 75°52′ E longitude, with an altitude of 247 m above mean sea level. The climate of the region is sub-tropical semi-arid, characterized by hot summers and very cold winters. The soil of the experimental field was loamy sand in texture with a slightly alkaline reaction (pH 8.0), low in organic carbon (0.30%) and available nitrogen (115.0 kg ha^{-1}), and medium in available phosphorus (21.5 kg ha^{-1}) and potassium (248.0 kg ha^{-1}).

Experimental design and crop establishment

The experiment was laid out in a randomized complete block design (RCBD) with seven treatments and three replications. Sixty-day-old celery seedlings, raised separately in the nursery, were transplanted during the third week of December in both the years. Celery inter-row spaces were prepared with a wheel hoe, and Mentha species were introduced according to the treatment details. One row of *Mentha arvensis* (varieties Kosi and CIM Kranti) and *Mentha piperita* (local variety) was planted either directly or through transplanting of 45-day-old seedlings between two rows of celery. Planting or transplanting of Mentha species was carried out on 20 February 2020 and 9 February 2021 during the respective seasons.

Nutrient management

A fertilizer dose of 100 kg nitrogen and 40 kg P_2O_5 ha^{-1} was applied to celery through urea and single super phosphate, respectively. Half of the nitrogen, along with the full dose of phosphorus, was applied at the time of transplanting, and the remaining half of the nitrogen was applied 45 days after transplanting. Mentha crops received an additional fertilizer dose of 75 kg nitrogen and 40 kg P_2O_5 ha^{-1}, of which half of the nitrogen and the full dose of phosphorus were applied at the time of planting or transplanting, while the remaining half of nitrogen was applied 40 days thereafter.

Harvesting and observations

Celery was harvested during the first week of May in both years, followed by the harvesting of Mentha species during the fourth week of June. Data on growth and yield parameters of celery and mentha species were recorded at harvest.

Essential oil extraction and yield estimation

Essential oil extraction of Mentha species was carried out using a Clevenger's apparatus following standard procedures, and oil content was expressed as a percentage on a fresh weight basis. Oil yield was calculated as the product of oil content and fresh herb yield of Mentha species.

Equivalent yield calculation

Equivalent celery yield was computed following the standard method using prevailing market prices of celery (₹ 9000 q^{-1}), *Mentha arvensis* oil (₹ 1100 l^{-1}) and peppermint oil (₹ 2200 l^{-1}).

Results and Discussion

Growth Performance of Celery

The growth attributes of celery, namely plant height, number of branches per plant, and number of umbels per plant, were not significantly affected by intercropping with Mentha spp. during both years of experimentation (Table 1). Plant height ranged from 146.0 to 153.7 cm in 2019–20 and from 153.1 to 163.7 cm in 2020–21. Sole celery recorded marginally higher height; however, intercropping with menthol mint var. CIM Kranti (1:1) resulted in the tallest plants during the second year (163.7 cm).

Similarly, the number of branches per plant (7.7–10.7) and umbels per plant (49.0–62.6) remained statistically comparable across treatments. The non-significant differences (CD p=0.05: NS) indicate that intercropping did not exert adverse competitive effects on celery growth. This may be attributed to complementary growth habits, differential nutrient uptake patterns, and efficient utilization of light and space by the component crops. Comparable findings have been reported by Singh *et al.* (2017) and Yadav *et al.* (2020) in spice–aromatic intercropping systems.

Seed and Straw Yield of Celery

Seed yield of celery ranged from 13.6 to 15.0 q ha^{-1} during 2019–20 and from 14.0 to 16.3 q ha^{-1} during 2020–21. Although sole celery recorded the highest seed yield, intercropping treatments produced statistically similar yields, confirming that inclusion of mentha did not significantly reduce celery productivity (Table 1).

Straw yield followed a similar trend, with values ranging from 41.6 to 45.2 q ha^{-1} in 2019–20 and from 45.9 to 49.1 q ha^{-1} in 2020–21. The maintenance of seed and straw yield under intercropping highlights the biological compatibility of celery with mentha spp. and supports earlier findings that aromatic intercrops do not impose severe competition when appropriately spaced (Kumar *et al.*, 2018).

Productivity of Mentha spp. as Intercrop

Intercropped mentha produced substantial herb and oil yields, contributing significantly to system productivity (Table 2). Among treatments, menthol mint var. CIM Kranti (1:1) recorded the highest herb yield (97 and 92 q ha^{-1}) and oil yield (59 and 53 l ha^{-1}) during 2019–20 and 2020–21, respectively. Oil content varied from 0.38 to 0.64%, which falls within the standard range reported for mentha under Indian conditions (ICAR-DMAPR, 2020).

Peppermint recorded comparatively lower herb and oil yields, likely due to varietal differences in growth rate and oil biosynthesis potential, as also reported by Singh *et al.* (2019).

Equivalent Celery Yield and System Productivity

Equivalent celery yield (ECY) provides a comprehensive assessment of the productivity and economic advantage of intercropping systems by converting the yield of the intercrop into the yield of the base crop on a price-equivalent basis. In the present study, all celery-based intercropping treatments recorded significantly higher ECY compared to sole celery during both years of experimentation, clearly demonstrating the superiority of intercropping over monocropping (Table 2).

During 2019–20, sole celery recorded an ECY of 15.0 q ha^{-1}, whereas celery-based intercropping systems enhanced ECY to a range of 18.7–20.9 q ha^{-1}. The highest ECY (20.9 q ha^{-1}) was observed under celery intercropped with menthol mint var. CIM Kranti (1:1) and celery + peppermint (1:1) transplanting, representing an increase of approximately 39.3% over sole celery. Similarly, celery intercropped with menthol mint var. CIM Kranti (1:1) transplanting resulted in an

ECY of 20.6 q ha^{-1}, 37.3% higher than that of the sole crop. Other intercropping treatments also exhibited substantial yield advantages, with increases ranging from 24.7% to 36.0% over sole celery. The improvement in ECY during the first year can be attributed to the additional economic yield obtained from mentha without a corresponding reduction in celery seed yield.

A similar trend was observed during 2020–21, when sole celery recorded an ECY of 16.3 q ha^{-1}, while intercropping systems increased ECY to values between 18.9 and 21.1 q ha^{-1}. The maximum ECY (21.1 q ha^{-1}) was again recorded with celery intercropped with menthol mint var. CIM Kranti (1:1), corresponding to a 29.4% increase over sole celery. Other treatments also showed notable improvements, with ECY increases ranging from 15.9% to 25.8% compared to monocropping. Although the magnitude of yield advantage was slightly lower in the second year, the consistency of ECY improvement across years highlights the stability and resilience of celery based intercropping systems.

The enhanced ECY under intercropping systems may be attributed to better utilization of available resources such as light, nutrients, moisture, and space, resulting in higher overall biological productivity. The complementary growth patterns and non-overlapping peak nutrient demands of celery and mentha likely minimized interspecific competition, allowing both crops to perform efficiently within the same unit area. Furthermore, the higher herb and oil yields, particularly from menthol mint var. CIM Kranti, substantially contributed to increased equivalent yields due to its superior oil content and market value.

These findings are in close agreement with earlier reports by Singh et al. (2017) and Kumar et al. (2018), who observed significant improvements in equivalent yields and system productivity in spice–mentha intercropping systems. The present study thus confirms that intercropping celery with mentha spp., especially menthol mint var. CIM Kranti, is an efficient and economically advantageous production system capable of enhancing total productivity without compromising the yield of the base crop.

Conclusion

Based on two years of field experimentation, it can be concluded that intercropping mentha with transplanted celery is agronomically feasible and economically beneficial. Intercropping did not significantly affect growth or yield attributes of celery, but it provided substantial additional returns through mentha herb and oil yields. Among the treatments, celery intercropped with menthol mint var. CIM Kranti (1:1) proved most productive in terms of mentha yield and equivalent celery yield. The study strongly supports the adoption of celery-based intercropping systems in celery for sustainable intensification, improved land-use efficiency, and higher overall system productivity.

Table 1: Impact of intercropping of mentha sp. in transplanted celery on growth and yield

	Plant height (cm)		Branches/plant		Umbels/plant		Seed yield (q/ha)		Straw yield (q/ha)	
Treatments	**2019-20**	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**
Celery sole crop	153.7	156.1	8.7	9.4	56.3	57.5	15.0	16.3	45.2	49.1
Celery+ Menthol mint var. Kosi (1:1)	146.0	153.1	8.0	9.9	51.0	59.7	14.6	15.0	44.1	46.3
Celery+ Menthol mint var. Cim Kranti (1:1)	152.0	163.7	8.3	9.4	55.0	61.6	13.6	14.4	42.3	47.5
Celery +Pepper mint (1:1)	149.0	158.5	7.7	10.7	52.0	62.6	14.2	14.9	41.6	45.9
Celery+ Menthol mint var. Kosi (1:1) Transplanting	151.3	161.5	8.0	9.9	49.0	59.7	13.8	15.1	43.6	47.9
Celery+Menthol mint var. CIM Krant(1:1) Transplanting	149.0	157.9	8.0	9.0	53.0	57.9	14.1	14.5	44.8	48.9
Celery +Pepper mint (1:1) Transplanting	149.3	160.1	8.7	10.0	50.0	58.8	13.9	14.0	42.9	46.5
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Yield realization of mentha spp as intercrop in transplanted celery and its impact on equivalent celery yield

	Herb yield (q/ha)		Oil content %		Oil yield (l/ha)		Equivalent celery yield (q/ha)	
Treatments	**2019-20**	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**	**2019-20**	**2020-21**
Celery sole crop	0	0	0.00	0.00	0	0	15.0	16.3
Celery+ Menthol mint var. Kosi (1:1)	81	70	0.59	0.57	48	40	20.4	19.9
Celery+ Menthol mint var. Cim Kranti (1:1)	97	92	0.61	0.58	59	53	20.9	21.1
Celery +Pepper mint (1:1)	52	50	0.40	0.38	21	19	19.3	19.6
Celery+ Menthol mint var. Kosi (1:1) Transplanting	68	53	0.60	0.58	41	31	18.7	18.9
Celery+Menthol mint var. CIM Kranti (1:1) Transplanting	83	68	0.64	0.61	53	42	20.6	19.6
Celery+Pepper mint (1:1) Transplanting	66	63	0.43	0.45	29	26	20.9	20.5
CD (p=0.05)							2.3	2.7

Prevailing market price Celery: Rs.9000/q, *Mentha arvensis*: Rs.1100, Peppermint: Rs. 2200

Conflict of Interest

The authors declare that they have no conflict of interest.

References

FAO. 2021. *FAOSTAT: Crops and livestock products*. Food and Agriculture Organization of the United Nations.

ICAR-DMAPR. 2020. *Vision 2050: Directorate of Medicinal and Aromatic Plants Research*. Anand, India.

Kumar, R., Singh, V., and Meena, S. S. 2018. Intercropping of aromatic plants with seed spices: A sustainable approach. *Indian.J. Agron.*, 63(3): 345–350.

Kumar, R., Singh, J., and Uppal, S. K. 2015. Intercropping of medicinal and high value crops in autumn sugarcane (*Saccharum* spp. hybrid) for higher productivity and profitability. *Indian. J. Agron.*, 60(4): 456–461.

Meena, R. S., G. Lal, S. Choudhary and Meena R.D. 2024. A high yielding Celery *(Apium graveolens)* variety A-Cel-2 (Ajmer Celery-2) for better resistance, quality with higher essential oil content to grow in Rajasthan. *Int J Seed Spice,* 13 (1 & 2): 64-69.

Singh, A., Singh, R., and Yadav, R. S. 2017. Performance of fennel–mentha intercropping systems under semi-arid conditions. *J. Spices Aromat. Crops,* 26(2): 98–103.

Singh, M., Verma, R. K., and Chauhan, A. 2018. Role of medicinal and aromatic plants in crop diversification. *Indian Farming*, 68(6): 15–19.

Singh, P., Yadav, A. C., and Meena, R. S. 2019. Productivity and profitability of mentha varieties under different cropping systems. *Ind. Crop. Prod.,*140: 111–118.

Yadav, R. S., Meena, S. S., and Singh, B. 2019. Intercropping systems for sustainable spice production. *Agric. Rev.,* 40(1): 1–9.

Yadav, R. S., Singh, A. and Kumar, S. 2020. Economic analysis of spice-based intercropping systems. *J. Appl. Nat. Sci.,*12 (2): 220–225.