



Productivity and profit enhancement through turmeric (*Curcuma longa*) intercropped with okra (*Abelmoschus esculentus*) in Punjab

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ABSTRACT

Turmeric (*Curcuma longa* L.), a long-duration crop overlapping with the rainy (*khariif*) season, limits the growth period of subsequent winter (*rabi*) crops. To enhance income, intercropping with short-duration crops is viable due to turmeric's slow initial growth, which leaves inter-row spaces uncovered for about four months. Therefore, an experiment was conducted during rainy (*khariif*) season of 2020 and 2021 at School of Organic and Natural Farming, Punjab Agricultural University (PAU), Ludhiana, Punjab to study the effects of intercropping okra (*Abelmoschus esculentus* L.) with turmeric on the growth, yield and profitability of primary crop and the intercropping system. The treatments, viz. Sole turmeric (30 cm × 20 cm spacing) flat planting (T₁); Turmeric + okra in 2:1 flat planting (T₂); Turmeric + okra in 3:1 flat planting (T₃); Sole turmeric crop on 67.5 cm bed planting (T₄); Turmeric + okra in 2:1 bed planting (T₅); Turmeric + okra in 4:1 bed planting (T₆); and Sole okra sown at 45 × 15 cm (T₇) were tested under randomised block design (RBD) using three replications. The results revealed that intercropping of turmeric and okra in a 2:1 ratio, under either flat or bed planting methods, resulted in higher yields of both okra and turmeric. The experiment revealed that cultivating turmeric and okra in a 2:1 ratio on either flat or bed planting methods improved the yield, growth, and profitability of both crops. Over two years, this intercropping system achieved 300 and 304.2 q/ha equivalent fresh rhizome yield, 16.2 and 18.8% higher than sole turmeric planted, respectively under the same methods. The system also generated additional returns of ₹38,600 and ₹49,388/ha indicating the potential of okra as an intercrop to enhance productivity and profitability, especially for small farmers.

Keywords: Economics, Equivalent yield, Intercropping, Okra, Turmeric

Turmeric (*Curcuma longa* L.) holds significant historical and agricultural importance in India. It belongs to the Zingiberaceae family and is commonly referred to as "Haldi" in the local language. The rhizomes of turmeric are a rich source of proteins, lipids, carbohydrates, dietary fibre, and essential minerals like phosphorus, calcium, iron, and vitamin A. Turmeric also exhibits a wide array of medicinal properties, including anti-inflammatory, anti-mutagenic, anti-carcinogenic, anti-tumor, anti-bacterial, anti-oxidant, anti-fungal, anti-parasitic, and detoxifying effects (Satpathya and Parida 2024). Turmeric is a slow-growing long-duration crop (Akamine *et al.* 2007), grows best in hot and humid climates, making it suitable for cultivation of faster-growing, short-duration intercrops (Hossain *et al.* 2005). Okra (*Abelmoschus esculentus* L.) is an important vegetable that belongs to the Malvaceae family. It is also grown in many tropical and subtropical areas around the world (Islam *et al.* 2021, Wu *et al.* 2022).

In the present scenario, it is important to increase the production of crops to meet the ever-increasing population needs while mitigating the adverse impacts on soil and environment (Timmusk *et al.* 2017). There is a need to innovate effective technologies that help in increasing the food production with maximum use of available land. One such promising method is intercropping, where two or more crops can grow together on the same piece of land at the same time (Wezel *et al.* 2014). The practice of intercropping is very common in Asian, African and Latin American countries because it helps in higher plant growth and yield of the crop in limited piece of land (He *et al.* 2013). The intercropping can also help in major problems in agriculture like low/stagnating crop yield, higher infestation of pests and diseases, degradation of soil and pollution, etc. The studies of the previous researchers also show the benefits of intercropping in managing the pests and diseases (Singh *et al.* 2017), improving better utilisation of resources (Ehrmann and Ritz 2014), and improved nutrient uptake (Guo *et al.* 2015).

A well-planned intercropping system helps in making the best use of space between two/three different crops grown together, helps the crops to grow healthier and

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increases both the production and quality of the final yield (Bedoussac *et al.* 2015). It also helps in utilising the available resources efficiently (Eskandari and Ghanbari 2009) while increasing the production and profitability of the crops. Further, it helps to reduce problems with insect-pests and weeds (Banik *et al.* 2006).

In the case of turmeric and okra intercropping, the longer germination period of turmeric presents an excellent opportunity to intercrop okra along with turmeric (main crop). This can improve the overall productivity and profitability of the system while promoting the area of turmeric cultivation among the farmers. To investigate the effects of the turmeric and okra intercropping system under Punjab conditions, a field experiment was conducted at Punjab Agricultural University, Ludhiana, Punjab to evaluate the effectiveness of turmeric intercropped with okra, find the best suitable intercropping ratio with higher productivity and net returns under Punjab conditions and to generate the scientific evidence of potential benefits/drawbacks of intercropping okra with turmeric.

MATERIALS AND METHODS

A field experiment was conducted during rainy (*khariif*) season of 2020 and 2021 at School of Organic Farming, Punjab Agricultural University, Ludhiana (30°54' N, 75°56' E; at an elevation of 247 m amsl), Punjab to find out the suitable combination of component crops for higher productivity and profitability of turmeric + okra intercropping system. The climate at the experimental site was hot, humid, and semi-arid. The mean maximum and minimum temperatures varied throughout the year. In summer, the temperature often reaches 45°C with dry spells, while in winter, frost occurs in December and January, and temperatures can drop close to 0°C. The monsoon causes the majority of the rainfall during summer, with 75–80% of the total rainfall occurring between June and September. In winter, the main source of rainfall is western disturbances. Before starting the experiment, the soil samples were collected from different parts of the field (0–15 cm) for physical and chemical analysis. It was loamy sand in texture (Typic Ustochrept) with a pH of 7.3 (1:2, soil: water suspension). The organic carbon content (0.26%) and available nitrogen (118.9 kg/ha) were low, while having a medium level of phosphorus (19.1 kg/ha) and potassium content (158.5 kg/ha). A randomised complete block design (RCBD) with three replications was used for the laying out the experiment. The experiment included seven different treatments, viz. Sole turmeric (30 cm × 20 cm flat planting) (T₁); Turmeric + okra (2:1 flat planting) (T₂); Turmeric + okra (3:1 flat planting) (T₃); Turmeric sole crop (67.5 cm bed planting) (T₄); Turmeric + okra (2:1 bed planting) (T₅); Turmeric + okra (4:1 bed planting) (T₆); and Sole okra (45 cm × 15 cm recommended) (T₇). The gross plot size for each plot was 18 m² (6.0 m × 3.0 m) during both the years. The sole crop of turmeric and okra was sown, maintaining 30 cm × 20 cm and 45 cm × 15 cm spacing, respectively. Turmeric (Punjab Haldi-1) was planted during

the 1st week of May and okra (Punjab Suhawani) as intercrop was sown in the 1st week of July during both the years. The pre-sowing irrigation was applied to keep the soil at a better moisture level in the experimental field. Then the field was prepared by ploughing with a disc harrow twice, followed by a cultivator and planking. The recommended seed rate of turmeric (20 q/ha) and okra (15 kg/ha) were used for planting. For intercropping with okra, the seed rate was adjusted based on the area. For sole turmeric, 25 t/ha of well-rotted farmyard manure was applied before sowing. In addition, a basal dose of 25 kg P₂O₅ (60 kg Single Super Phosphate) and 25 kg K₂O (16 kg Muriate of Potash) was applied at pre-sowing. In order to keep the field free from weeds, paddy straw mulch @90 q/ha was uniformly applied immediately after sowing. Furthermore, in okra intercropping treatments, an additional dose of N (on the basis of area of okra) was applied in two equal splits, i.e. half at the time of sowing and the remaining half after the first picking. Other agronomic practices for raising turmeric and okra were followed as per recommended package and practices of PAU, Ludhiana. The harvesting of turmeric was done on complete drying of leaves at the end of December during both years. The harvesting of okra started 60 days after sowing during both the years; a total of eleven pickings were taken during the whole crop duration. Thereafter, the okra plants were cut to the soil level and removed from the field. For statistical analysis, analysis of variance was conducted for the randomised complete block design (RCBD) and significant mean differences were evaluated using Fisher's protected test at a 5% significance level.

RESULTS AND DISCUSSION

The mean data of two-year study (2020 and 2021) revealed that the growth characteristics of turmeric, viz. plant height, tillers/plant, number of mother, primary and secondary rhizomes, remained unaffected with intercropping okra (Table 1) as the statistical differences within the treatments were non-significant. However, numerically, on the basis of mean of two years of study, maximum plant height (172.9 cm) was recorded in turmeric + okra (2:1 flat planting) intercropping treatment, whereas the minimum plant height (150.8 cm) was recorded in turmeric + okra (4:1 bed planting) treatment. Similarly, the number of tillers/plant varied from 2.1–2.5. The maximum tillers were recorded in bed-planted sole turmeric, whereas minimum tillers (2.1) were recorded in flat-planted sole turmeric. The highest numbers of primary and secondary rhizomes were recorded in the sole turmeric crop, yet it was statistically similar with other intercropping treatments of turmeric and okra. Similar results were found in the okra as it was sown as intercrop in turmeric (main crop), it has not shown any statistical differences in terms of plant height, number of branches/plant and pod length (Table 1) when compared with those other treatments. However, numerically, the highest plant height (134.5 cm) was observed in the sole okra intercrop, followed by the turmeric + okra (2:1 flat planting) intercropping system. The number of branches/

Table 1 Effect of intercropping on growth and yield characters of turmeric and okra (mean of 2020 and 2021)

Treatments	Turmeric					Okra		
	Plant height (cm)	Tillers/plant	Mother rhizome	Primary rhizome	Secondary rhizome	Plant height (cm)	Number of branches	Fruit length (cm)
T ₁ , Turmeric sole crop (Flat planting)	168.7	2.1	1.3	6.9	7.0	-	-	-
T ₂ , Turmeric + Okra (2:1 Flat planting)	172.9	2.2	2.2	4.4	4.4	133.9	17.03	10.03
T ₃ , Turmeric + Okra (3:1 Flat planting)	159.7	2.5	1.9	4.1	5.9	130.5	15.80	9.98
T ₄ , Turmeric sole crop (Bed planting)	163.9	2.5	1.8	5.6	5.7	-	-	-
T ₅ , Turmeric + Okra (2:1 Bed planting)	162.9	2.1	1.2	5.7	5.9	132.0	16.67	10.05
T ₆ , Turmeric + Okra (4:1 Bed planting)	150.8	2.5	1.6	4.9	5.1	128.3	15.73	9.90
T ₇ , Sole okra (Recommended)	-	-	-	-	-	134.5	17.07	10.06
LSD ($p=0.05$)	NS	NS	NS	NS	NS	NS	NS	NS

NS, Non-significant.

plant ranged from 15.73–17.07 and fruit length ranged from 9.98–10.06 cm. The sole okra treatment recorded the maximum number of branches (17.07) and fruit length (10.06 cm), followed by turmeric + okra (2:1 flat planting) treatments. The results revealed that the intercropping of okra in turmeric did not show any adverse effect on the growth of turmeric, which might be due to the effect of short-duration intercrop (okra) and the coincidence of the slow initial growth period of turmeric. The turmeric's growth soared in the month of July-August, which coincided with the harvesting of okra (after June), thus, benefiting

the okra and turmeric intercropping system. The higher biomass under intercropping is indicative of more efficient utilisation of land and available resources, such as water, nutrients and sunlight. These optimised conditions and judicious use of resources might have helped in achieving a higher yield of turmeric with okra intercropping. The plants grew taller and recorded a higher number of tillers/plant, which led to higher growth and yield of turmeric (Table 2). Another reason for achieving higher intercropping yield is by applying recommended nutrients to both the crops in the intercropping system, so that the main crop doesn't

Table 2 Effect of intercropping of okra in turmeric on system productivity (2020 and 2021)

Treatments	Fresh rhizome yield (q/ha)		Okra yield (q/ha)		Equivalent fresh rhizome yield (q/ha)		Additional % increase in yield over control (based on eq. yield)	
	2020	2021	2020	2021	2020	2021	2020	2021
T ₁ , Turmeric sole crop (Flat planting)	250.0	266.5	-	-	250.0	266.5	-	-
T ₂ , Turmeric + Okra (2:1 Flat planting)	244.2	240.7	62.21	91.2	290.8	309.1	16.3	15.9
T ₃ , Turmeric + Okra (3:1 Flat planting)	247.2	246.9	54.19	52.4	287.9	286.3	15.1	7.4
T ₄ , Turmeric sole crop (Bed planting)	252.0	260.2	-	-	252.0	260.2	-	-
T ₅ , Turmeric + Okra (2:1 Bed planting)	247.5	250.5	59.24	88.0	291.9	316.5	15.8	21.6
T ₆ , Turmeric + Okra (4:1 Bed planting)	248.5	254.5	30.57	47.6	271.3	290.2	7.7	11.5
T ₇ , Sole okra (Recommended)	-	-	81.81	115.9	-	-	-	-
LSD ($p=0.05$)	NS	NS	3.91	7.3	20.8	19.37	-	-

*Price of okra: ₹1500/q as per prevailing market price. **Price of turmeric fresh rhizomes: ₹2,000/q used for calculation of equivalent yield. NS, Non-significant.

compete for nutrients and resources and is able to maintain its growth throughout the crop cycle.

The fresh rhizome yield of turmeric was statistically similar in all the treatments during both years (Table 2). The equivalent fresh rhizome yield produced (q/ha) under turmeric + okra (2:1) intercropping systems in flat (300 q/ha) and bed planting methods (304.2 q/ha) was significantly higher than the fresh rhizome yield produced under the sole turmeric crop (258.3 q/ha). This increase was 18.7% and 16.2% higher in bed planting and flat planting, respectively over control (based on equivalent yield).

In the early growth stages, intercropping turmeric and okra might have faced minimal competition for essential resources such as water, nutrients, and sunlight. This reduced competition helped in various intercultural operations, which are important for improving the growth and yield of both the component crops. These favourable conditions might have helped in efficient partitioning of photosynthates from the source to the sink (such as roots, stems, and developing fruits) that require nutrients for growth (Patra and Purkayastha 2020). This effective allocation and use of resources might have helped the vigorous plant growth and contributed to the comparable yield (Table 1 and 2) of the main crop (turmeric), which was also recorded in past

studies of intercropping (Kumar *et al.* 2022, Singhshetty *et al.* 2025). Another reason for the higher equivalent fresh rhizome yield in the intercropping system as compared to the sole crop might be due to complementary and better use of growth resources by both the component crops. However, sole turmeric had a slightly higher fresh rhizome yield compared to intercropping with okra. This might be due to the absence of competition, if any, from intercropped okra for space, light, water and nutrients. The intercropping increases the yield per unit area, thereby enhanced the overall productivity, leading to higher economics. The curcumin content in both the years in all of the treatments was not affected by the intercropping of turmeric with okra. The mean curcumin content in both the years ranged from 4.06–4.24%. Turmeric + okra (4:1 bed planting) intercropping recorded the minimum curcumin content percentage while sole turmeric (flat and bed planting) recorded the highest curcumin content (Table 3). The analysis of different intercropping treatments indicates that bed planting of turmeric with a 2:1 ratio of okra recorded the highest additional net returns, amounting to ₹49,388.3 (Table 4), due to an 18.7% increase in yield over the control. These results highlight the benefit of increased equivalent yield, attributed to the effective synergy between turmeric

Table 3 Effect of intercropping of okra in turmeric on system productivity and curcumin content (mean of 2020 and 2021)

Treatments	Fresh rhizome yield (q/ha)	Okra (q/ha)	Equivalent fresh rhizome yield (q/ha)	Additional % increase in yield over control (based on eq. yield)	Curcumin content (%)
T ₁ , Turmeric sole crop (Flat planting)	258.3	-	258.3	-	4.34
T ₂ , Turmeric + Okra (2:1 Flat planting)	242.5	76.7	300.0	16.2	4.10
T ₃ , Turmeric + Okra (3:1 Flat planting)	247.1	53.3	287.1	11.1	4.15
T ₄ , Turmeric sole crop (Bed planting)	256.1	-	256.1	-	4.34
T ₅ , Turmeric + Okra (2:1 Bed planting)	249.0	73.6	304.2	18.8	4.15
T ₆ , Turmeric + Okra (4:1 Bed planting)	251.5	39.1	280.8	9.6	4.06
T ₇ , Sole okra (Recommended)	-	98.9	-	-	-
LSD ($p=0.05$)	NS				NS

NS, Non-significant.

Table 4 Economics of intercropping of okra in turmeric on system productivity (mean of 2020 and 2021)

Treatments	Additional % increase in yield over control (based on eq. yield)	Additional cost of cultivation (₹)	Additional income (₹)	Additional net returns (₹)
T ₁ , Turmeric sole crop (Flat planting)	-	-	-	-
T ₂ , Turmeric + Okra (2:1 Flat planting)	16.2	44,799.5	83,400	38,600.5
T ₃ , Turmeric + Okra (3:1 Flat planting)	11.3	30,945.5	57,700	26,754.5
T ₄ , Turmeric sole crop (Bed planting)	-	-	-	-
T ₅ , Turmeric + Okra (2:1 Bed planting)	18.7	42,511.7	91,900	49,388.3
T ₆ , Turmeric + Okra (4:1 Bed planting)	9.6	22,407.9	45,000	22,592.1
T ₇ , Sole okra (Recommended)	-	-	-	-

and okra in bed planting. Following this, flat planting of turmeric with okra in 2:1 ratio recorded an additional net return of ₹38,600.5, with a 16.2% yield increase over the control. This treatment was cost-effective, balancing the additional income from increased yield with cultivation costs. Comparatively, a 3:1 ratio in flat planting and a 4:1 ratio in bed planting yielded lower additional returns (₹26,754.5 and ₹22,592.1, respectively), with respective yield increases of 11.3% and 9.6% (Table 4) over the control. These lower yields suggest that reduced okra density in these ratios may affect the system's overall productivity, thereby influencing profitability. Therefore, bed planting turmeric with a 2:1 okra ratio recorded the most profitable approach, yielding the highest income from intercrops with minimal adverse effects on turmeric yield. This method provided a sustainable way to enhance system productivity and income for farmers while promoting effective land utilisation (Kumar *et al.* 2015). The higher extra profits from turmeric + okra intercropping (both flat and bed planting) as compared to sole turmeric was due to higher diversified income sources, better land use, synergistic effects between the crops, and potentially favourable market conditions.

Since turmeric initially grows slowly, okra can be raised in between the rows without affecting the growth, yield and quality of the main crop. Plant height, tiller number and rhizome development in turmeric remained statistically similar across treatments, while okra also showed no significant variation in plant height, branch number and pod length. Numerically, some treatments performed slightly better, but differences were not statistically significant. Turmeric + okra intercropping system, particularly the 2:1 ratio in bed and flat planting, produced higher equivalent rhizome yields of 16–19% more than sole turmeric due to complementary resource use, minimal early competition, efficient light and nutrient utilisation, and favourable weather conditions. Economic analysis confirmed that the 2:1 bed-planted system yielded the highest additional net returns. Intercropping resulted in overall higher land productivity without affecting the curcumin content, which remained comparable across treatments. Hence, turmeric + okra intercropping system proved agronomically compatible, resource-efficient and economically superior to monocropping.

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