Int.J.Curr.Microbiol.App.Sci (2023) *12*(09): 105-113

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 12 Number 9 (2023)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2023.1209.010

Studies on Ginger Based Intercropping Systems for Higher Yield and Income

Muskan Sharma*, Vipin Sharma and H. Dev Sharma

Department of Vegetable Science, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, HP - 173 230, India

**Corresponding author*

Keywords

Zingiber officinale Rosc., Zingiberaceae, cultivation, ginger, respiratory issues

Article Info

Received:
14 July 2023
Accepted:
21 August 2023
Available Online:
10 September 2023

A B S T R A C T

The present investigation entitled, "Studies on ginger based intercropping systems for higher yield and income" was carried out in Randomized Complete Block Design with three replications in plot size of 3 m × 1 m and spacing 30 cm × 20 cm at Vegetable Research Farm and Quality Analysis Laboratory of the Department of Vegetable Science, Dr YSPUHF, Nauni, Solan (HP) during *Kharif* 2022. The treatments comprised of seven treatments i.e. Fenugreek, Coriander, Oriental Mustard, Sweet corn, French bean, Arhar and Elephant foot yam. The observations recorded were plant height (cm), tiller girth (cm), number of tillers per plant, number of leaves per tiller, leaf length (cm), leaf width (cm), incidence of rhizome rot (%), rhizome length (cm), rhizome breadth (cm), yield of main crop per plant (g) and per hectare (q), yield of intercrops per plant (g) and per hectare (q), total ginger yield and ginger equivalent projected yield per hectare (q), dry matter recovery (%), oleoresin content (%), essential oil (%), crude fibre (%) and benefit cost ratio. Therefore, it was concluded that ginger variety Solan Giriganga intercropped with three crops of Sweet corn during Summer, *Kharif* and *Rabi* seasons with planting ratio 2:2 gave the highest yield of ginger (188.33 q/ha) and Sweet corn (444.16 q/ha) along with maximum net returns per hectare (₹ 5,29,442) and B:C ratio (1.81) under mid hill conditions of Himachal Pradesh.

Introduction

Ginger (*Zingiber officinale* Rosc.) belonging to family Zingiberaceae, is one of the most important and widely used spices worldwide. It is amongst important cash and principal spice crops all over the country and world. The Latin term *Zingiber* was derived from the ancient Tamil word, *ingiver*, meaning ginger rhizome. Ginger is native of South East Asia and originated in Indo-China region. Worldwide, ginger is used as a seasoning, condiment and herbal remedy. For the last 2500 years, Chinese have been utilising ginger as a digestive aid, in addition to treating rheumatism and bleeding issues. It is also used to cure respiratory issues, toothaches, snakebites and baldness (Duke and Ayensu, 1985). In Ayurveda, the Indian system of traditional medicine, ginger is frequently used to prevent excessive blood clotting, lower cholesterol and treat arthritis. For commercial cultivation, ginger needs a tropical, subtropical and humid climate. It can be effectively cultivated anywhere

between sea level in the south and 1500 m amsl in the Himalayas. The ideal elevation range is 300-900 m. The ideal temperature range is 19-28℃. The ideal soil temperature for sprouting and growth is 25-26℃. During its resting stage, the crop is unaffected by cold weather. Ginger grows on a wide variety of soil but crop performs best on medium loam with good supply of humus.

According to reports, ginger is a crop that loves the shadow and does well in partial shade and can be cultivated as an intercrop. India is the world's greatest producer as well as exporter of ginger, accounting for 50% of global production (Pakrashi and Pakrashi, 2003). Before the turn of the century, farmers were not known to intercrop any other crop with ginger on their farms. The crop is now being intercropped with other crops and its cultivation is growing (Lyocks *et al.,* 2013). The primary cash crop of the tribal populations in the north-eastern region of India is ginger, which is grown either as a mixed crop or as an intercrop (Sanwal *et al.,* 2006).

When ginger intercropped with turmeric under rainfed conditions for quality parameters it was seen that oil content in ginger and oleoresin content in turmeric showed differences. Turmeric cultivation turned out to be more profitable than ginger (Jaswal *et al.*, 1993). Ginger intercropped with Elephant foot yam found to reduce the incidence of collar rot.

In terms of overall production, starch content, intercropping systems out performed solitary cropping. Elephant foot yam had the highest corm equivalent yield and benefit cost ratio (Nedunchezhiyan, 2015). In terms of ginger leafiness, tiller production and fresh rhizome yield, intercropping ginger with mung-bean produced the best results compared to cowpea, soyabean or lablab. When ginger intercropped with legume crops the highest improvement in ginger yield and soil chemical characteristics was obtained (Nwaogu and Muogbo, 2015). It was also seen that ginger performs better in an agroforestry system (AFS) based on bamboo than it does in a single crop system and the use of green mulches has been shown to be effective in improving ginger yield and quality, soil health, soil moisture and weed control (Sharma *et al.,* 2022). So the present study was carried out to evaluate the effect of intercropping systems on yield and quality of ginger (*Zingiber officinale* Rosc.).

Materials and Methods

The present investigation was carried out at the Vegetable Research Farm, Department of Vegetable Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) from April to November, 2022. The experimental site was located at Nauni, about 13 km from Solan, at an altitude of 1270 meters above mean sea level lying between longitude of 77˚ 11' 30" E and a latitude of 30˚ 52' 30" N. It falls in sub-humid, sub-temperate and mid hill zone of Himachal Pradesh (Mehra, 2012).

The experiment was laid out in randomized complete block design with seven treatments and three replications *viz*., T_1 : Sole ginger, T_2 : Ginger + Fenugreek (Planting ratio 2:2. Fenugreek – two crops, *Kharif* and *Rabi*), T_3 : Ginger + Coriander + Oriental mustard (Planting ratio 2:2. Coriander followed by Oriental mustard), T_4 : Ginger + Sweet corn (Planting ratio 2:2. Sweet corn- three crops, Summer, *Kharif* and *Rabi*), T_5 : Ginger + French bean (Planting ratio 2:2. French bean- three crops, Summer, *Kharif* and *Rabi*), T_6 : Ginger + Arhar (Planting ratio 4:1) and T_7 : Ginger + Elephant foot yam (Planting ratio 2:2).

Crop was grown at a spacing of 30 × 20 cm in raised beds of 3 m × 1 m size. Observations on growth, yield, quality and economic parameters recorded were : plant height (cm), tiller girth (cm), number of tillers per plant, number of leaves per tiller, leaf length (cm), leaf width (cm), incidence of rhizome rot (%), rhizome length (cm), rhizome breadth (cm), yield of main crop [per plant (g) and projected yield per hectare (q)], yield of intercrops [per plant (g) and projected yield per hectare (q)], total ginger yield and ginger equivalent yield [per plant (g) and projected yield per hectare (q)], dry matter recovery

(%), oleoresin content (%), essential oil (%), crude fibre (%) and benefit cost ratio (B:C). Analysis of variance for the experiment was done as per the model suggested by Panse and Sukhatme (2000).

Results and Discussion

Analysis of variance found significant variations for the influence of ginger based intercropping systems on growth, leaf characters and incidence of rhizome rot as shown in Table 1. The maximum plant height of ginger was obtained in T_4 intercropping with Sweet corn (82.67cm). Lyocks *et al.,* (2013) observed that ginger generated the highest plant height (47.33 cm) when intercropped with 27,074 maize plants per hectare as opposed to solitary ginger (44.66 cm). The maximum tiller girth of ginger was obtained in T_4 intercropping with Sweet corn (2.55 cm). The maximum number of tillers per plant of ginger was obtained in T_4 intercropping with Sweet corn (9.28). Bari and Rahim (2010) reported maximum tillers per hill (13.97 in 2005 and 12.80 in 2006) in the sissoo (spacing 6 x 6 m) + guava (3 x 3 m) + ginger treatment, which was comparable to the sissoo (spacing 5 x 5 m) + guava (spacing 2.5 x 2.5 m) + ginger.

The maximum number of leaves per tiller of ginger was obtained in T_4 intercropping with Sweet corn (19.01). The maximum leaf length of ginger was obtained in T_4 intercropping with Sweet corn (26.94 cm). The maximum leaf width of ginger was obtained in T_4 intercropping with Sweet corn (4.22 cm). The maximum incidence of rhizome rot of ginger was obtained in T_6 intercropping with Arhar (14.36%).

Observations found significant variations for the influence of ginger based intercropping systems on rhizome characters, yield characters of main crop [per plant (g) and per hectare (q)] and yield characters of intercrops [per plant (g) and per hectare (q) (projected)] as shown in Table 2. The maximum rhizome length of ginger was obtained in T_5 intercropping with French bean (18.56 cm). Sanwal *et al.,* (2006) reported that when intercropped with french bean, discovered the longest rhizome length (14.68 cm). The maximum rhizome breadth of ginger was obtained in T_4 intercropping with Sweet corn (9.00 cm).

The maximum yield of main crop per plant of ginger was obtained in T_4 intercropping with Sweet corn (197.74 g). The maximum yield of main crop per hectare of ginger was obtained in T_4 intercropping with Sweet corn (188.33 q). Ali *et al.,* (2006) reported that ginger yield were higher near bamboo rows (1-2 m). Bhuiyan *et al.,* (2012) revealed that the yield of ginger was shown to be significantly greater (32.88 t/ha) under an agroforestry system based on coconut and guava that permitted 70-80 % of shade level. The maximum yield of intercrops per plant of ginger was obtained in T_4 intercropping with Sweet corn (233.03 g). The maximum yield of intercrops per hectare of ginger was obtained in T_4 intercropping with Sweet corn (222.08 q).

Analysis found significant variations for the influence of ginger based intercropping systems on total ginger yield and ginger equivalent yield per hectare (q) projected and quality characters as shown in Table 3. The maximum total ginger yield and ginger equivalent yield per hectare (205.20 q) was obtained in T_4 intercropping with Sweet corn.

The maximum dry matter recovery of ginger was obtained in T_4 intercropping with Sweet corn (21.14 %). The maximum oleoresin content of ginger was obtained in T_3 intercropping with Coriander and Oriental mustard (4.94 %). The maximum essential oil of ginger was obtained in T_3 intercropping with Coriander and Oriental mustard (1.61 %). The maximum crude fibre of ginger was obtained in T_7 intercropping with Elephant foot yam (4.34 %). Ajithkumar and Jayachandran (2003) observed the highest crude fibre content (4.25 % in 1997 and 4.30 % in 1998), after 180 days of planting in an open condition. Hegde *et al.,* (2006) reported that cultivar Mahima had a greater crude fibre content (5.18 %) when grown in the open and (4.95 %) when grown in coconut shadow.

Table.1 Effect of ginger based intercropping systems on growth character, leaf character and incidence of rhizome rot (%) in ginger.

	Details of Treatments	Plant height (cm)	Tiller girth (cm)	Number of tillers per plant	Number of leaves per tiller	Leaf length (cm)	Leaf width (cm)	Incidence of rhizome rot (%)
T_1	**Sole ginger**	74.43	2.44	8.41	17.93	26.06	2.28	12.09 (3.61*)
T_2	**Ginger + Fenugreek (Planting ratio 2:2. Fenugreek- two crops, *Kharif* and *Rabi*)**	78.67	2.25	8.42	18.40	24.20	3.99	12.13 (3.62*)
T_3	**Ginger + Coriander + Oriental mustard (Planting ratio 2:2. Coriander followed by Oriental mustard)**	77.46	2.54	7.36	18.25	25.09	4.04	13.21 (3.76*)
T_4	**Ginger + Sweet corn (Planting ratio 2:2. Sweet corn- three crops, Summer, *Kharif* and *Rabi*)**	82.67	2.55	9.28	19.01	26.94	4.22	11.09 (3.47*)
T_5	**Ginger + French bean (Planting ratio 2:2. French bean- three crops, Summer, *Kharif* and *Rabi*)**	74.06	2.52	8.34	18.23	19.33	3.86	12.03 (3.61*)
T_6	**Ginger + Arhar (Planting ratio 4:1)**	64.76	2.26	5.68	13.80	23.36	3.77	14.36 (3.91*)
T_7	**Ginger + Elephant foot yam (Planting ratio 2:2.)**	73.80	2.30	8.28	17.12	25.29	4.08	14.28 (3.90*)
	Mean	**75.12**	**2.40**	**7.96**	**17.53**	**24.32**	**3.74**	**12.74 (3.69*)**
	Range	**64.76-82.67**	**2.25-2.55**	**5.68-9.28**	**13.80-19.01**	**19.33-26.94**	**2.28-4.22**	**11.09-14.36 (3.47-3.91*)**
	SE±(m)	**0.78**	**0.05**	**0.12**	**0.21**	**0.31**	**0.10**	**0.19 (0.01*)**
	$CD_{(0.05)}$	**2.40**	**0.16**	**0.27**	**0.65**	**1.00**	**0.34**	**0.41 (0.84*)**

** Figures in parenthesis are square root transformations*

Table.2 Effect of ginger based intercropping systems on rhizome characters, yield characters of main crop ginger [per plant (g) and per hectare (q) (projected)] and yield characters of intercrops [per plant (g) per hectare (q) (projected)]

	Details of Treatments	Rhizome length (cm)	Rhizome breadth (cm)	Yield of main crop per plant (g)	Yield of main crop per hectare (q)	Yield of intercrops per plant (g)	-Yield of intercrops per hectare (projected) (q)
T_1	**Sole ginger**	18.20	8.87	195.30	186.00	-	-
T_2	**Ginger + Fenugreek (Planting ratio 2:2. Fenugreek- two crops, *Kharif* and *Rabi*)**	17.73	7.83	191.27	182.17	12.47 (9.35*)	49.95 (37.46*)
T_3	**Ginger + Coriander + Oriental mustard (Planting ratio 2:2. Coriander followed by Oriental mustard)**	17.80	8.63	190.75	181.67	11.47 (15.29*)	45.90 (61.20*)
T_4	**Ginger + Sweet corn (Planting ratio 2:2. Sweet corn- three crops, Summer, *Kharif* and *Rabi*)**	17.83	9.00	197.74	188.33	466.05 (233.03*)	444.16 (222.08*)
T_5	**Ginger + French bean (Planting ratio 2:2. French bean- three crops, Summer, *Kharif* and *Rabi*)**	18.56	7.73	191.10	182.00	77.47 (77.47*)	73.80 (73.80*)
T_6	**Ginger + Arhar (Planting ratio 4:1)**	15.40	6.87	168.00	160.00	6.50 (19.50*)	6.20 (18.60*)
T_7	**Ginger + Elephant foot yam (Planting ratio 2:2)**	17.66	8.77	186.28	177.41	67.20 (100.80*)	64.00 (96.00*)
	Mean	**17.59**	**8.24**	**188.63**	**179.41**	91.60 **(75.91*)**	97.15 **(72.73*)**
	Range	**15.40-18.56**	**6.87-9.00**	**168.00-197.74**	**160.00-188.33**	6.50-466.05 **(9.35-233.03*)**	6.20-444.16 **(18.60-222.08*)**
	SE±(m)	**0.31**	**0.18**	**0.21**	**0.33**	0.10 **(0.02*)**	0.02 **(0.03*)**
	$CD_{(0.05)}$	**0.96**	**0.58**	**0.67**	**1.04**	0.33 **(0.07*)**	0.08 **(0.09*)**

** Figures in parenthesis are ginger equivalent yield of intercrops*

Table.3 Effect of ginger based intercropping systems on total ginger yield and ginger equivalent yield per hectare (q) projected and quality characters in ginger

	Details of Treatments	Ginger and ginger equivalent yield per hectare (q) (GE+GEY)	Dry matter recovery (%)	Oleoresin content (%)	Essential oil (%)	Crude fibre (%)
T_1	**Sole ginger**	186.00	21.11 (4.70*)	4.81 (2.41*)	1.36 (1.53*)	4.03 (2.24*)
T_2	**Ginger + Fenugreek (Planting ratio 2:2. Fenugreek- two crops, *Kharif* and *Rabi*)**	109.81	19.74 (4.56*)	4.58 (2.36*)	1.24 (1.49*)	4.13 (2.26*)
T_3	**Ginger + Coriander + Oriental mustard (Planting ratio 2:2. Coriander followed by Oriental mustard)**	121.43	20.37 (4.62*)	4.94 (2.43*)	1.61 (1.61*)	4.10 (2.25*)
T_4	**Ginger + Sweet corn (Planting ratio 2:2. Sweet corn- three crops, Summer, *Kharif* and *Rabi*)**	205.20	21.14 (4.70*)	4.54 (2.35*)	1.53 (1.59*)	4.04 (2.24*)
T_5	**Ginger + French bean (Planting ratio 2:2. French bean- three crops, Summer, *Kharif* and *Rabi*)**	127.90	20.74 (4.67*)	4.60 (2.36*)	1.08 (1.44*)	4.22 (2.28*)
T_6	**Ginger + Arhar (Planting ratio 4:1)**	131.72	17.46 (4.29*)	4.86 (2.42*)	1.43 (1.56*)	4.18 (2.27*)
T_7	**Ginger + Elephant foot yam (Planting ratio 2:2)**	136.70	20.44 (4.62*)	4.01 (2.23*)	1.28 (1.50*)	4.34 (2.31*)
	Mean	**145.54**	**20.14 (4.59*)**	**4.62 (2.36*)**	**1.36 (1.53*)**	**4.14 (2.26*)**
	Range	**109.81-205.20**	**17.46-21.14 (4.29-4.70*)**	**4.01-4.94 (2.23-2.43*)**	**1.08-1.61 (1.44-1.61*)**	**4.03-4.34 (2.24-2.31*)**
	SE±(m)	**0.11**	**0.38 (0.04*)**	**0.16 (0.03*)**	**0.51 (0.00*)**	**0.04 (0.00*)**
	$CD_{(0.05)}$	**0.35**	**1.19 (0.12*)**	**0.52 (0.11*)**	**1.60 (0.02*)**	**0.12 (0.02*)**

** Figures in parenthesis are square root transformations*

Table.4 Effect of ginger based intercropping systems on economics of ginger cultivation

	Treatments	Yield (q/ha)			Gross Return/ha (₹)	Cost of Cultivation/ha (₹)	Net Returns/ha (₹)	Increased Returns over Sole Crop/ha (₹)	B:C Ratio
		Main crop	Ginger equivalent yield of intercrops	Total					
T_1	**Sole ginger**	186.00	-	186.00	7,44,00	3,90,758	3,53,242	0	0.90
T_2	**Ginger + Fenugreek (Planting ratio 2:2. Fenugreek- two crops, *Kharif* and *Rabi*)**	182.17	37.46	109.81	4,39,240	2,92,108	1,47,132	-2,06,110	0.50
T_3	**Ginger + Coriander + Oriental mustard (Planting ratio 2:2. Coriander followed by Oriental mustard)**	181.67	61.20	121.43	4,85,720	2,93,233	1,92,487	-1,60,755	0.65
T_4	**Ginger + Sweet corn (Planting ratio 2:2. Sweet corn- three crops, Summer, *Kharif* and *Rabi*)**	188.33	222.08	205.20	8,20,800	2,91,358	5,29,442	1,76,200	1.81
T_5	**Ginger + French bean (Planting ratio 2:2. French bean- three crops, Summer, *Kharif* and *Rabi*)**	182.00	73.80	127.90	5,11,600	2,92,783	2,18,817	-1,34,425	0.74
T_6	**Ginger + Arhar (Planting ratio 4:1)**	160.00	18.60	131.72	5,26,880	2,71,118	2,55,762	-97,480	0.94
T_7	**Ginger + Elephant foot yam (Planting ratio 2:2)**	177.41	96.00	136.70	5,46,800	2,92,258	2,54,542	-98,700	0.87
	SE±(m)								**0.03**
	$CD_{(0.05)}$								**0.09**

Observations found significant variations for the influence of ginger based intercropping systems ratio on benefit cost ratio and net return/ha shown in Table 4. The maximum benefit cost ratio (1.81) and net return per ha (₹ 5,29,442) was observed in T_4 intercropping with Sweet corn. Hegde and Sulikeri (2001) observed that the intercropping system with the highest benefit cost ratio was arecanut + ginger (3.3:1). Haque *et al.*, (2004) reported that ginger intercropped with young mango trees produced greater gross returns (Tk 39,270/ha), net returns (Tk 54,450/ha), and benefit cost ratios (6.18).

From the present investigation, it was concluded that ginger variety Solan Giriganga intercropped with three crops of Sweet corn during Summer, *Kharif* and *Rabi* seasons with planting ratio 2:2 gave the highest yield of ginger (188.33 q/ha) and Sweet corn (444.16 q/ha) along with maximum net returns per hectare (₹ 5,29,442) and B:C ratio (1.81) under mid hill conditions of Himachal Pradesh.

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How to cite this article:

Muskan Sharma, Vipin Sharma and Dev Sharma, H. 2023. Studies on Ginger Based Intercropping Systems for Higher Yield and Income. *Int.J.Curr.Microbiol.App.Sci.* 12(09): 105-113.
doi: https://doi.org/10.20546/ijcmas.2023.1209.010