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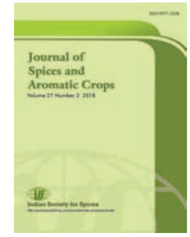

Intercropping summer moong (*Vigna radiata*) in turmeric (*Curcuma longa* L.) -a feasibility study at Punjab

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Abstract

On farm trial on the effect of intercropping of summer moong (*Vigna radiata*) on growth, yield, and economics of turmeric (*Curcuma longa* L.) was conducted at farmer's fields in adopted villages of Krishi Vigyan Kendra *viz.*, Kandola Kalan, Kaimwala, Mehsampur and Fatehpur in Jalandhar district during 2012 and 2013. The experiment was laid out in randomized complete block design with nine treatments. The treatments were T_1 - sole turmeric flat (30 cm x 20 cm), T_2 - sole turmeric ridge (45 x 15 cm), T_3 - sole turmeric ridge (60 x 10 cm), T_4 - sole turmeric bed (67.5 cm), T_5 - turmeric : summer moong (1:1) flat, T_6 -turmeric : summer moong (1:1) ridge 45 x 20 cm, T_7 - turmeric : summer moong (1:1) ridge 60 x 20 cm, T_8 -turmeric : summer moong (2:1) bed 67.5 cm and T_9 - turmeric : summer moong (2:2) bed 67.5 cm. In intercropping treatments, the planting of turmeric was done on the top of ridge and bed and summer moong was sown in furrows. The data on emergence count (30 and 60 DAS), plant height, tillers plant^{-1} (No.), dry matter accumulation, number of rhizomes (mother, primary, secondary), total rhizomes plant^{-1}, rhizome yield (q ha^{-1}) (fresh, dry and processed) were recorded. The treatments T_8 and T_9 where turmeric was planted on bed with summer moong in the furrow were found to be better for all the characters under study. The highest net returns of Rs 2.27 x 10^5 ha^{-1} with B : C ratio 4.89 was obtained in T_9 -turmeric : summer moong (2:2) bed 67.5 cm followed by T_8 -turmeric : summer moong (2:1) bed 67.5 cm and recorded lowest net returns of Rs 1.58 x 10^5 ha^{-1} with benefit: cost ratio 3.51 in T_5 - turmeric : summer moong (1:1) flat. The study revealed that summer moong can be a better option as intercrop in turmeric than the sole turmeric crop for proper utilization of all resources.

Keywords: economics, intercropping, moong, turmeric, yield

Introduction

The economy of the Punjab state is based on the cereal production. But due to rise in cost of inputs and monoculture limitation, it seems probably that the existing cereal based cropping pattern may not last long. So there is a need to diversify and find the alternative crops for the state. Turmeric offers good scope in diversification of cereal based cropping system. After harvest of this crop, late wheat or onion can be grown successfully. The turmeric cultivation in the state will be helpful not only to meet its own demand but also to help country to boost its export. The thick underground stem (rhizome) is the major produce of turmeric crop. The yellow colour of turmeric is due to the presence of a crystalline substance called curcumin. The rhizome has 1.8-5.4% curcumin and 2.5-7.2% essential oil (termerol).

In Punjab, planting of turmeric is done in the month of April after the harvesting of wheat. This crop takes long time to emerge and its growth rate is also poor in initial stages. Intercropping can help the farmers by providing alternate source of income from same piece of land. Intercropping systems have proved to be better than sole crops in terms of yield because it makes better use of one or more agricultural resources both in terms of time and space. There are many processes both competitive and complementary to the component crops involved in intercropping systems (Layek *et al*. 2014). So, there is a scope for intercropping of short duration pulses like summer moong in this crop. Green gram like summer moong may be a good intercrop which matures in 60 days and increases the per unit area production, which adds to monetary benefits. Being leguminous crop it improves the soil fertility by fixing atmospheric nitrogen through N-fixing bacteria, adds organic matter to soil and also modify the microclimate of the main crop. An increase in yield was observed under intercropping in turmeric (Yamgar *et al.* 2006; Mahfuza *et al.* 2012; Chitra & Hemalatha 2017). Intercropping offers more benefits under proper spacing, changing the spacing of main crop and intercropping with other crops provide additional benefits. The yield of turmeric can be increased by adopting improved production technologies. Keeping all these points in view the present study was planned.

Materials and methods

On farm trial on the effect of intercropping of summer moong (*Vigna radiata*) on growth, yield and economics of turmeric (*Curcuma longa* L.) was conducted during 2012 and 2013 in adopted villages of Krishi Vigyan Kendra *viz*., Kandola Kalan, Kaimwala, Mehsampur and Fatehpur in Jalandhar district of Punjab under irrigated condition. The climate of this region is characterized as sub tropical semi arid with hot summer and very cold winters. The soil of experimental site was loamy sand in texture, with 0.32-0.35% organic carbon, 114.6 -120.7 kg ha^{-1} available nitrogen, 20.1-20.2 kg ha^{-1} phosphorus and 239-246.7 kg ha^{-1} K. The experiment was conducted in a randomized complete block design with nine treatments (Table1). Each location was considered as one block and replication. The planting of fresh, disease free and uniform sized rhizomes of turmeric (Cv. Punjab Haldi 1) was done manually in last week of April in both the years. Well rotten farm yard manure @25 t ha^{-1} was thoroughly mixed in to the soil before planting. A basal dose of 25 kg ha^{-1} each of phosphorus and potash was also applied through Single Super Phosphate and Muriate of Potash, respectively at the time of sowing. The field was prepared by giving two ploughings followed by planking. Sowing of summer moong (Var. SML 668) was done during last week of April in both the years along with turmeric crop. The data on emergence count (plants m^{-2}) was recorded at 30 and 60 days after planting. The data on plant height (cm) at 120 DAP, tillers $plant^{-1}$ (No.), dry matter accumulation (g $plant^{-1}$), mother, primary and secondary rhizome $plant^{-1}$ (No.) and fresh rhizome yield (q ha^{-1}) were recorded at harvest. Dry rhizome yield was recorded after drying the rhizome in sunlight for two days followed by

Table 1. Detail of treatments

Treatment	Treatment detail
T_1	Sole turmeric flat (30 cm x 20 cm)
T_2	Sole turmeric ridge (45 x 15 cm)
T_3	Sole turmeric ridge (60 x 10 cm)
T_4	Sole turmeric bed (67.5 cm)
T_5	Turmeric : summer moong (1:1) flat
T_6	Turmeric : summer moong (1:1) ridge (45 x 20 cm)
T_7	Turmeric : summer moong (1:1) ridge (60 x 20 cm)
T_8	Turmeric : summer moong (2:1) bed (67.5 cm)
T_9	Turmeric : ummer moong (2:2) bed (67.5 cm)

drying in shade. The dry rhizomes were powdered in mill and data on the processed yield was recorded. For economic analysis, prevailing market prices were used. The pooled data of two years collected on various parameters under study were statistically analyzed and comparisons were made at 5 per cent level of significance.

Results and discussion

Emergence count (Plants m^{-2})

Emergence count after 30 and 60 days of planting was done by number of emerging plants per m^2 area and data showed significant difference in emergence count after 30 days while emergence count after 60 days was non-significant. It ranged from 6.89 -8.96 after 30 days of sowing and15.46 - 16.73 after 60 days of sowing with mean value of 7.71 and 16.1, respectively. The highest emergence count at 30 days after sowing was recorded in T_1 (8.68) followed by T_9 (8.26), T_8 (8.21), and T_4 (8.10) which were statistically at par with each other. The minimum emergence count was recorded in T_3 (6.89) closely followed by T_7 (6.98).

Plant height

The plant height is an important parameter of growth and general development of the crop. It indicates the adaptability, vigour and strength of the crop to the existing environmental conditions. Plant height (cm) recorded at 120 DAP showed significant difference among treatments under study and ranged from 100.3-117.3 with mean value of 108.8. The maximum plant height was recorded in T_9 (117.3) followed by T_8 (116.6) and T_1 (115.2) while the minimum plant height at harvest was recorded in T_5 (100.3) followed by T_3 (101.2) which was statistically at par with T_7 (103.6). The intercropping of green gram with less spacing and mulch treatments produced significantly taller plants than sole turmeric. The results were also supported by Islam *et al.* (2002). Highest plant height (75.83 cm) was found from wider spacing (60 X 30 cm^2) while the lowest (71.41 cm) was noticed in closer spacing (45 X 10 cm^2).

Dry matter accumulation

Data revealed significant difference in dry matter accumulation (g plant^{-1}) among treatments at harvest (Table 1) which ranged from 15.2 - 22.1

Table 2. Effect of different treatments on emergence count, plant height, dry matter accumulation and tillers plant^{-1} of turmeric (Pooled data of two years)

Treatment	Emergence count (Plants m^{-2})		Plant height (cm) at 120 DAP	Dry matter accumulation (g plant^{-1})	Tillers plant^{-1} (No.) at harvest
	30 DAP	60 DAP			
T_1	8.68	16.59	115.2	22.10	3.04
T_2	7.12	16.02	104.9	18.13	2.78
T_3	6.89	15.86	101.2	17.20	2.69
T_4	8.10	16.50	114.9	20.91	3.01
T_5	7.99	15.46	100.3	15.2	2.51
T_6	7.18	15.92	105.2	18.7	2.82
T_7	6.98	15.85	103.6	17.9	2.71
T_8	8.21	16.73	116.6	21.2	3.01
T_9	8.26	16.43	117.3	20.6	3.08
Mean	7.71	16.1	108.8	19.1	2.8
LSD (0.05)	1.00	NS	3.8	4.1	0.19

with mean value of 19.0 g. The highest dry matter accumulation at harvest was recorded in T_1 (22.1) followed by T_8 (21.2), T_4 (20.91) and T_9 (20.6) which were statistically at par with each other. The minimum value for dry matter accumulation was recorded by T_5 (15.2) followed by T_3 (17.20), T_7 (17.9) and T_2 (18.13).

Number of tillers

Number of tillers plant^{-1} recorded at harvest showed significant difference among the treatments. The highest tiller plant^{-1} was recorded in T_9 (3.08) which was statistically at par with T_4 (3.01) and T_8 (3.01). The lowest number of tillers plant^{-1} were recorded by T_5 (2.51) followed by T_3 (2.69), T_2 (2.78) and T_7 (2.71). The number of tillers plant^{-1} also increased in those plots where spacing was more as compared to closer spacing. Similar result was reported by Sidhu *et al* (2016) where they concluded that the number of tillers plant^{-1} increased in those plots where spacing was more as compared to closer spacing.

Number of rhizomes

There was significant difference in the number of mother, primary, secondary rhizomes among different treatments under study (Table 3). It was revealed from the results that number of mother rhizomes plant^{-1} ranged from 2.96-4.01, primary rhizomes from 7.65-9.42 and secondary rhizomes from 5.21-7.68 with mean value of 3.6, 8.7 and 6.6, respectively. The highest number of primary rhizomes was recorded in T_9 (4.01) followed by T_8 (3.99), T_4 (3.96) and T_1 (3.91) while minimum number of rhizomes plant^{-1} was recorded in T_5 (2.96) and remaining treatments were at par. In case of number of secondary rhizomes plant^{-1}, the highest value was recorded in T_8 (9.42) followed by T_1 (9.39) and T_9 (9.34) which were statistically at par with each other. The minimum value was recorded in T_5 (7.65) followed by T3 (8.01) and T_7 (8.13). Number of secondary rhizome plant^{-1} was found highest in T_9 (7.68) which was statistically at par with T_8 (7.65), T_6 (6.53) and T_2 (6.21) while minimum value was recorded in T_5 (5.21) followed by T_3 (5.96). The highest number of total rhizomes was recorded in T_8 (21.06) followed by T_9 (21.03) and lowest in T_5 (15.82).

Rhizome yield

Rhizome yield recorded as fresh, dry and processed rhizome yield showed significant difference among treatments. Fresh rhizome yield (q ha^{-1}) was highest in T_8 (286.1) followed by T_9

Table 3. Effect of different treatments on rhizomes plant^{-1}, total rhizome plant^{-1} and yield of turmeric (Pooled data of two years)

Treatment	Rhizomes plant^{-1} (No.)			Total rhizomes plant^{-1} (No.)	Yield (q ha^{-1})		
	Mother	Primary	Secondary		Fresh rhizome yield	Dry rhizome yield	Processed rhizome yield
T_1	3.91	9.39	7.09	20.39	285.60	62.81	59.04
T_2	3.62	8.49	6.21	18.32	262.80	54.61	51.88
T_3	3.46	8.01	5.96	17.43	243.60	52.91	50.42
T_4	3.96	9.31	7.61	20.88	284.70	61.50	58.09
T_5	2.96	7.65	5.21	15.82	221.50	47.61	45.51
T_6	3.71	8.65	6.53	18.89	263.20	55.01	51.98
T_7	3.51	8.13	6.02	17.66	244.10	53.05	50.76
T_8	3.99	9.42	7.65	21.06	286.10	63.16	59.17
T_9	4.01	9.34	7.68	21.03	285.90	63.06	59.12
Mean	3.60	8.70	6.60	19.00	264.10	57.00	53.90
LSD (0.05)	0.55	1.20	1.40	2.50	11.20	8.20	7.80

(285.9), T_1 (285.6) and T_3 (284.7) which were statistically at par with each other. The minimum fresh rhizome yield was recorded in T_5 (221.5) followed by T_3 (243.6) and T_7 (244.1). It was concluded from the study that number of rhizomes was directly correlated to rhizome yield. In case of dry rhizome yield which was recorded after drying the rhizome, the highest dry yield was recorded in T_8 (63.16) followed by T_9 (63.06), T_1 (62.81) and T_4 (61.50), which were statistically at par with each other whereas lowest dry yield was recorded in T_5 (47.61) followed by T_3 (52.91) and T_7 (53.05). The highest processed yield was recorded in T_8 (59.17), T_9 (59.12) and T_1 (59.04) which were at par with each other. The treatment T_5 (45.51) recorded minimum processed rhizome yield followed by T_3 (50.42), T_7 (50 .76), T_2 (51.88) and T_6 (51.98) (Table 3). It is clear from the study that total yield in terms of fresh, dry and processed turmeric was highest in treatments where bed planting of turmeric was done as in T_8 and T_9 and as sole crop in T_1. Turmeric at optimum spacing recorded higher yield as compared to closer spacing. Turmeric sown with intercrop at optimum spacing and with addition of mulch produced significantly higher fresh, dry and processed rhizome yield as compared to no mulching or other treatments was also reported by Sidhu *et al* (2016). Choudhury *et al.* (2000) conducted an experiment with different spacings and it was found that 50 × 15 cm spacing recorded higher yield of turmeric. Turmeric intercropped with cowpea recorded the maximum fresh rhizome yield ha^{-1} (30.78 t ha^{-1}) (Chitra & Hemalatha 2017).

Economics

Economic analysis of different treatments was done to find out the most suitable and economical treatment. Yield data of intercrop (summer moong) under different treatments is given in Table 4. Highest intercrop yield (4.3 q ha^{-1}) was registered in T_9 where two lines of summer moong were sown in furrows. In treatment $T_{8,}$ it was 2.37 q ha^{-1} where one line of summer moong was sown. Treatments T_6, T_5 and T_7 recorded an additional benefit of returns due to intercrop as they provided an additional yield of 1.89, 1.25 and 1.12 q ha^{-1} of summer moong, respectively. Gross return and net return from sole as well as intercrop is presented in Table 4, which showed higher net return in T_9 (Rs 2.27 x $10^5 ha^{-1}$) and T_8 (Rs 2.20 x $10^5 ha^{-1}$). Highest benefit cost ratio was obtained in T_9 (4.98) and T_8 (4.86) whereas it was found to be 4.84 in T_1 (Sole crop of turmeric).

Table 4. Economics of turmeric as influenced by different treatments (Pooled data of two years)

Treatment	Intercrop yield	Return from intercrop (Rs)	Turmeric equivalent	System total turmeric yield	Gross return (Rs x 10^5 ha^{-1})	Net return (Rs x 10^5 ha^{-1})	B:C ratio
T_1	-	-	-	285.6	2.57	2.13	4.84
T_2	-	-	-	262.8	2.36	1.92	4.33
T_3	-	-	-	243.6	2.19	1.75	3.94
T_4	-	-	-	284.7	2.56	2.12	4.78
T_5	1.25	4375	4.9	226.4	2.04	1.58	3.51
T_6	1.89	6615	7.4	270.6	2.43	1.98	4.38
T_7	1.12	3920	4.4	248.5	2.24	1.78	3.94
T_8	2.37	8295	9.2	295.3	2.66	2.20	4.86
T_9	4.3	15050	16.7	302.6	2.72	2.27	4.98

*Turmeric fresh rhizome price (Rs 900/quintal)
*Summer moong price (Rs 3500/ quintal)

It was concluded from the study that turmeric intercropping with summer moong on bed planting is a better than other planting methods for higher yield and economic returns. Moreover, summer moong is a leguminous crop which will help in sustaining the soil health.

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