Indian Journal of Ecology (2023) 50(5) (SI): 1678-1681
DOI: https://doi.org/10.55362/IJE/2023/4117

Manuscript Number: 4117
NAAS Rating: 5.79

Sustainable Production of Tomato (*Solanum lycopersicum* L.) through Intercropping

P. Das and P. Choudhuri*
Department of Vegetable Science
Bidhan Chandra Krishi Vishwavidyalaya Mohanpur, Nadia-741 252, India
**E-mail: partha2909@rediffmail.com*

Abstract: The present study was undertaken during 2021-22 to observe the effect of intercropping on tomato with nine treatments. Four intercrops were sown with tomato in 1:1 proportion. Tomato + fenugreek intercropping system recorded significantly maximum values for all the growth attributes like plant height (60.62 cm), number of branches per plant (9.65) and leaf no/plant (118.17) and yield attribute like tomato equivalent yield (80.76 t/ha). Perusal of data on quality parameter also showed similar trend as highest TSS, ascorbic acid, lycopene content of tomato fruit were observed in tomato + fenugreek intercropping model (6.87°Brix, 25.77 mg/100g 3.98 mg/100g respectively).The treatment tomato + spinach recorded minimum TSS was 4°Brix,24.09 mg/100g and 2.75 mg/100g for, ascorbic acid, lycopene content respectively. Enumeration of economic of cultivation of the trial revealed that tomato + fenugreek model recorded maximum B:C ratio (3.17) and minimum in tomato + spinach treatment (2.56). Considering the findings it may be concluded that inclusion of fenugreek with tomato can be a profitable and sustainable production system for the farmers of Gangetic plains of West Bengal.

Keywords: Intercropping, *Solanum lycopersicum* L, Fenugreek

Tomato (*Solanum lycopersicum* L) belonging to the family Solanaceae is one of the most important fruit vegetables grown throughout the world. Tomato is universally treated as a "Protective Food" as it is packed several nutrients (Kichu et al 2022) and is also a very good source of income to small and marginal farmers. India produced 19.07 million tonnes tomato from an area of 7.81 million (NHB 2020). Tomato fruit is packed with minerals, vitamins, proteins, essential amino acids like leucine, threonine, valine, histidine, lysine and arginine (Ali et al 2021). Massive growth rate of population has decreased per capita holding size in India at an alarming rate. On the other hand, degradation of soil fertility, natural hazards, pest and disease incidences, market price fluctuation put to the farming families in insecurity of income generation for their livelihood. Hence, intensive cultivation and effective utilization of land resources is demanded by the prevalent situation. Among different cropping system intercropping is the most suitable practice to stabilize the production (Kabiraj et al 2017) and two or many crops can be grown at a time from the same land having huge advantages over mono cropping (Islam et al 2021). Intercropping with vegetables is also profitable as it generates more income of the farm through increased production unit^{-1} area from a greater number of crops in a season of a year (Dodiya et al 2018) as it provides complete and economical use of natural resources like soil, water, space, nutrients and sunlight (Qinyu et al 2022) through selection of crop combination of different duration and rooting pattern. Intercropping is mostly practiced by poor or marginal farmers of many tropical parts of the world (Bitew and Abera 2018). Tomato is one of the important cash earning crops for the vegetable growers of this zone in Gangetic plains of West Bengal tomato is cultivated with great care. Farmers of this zone sometimes apply indiscriminate fertilizers or plant protection chemicals which have ultimately degraded the soil structure and texture. On the other hand prevalence of early and late blight due to unusual environmental conditions makes havoc for the crop and the farmers face tremendous crop loss.

So mono cropping of tomato cannot address these problems. The tomato is grown with wider spacing which offers ample scope for taking intercrops in between Intercropping with some companion plants could increase tomato quality, suppress nematodes, and improve soil environment without decreasing tomato yield. Keeping all these present study was undertaken.

MATERIAL AND METHODS

This experiment was carried out at Bidhan Chandra Krishi Vishwavidyalaya, Kalyani, Nadia, during *rabi* season of the year 2021-22. The location of the experimental site is 23.5^0 North latitude and 80^0 East longitudes with average altitude of 9.75 m above the MSL. The experimental soil contained 0.65% organic carbon, 186.19 kg/ha available nitrogen, 57.20 kg/ha available P and 136.70 kg/ha available K.

The research work was conducted in the randomized block design with nine) treatment combinations and replicated thrice. The treatments combinations were T_1-Sole Tomato; T_2-Sole Cabbage; T_3-Sole Radish; T_4-Sole Fenugreek; T_5-Sole Spinach; T_6-Tomato + Cabbage; T_7-Tomato + Radish; T_8-Tomato + Fenugreek; T_9-Tomato + Spinach. Forty five days old PAN 1286 variety of tomato seedlings were transplanted in the individual plots measuring 7.5 square meter area with a spacing of 60 cm x 50 cm. Seeds of the intercrops were sown in between the rows of tomato in 1:1 ratio i.e. in additive series and received same inputs as in case of tomato. Forty-five days old cabbage seedlings were transplanted with a spacing of 50 cm x 50 cm whereas other intercrops like fenugreek, radish and spinach were grown as sole crop at spacing of 20 cm x 10 cm each. Sole main and intercrops were raised and suitable measures and methods were adopted for fertilizer application, weed minimization, harvesting, disease and pest control following standard cultivation practices. Observations were on plant height (cm), number of branches plant^{-1}, number of leaves plant^{-1}, number of fruitsplant^{-1}, fruit yield plant^{-1} (kg), fruit yield plot^{-1} (kg), yield ha^{-1} (ton) and tomato equivalent yield ha^{-1} (ton). Biochemical parameters Total soluble solids (TSS) content was estimated with the help of a digital refractometer (0 to 32°Brix), ascorbic acid and lycopene content of ripe tomato fruits were estimated (Ranganna 1986). In association of crop yield, tomato Equivalent Yield (CEY) (Verma and Modgal 1983), land equivalent ratio (LER) (Mead and Willey 1980), aggressivity (A) (McGilchrist 1965) and relative crowding coefficient (K) (Hall 1974) were measured.

Tomato equivalent yield: This was measured as:

$$\text{Yield of tomato in intercrop} + \frac{\text{Yield of intercrop in a mixed stand x price of intercrop}}{\text{Price of tomato}}$$

LER = ∑ Yij/Yii,

Where, Yij = yield of crop in intercropping system, Yii = yield of the crop in sole cropping system.

Aggressivity (A) : This was estimated as

$$Aab = \frac{Yab}{Yaa \times Zab} - \frac{Yba}{Ybb \times Zba}$$

Where, Aab = Aggressivity value for the component crop “a”.

Relative crowding coefficient (K):

$$Kab = \frac{Y_{ab} \text{ X } Z_{ba}}{(Y_{aa}-Y_{ab}) \text{ x } Z_{ab}}$$ (a and b are two crops in intercropping system)

Where, Yab= yield of crop a in mixed stand, Yaa= yield of crop a in pure stand, Zab= sown proportion of crop a (in mixed stand with b), Zba= sown proportion of crop b (in mixed stand with crop a. Mean values of each entry in each replication for all the traits were subjected to statistical analysis by using MS Office Excel software.

Economics of tomato production under intercropping system was calculated by computing the market price of tomato and their intercrops and net returns and benefit cost ratios were worked out for each treatment (Zivenge et al 2013).

Net returns = Gross returns – Total production cost.

Benefit: Cost = Gross returns / Total production cost

RESULTS AND DISCUSSION

Growth parameters: Intercropping had significantly affected most of the growth parameters of tomato (Table 1). Tomato intercropped with fenugreek recorded significantly maximum values for plant height (60.62 cm), number of leaves and branches plant-1 (118.17 and 9.65 respectively) over all other treatments under study except with sole tomato where it was significantly *at par*. Among different intercropping combinations, higher values for all these growth attributes were observed with tomato + fenugreek intercropping system which might be due to better utilization of resources and less competition between both the component crops for different horizontal and vertical resources like solar radiation, moisture, nutrients, etc. compared to other intercropping treatments (Kichu et al 2022). The tomato + fenugreek model recorded maximum land equivalent ratio, Relative crowding coefficient and minimum aggressivity, tomato, the main crop faced least competition for the biological resources with fenugreek resulting tallest plant, maximum number of leaves and branches. Fenugreek, being a legume vegetable can fix ample amount nitrogen and this phenomenon might have encouraged plant growth and branching process. Similar observation with higher values of growth attributing characters of tomato was observed when tomato was intercropped with another legume vegetable like common bean (Abd El-Gaid et al 2014).

Yield parameters: Maximum values for number of fruits plant^{-1}(20.23), yield plant^{-1} (2.05kg), yield plot^{-1} (61.15kg), yield ha^{-1} (77.53 ton/ha) and tomato equivalent yield (80.76 ton/ha) were observed in tomato + fenugreek intercropping system (Table 1). In all the cases tomato + spinach model recorded minimum values for yield attributing characters. Intercropping tomato with legume i.e. fenugreek might have influenced the performance of component crops and improved residual nitrogen contribution to the cropping systems (Nwofia et al 2017), thus produced a high degree of complimentary effect. The maximum tomato equivalent yield in tomato + fenugreek intercropping might be due to higher yield of the main crop and greater market price of component crop.

Quality parameters: Biochemical parameters of tomato was also influenced by intercropping of different short duration vegetable crops (Table 2). Tomato intercropped with Fenugreek (T_8) recorded significantly maximum TSS (6.87°Brix), ascorbic acid content (25.77 mg) and lycopene content (3.98) content over all other treatments. This might be due to lesser competition between tomato and fenugreek resulting additional uptake of nutrients by the main crop and less uptake of nutrients by intercrops. The higher values of ascorbic acid content was in tomato and fenugreek intercropping and sole cropping of tomato may be attributed to increase the availability of nutrients in the soil that might lead to synthesis and accumulation of more photosynthates which could have mobilized the biosynthesis of ascorbic acid.

Competitive Function

Land equivalent ratio: Data regarding competitive functions also varied due to intercropping (Table 2). Tomato + fenugreek intercropping gave the highest LER (1.92). Highest value of LER with tomato + fenugreek intercropping system might be due to efficient utilization of natural resources viz., space, light, and on other hand symbiotic relationship between tomato and fenugreek was compatible due to differential rooting pattern of the two crops along with advantage of biological nitrogen fixation from a component crop. Nwofia et al (2017) recorded highest value of LER in cowpea + eggplant intercropping system.

Aggressivity: Experimental results showed that tomato grown with fenugreek was least aggressive (-6.60) preceded by tomato+ cabbage (-0.05). Tomato grown with spinach and radish was most aggressive (-0.04) than all of the intercropping. Tomato + spinach and tomato + radish intercropping system were most competitive than all other combinations and increased the power of dominance of tomato and thereby led to the maximum aggressivity value for this systems. The fenugreek and cabbage were most compatible with minimum aggressivity for growing with tomato.

Relative crowding coefficient: Relative crowding coefficient of intercropping was greater than one for all the treatments which indicated that it was advantageous for yield and land utilization efficiency over monocropping. Tomato + fenugreek system recorded maximum value for this parameter (4.33) followed by tomato + cabbage (3.91) and tomato + radish (3.88) systems of intercropping. Minimum value was obtained from tomato + spinach intercropping system (3.19). This result was in conformity with Seran and Brintha (2009) on capsicum based intercropping system and highest value (28.18) for relative crowding coefficient (RCC) was recorded when 30/60 cm paired row planting of capsicum was done in one row of vegetable cowpea.

Table 1. Effect of intercropping on growth and yield parameters of tomato

Treatments	Plant height (cm)	No. of leaves plant^{-1}	Number of branches plant^{-1}	Number of fruits plant^{-1}	Yield plant^{-1} (kg)	Yield plot^{-1} (kg)	Yield ha^{-1} (ton)	Tomato equivalent yield ha^{-1} (t)
T1	54.96	111.53	8.04	19.14	1.88	52.59	70.12	70.12
T6	41.74	87.31	7.50	14.93	1.53	47.00	65.50	72.65
T7	41.16	82.47	6.47	11.04	1.21	45.00	59.35	67.63
T8	60.62	118.17	9.65	20.23	2.05	61.15	77.53	80.76
T9	40.43	68.42	5.80	9.33	1.10	43.00	56.10	62.77
CD (p =0.05)	14.64	13.17	1.80	5.41	0.37	5.07	7.33	7.76

Table 2. Effect of intercropping on quality parameters and competitive functions of tomato

Treatments	TSS content (°Brix)	Ascorbic acid (mg/100g)	Lycopene (mg/100g)	Land equivalent ratio	Aggressivity	Relative crowding coefficient
T1	6.30	25.65	3.85	1.00	-	-
T6	5.63	25.30	3.63	1.80	-0.05	3.91
T7	4.97	24.26	3.20	1.65	-0.04	3.88
T8	6.87	25.77	3.98	1.92	-6.60	4.33
T9	4.00	24.09	2.75	1.56	-0.04	3.19
CD (p =0.05)	0.34	1.27	0.51	-	-	-

Table 3 .Economics of tomato based intercropping system

Treatments	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	Benefit: Cost ratio
T1	136642	385660	249018	2.82
T2	21642	49360	27718	2.28
T3	27272	58426	31154	2.14
T4	10628	21840	11212	2.05
T5	22642	48180	25538	2.13
T6	140642	383866	243224	2.73
T7	148642	402966.67	254324.67	2.71
T8	147224	466199.99	318975.99	3.17
T9	137242	351999.99	214757.99	2.56

Economics of production: Tomato + fenugreek intercropping system was most remunerative as it recorded the highest gross return and B:C ratio (Rs. 466199 and 3.17, respectively). Among different combinations, tomato grown with fenugreek was most remunerative which might be due to maximum yield of tomato and comparatively lower cost of cultivation than all other treatments. Thapa (2015) also found that the intercropping system garlic + garden pea combination was the most economical.

CONCLUSION

Cultivation of fenugreek as an intercrop with tomato is can be a profitable venture as this system recorded highest yield as well as highest return through efficient utilization of land, water and light. Moreover intercropping with fenugreek, improves the nutritional quality of tomato with respect to increased amount of ascorbic acid TSS and lycopene content. Thus it may be concluded that intercropping of fenugreek with tomato can be adopted as sustainable and viable production system for the farmers of Gangetic plains of West Bengal.

REFERENCES

Abd El-Gaid MA, Al-Dokeshy MH and Dalia MT Nassef 2014. Effects of intercropping system of tomato and common bean on growth, yield components and land equivalent ratio in new valley governorate. *Asian Journal of Crop Science* **6**(3): 254-261.

Ali Muhammad Moaaz, Shafique M Waleed, Gull S, Naveed Waleed, Afzal Javed, Talha Yousef, Ahmed Fathy, Mauro Rosario and Paolo Rosario 2021. Alleviation of heat stress in tomato by exogenous application of sulfur. *Horticulturae* **7**(2): 21.

National Horticulture Board, Horticulture Database 2020. Accessed from www.nhb.gov.in.

Area, Production and productivity of capsicum in India.

Bitew Y and Abera M 2018. Conservation tillage based annual intercropping system: A means for sustainable crop production: A review. *Indian Journal of Ecology* **45**(4):

Dodiya TP, Gadhiya AD and Patel GD 2018. Effect of intercropping in horticultural crops. *International Journal of Current Microbiology and Applied Science* **7**(2): 1512-1520.

Hall RL 1974. Analysis of the nature of interference between plants of different species. II. Nutrient relations in a Nandi Setaria and Green leaf Desmodium association with particular reference to potassium. *Australian Journal of Agricultural Research* **25**: 749-756.

Islam MS, Rashid M and Hossain MS 2021. Productivity and profitability of chilli and intercrop with sugarcane in different planting system. *International Journal of Agriculture and Medicinal Plants* **2**(1): 16-20.

Kabiraj J, Das R, Das SP and Mandal AR 2017. A study on cauliflower (*Brassica oleracea var. botrytis*) based intercropping system. *International Journal of Current Microbiology and Applied Science* **6**(7): 2595-2602.

Kichu LT, Prasad VM and Das KS 2022. Study of intercropping in tomato (*Lycopersicon esculentum* MIll.). *The Pharma Innovation Journal* **11**(2): 2513-2515.

McGilchrist CA 1965. Analysis of competition experiments. *Biometrics* **21**: 975-985.

Mead R and Willey WR 1980. The concept of land equivalent ratio and advantages in yields from intercropping. *Experimental Agriculture* **16**: 217-228.

Nwofia GE 2017. Yield and productivity of eggplant genotypes intercropped with vegetable cowpea in the humid tropics. *International Journal of Vegetable Science* **23**(5): 400-410.

Qinyu L, Zeng T, Hu Y, Du Z, Liu Y, Jin M, Tahir M, Wang X, Yang W and Yan Y 2022. Effects of soybean density and sowing time on the yield and the quality of mixed silage in corn-soybean strip intercropping system. *Fermentation* **8**(40): 140.

Ranganna S 1986. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*. Tata McGraw Hill Publishing Co. Ltd., New Delhi, pp.190-210.

Sharma RP, Raman KR, Sharma MS and Poddar BK 2008. Effect of cereals and legumes intercropping on production potential, economics and quality of fodder during summer season, *Range Management and Agroforestry* **29**(2):129-33.

Seran TH and I Brintha 2009. Study on determining a suitable pattern of capsicum (*Capsicum annum* L.) vegetable cowpea (*Vigna unguiculata* L.) intercropping. *Karnataka Journal of Agricultural Sciences* **22**(5) : 1153-1154.

Thapa A 2015. *Effect of intercropping on garlic* (*Allium sativum L.*) M.Sc. Dissertation. Uttar Banga Krishi Vishwavidyalaya, Pundibari, Coochbehar, West Bengal, India.

Verma SP and Modga SC 1983. Production potential and economics of fertilizer application as resource constraints in maize-wheat crop sequence. *Himachal Journal of Agriculture Research* **9**: 89-92.

Zivenge E, Shiferaw-Mitiku T, Thomas J and Ushadevi KN 2013.Economic performance of community garden in Zimbabwe. Russian *Journal of Agricultural and Socio-Economic Sciences* **9**(21): 18-22.

Received 17 May, 2023; Accepted 27 October, 2023