Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

December 2022, Volume 35, Issue 2, Page 01-05

Profit Maximization through Efficient Land Use as influenced by Broccoli Based Intercropping (*Brassica oleracea* var. *italica*)

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ARTICLE INFO

Article history:
Received: 03 June, 2022
Revision: 09 July, 2022
Accepted: 14 December, 2022

Key words: *broccoli, intercrops, land equivalent ratio, broccoli equivalent yield, and economics*

DOI: 10.56678/iahf-2022.35.02.1

ABSTRACT

The field investigation was conducted out at Experimental Farm, Division of Vegetable Science and Floriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu to study the effect of intercropping systems on production and economics of Broccoli based system. The treatments comprised of 15 treatments where, eight treatments taken as sole crop, namely, T_1- Broccoli, T_2- Knol-khol, T_3- Beetroot, T_4- Spinach beet, T_5- Fenugreek, T_6- Coriander, T_7- Lettuce, T_8- Swiss chard and seven treatments taken as intercrop, namely, T_9- Broccoli + Knol-khol, T_{10}- Broccoli + Beetroot, T_{11}- Broccoli + Spinach beet, T_{12}- Broccoli + Fenugreek, T_{13}- Broccoli + Coriander, T_{14}- Broccoli + Lettuce, T_{15}- Broccoli + Swiss chard. The experiment was allocated in Randomized Block Design (RBD) compromising of three replications comprising of fifteen treatments. Broccoli out performed in terms of maximum yield (172.53 q/ha) when grown as as sole crop. Under intercropping system, broccoli + swiss chard combination recorded maximum LER (1.42) while, broccoli + coriander combination recorded maximum value for BEY (164.02 q/ha). Among the cropping systems, broccoli + swiss chard recorded highest values of gross return (Rs. 698091.2), net return (Rs. 588524.4) and B:C ratio (6.37). It concluded that broccoli intercropping with swiss chard is more productive and remunerative than sole broccoli.

1. Introduction

The increasing population has increased demands for food, feed, fibre and forest products which need to be produced from available land resources. Apart from cereals, the vegetables are best source of nutritional security (Noopur, *et al.,* 2019) and can ensure year round availability of vegetable (Noopur *et al.,* 2021). Horticulture, a component of the agricultural industry, contributes to improved nutrition, economic growth and food security. When compared to the growth of single crops, intercropping can dramatically increase crop productivity through the more efficient use of nutrients, water and solar energy (Midmore, 1993). Intercropping systems are encouraged to be maintained because of their positive effects on improvement of soil fertility and soil conservation (Jarenyama *et al.*, 2000). Intercropping in vegetables has been demonstrated to provide advantages that could improve land use efficiency and are a crucial component of sustainable agriculture (Guvenc and Yildirim, 1999).These vegetables are grown as sole crops but can be successfully grown in intercropping system under open as well as protected cultivations (Singh et al, 2019).Therefore, it is necessary to develop efficient cropping systems (Panwar *et al.,* 2019) which will not only increase the production and productivity per unit area but also will be of great help to the farmers to increase their production and income per unit area (Noopur *et al.*, 2021).

Consuming broccoli facilitates a number of processes, such as supplying antioxidants, modulating enzymes and regulating cell cycle and apoptosis. The S-methyl cysteine sulfoxide and glucosinolates found in it, along with other nutrients like vitamins C, E, and K, minerals like iron, selenium, zinc and polyphenols like kaempferol, quercetin glucosides, and isorhamnetin are thought to be the primary contributors to the variety of health benefits of broccoli (Alanís-Garza *et al.*, 2015). Since,broccoli is a widely spaced crop, long duration with slow initial growth crop so, it becomes imperative to use interspace for at least two months before spread of the crop canopy which will

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allow better resource use efficiency (Panwar *et al.,* 2021). Hence, growing of short duration companion crops is of great importance for efficient use of land and other applied inputs for the production of main crop and to maximize the returns per unit area. Knol-khol, Beetroot, Spinach beet, Fenugreek, Coriander, Lettuce and Swiss chard are few other important low input requiring, short duration winter vegetable crops. Most of these crops are dwarf in growth habit, matures in a short period of time with multiple harvests and are capable of performing well as inter and relay crops with long duration vegetable crops like cauliflower, cabbage and broccoli. Hence, a study on effect of broccoli based intercropping system with vegetable crops for efficient land, resource and input use management was taken up with the objectives to find out best crop combination with broccoli based intercropping system for improving production and productivity per unit are and time.

2. Material and Methods

Field experiment was carried at Vegetable Research Farm, Division of Vegetable Science & Floriculture, SKUAST-J, Chatha, Jammu (J&K) during the rabi season of 2019-20. The experimental site's soil was sandy loam with a pH of 7.40 having 0.37% organic carbon and 216.13, 17.20, and 130.70 kg/ha available N, P and K, respectively. The experiment comprising of fifteen (15) treatments out of which eight (8; T1-T8) were sole crop treatments, viz., T_1- Broccoli, T_2- Knol-khol, T_3- Beetroot, T_4- Spinach beet, T_5-Fenugreek, T_6- Coriander, T_7- Lettuce, T_8- Swiss chard and seven (7; T9-T15) were intercrop treatments, viz, T_9- Broccoli + Knol-khol, T_{10}- Broccoli + Beetroot, T_{11}- Broccoli + Spinach beet, T_{12}- Broccoli + Fenugreek, T_{13}- Broccoli + Coriander, T_{14}- Broccoli + Lettuce, T_{15}- Broccoli + Swiss chard (4:3,respectively). The experiment was laid in Randomized Block Design (RBD) replicated thrice. The verities used were for Broccoli (KTS-1), Knol-Khol (G-40), Beetroot (Detroit Dark Red), Spinach beet (Jammu Spinach beet- 07), Fenugreek (Jammu Fenugreek-07), Coriander (Jammu Coriander-07), Lettuce (Chinese Yellow), Swiss chard (SJSC-01). The standard agronomic practices were done for raising respective crops. While recommended fertilizer dose was provided to respective crop when sown as sole whereas under intercropping system, recommended cultural operations and fertilizer dose of broccoli (25t/ha FYM, 120kg N/ha, 60kg P_2O 5/ha and 60kg K_2O/ha) was applied to all the treatment combinations. Well rotten FYM was applied in the individual plot during land preparation along with $1/3^{rd}$ dose of N and full doses of P_2O_5 and K_2O.Remaining $2/3^{rd}$ of N was top dressed in two equal amounts after 30 and 45 days of transplanting. According to the package of practices recommendations, intercultural operations were conducted from time to time (Package of Practices for Vegetable Crops, Directorate of Extension, SKUAST-J, 2016). The crop duration of broccoli was taken as benchmark for harvesting of sole and intercrops. In sole cultivation, along with the harvesting of broccoli, single crop of beetroot, double crop of lettuce and knol-khol were harvested. Meanwhile in leafy vegetables (spinach beet, fenugreek, coriander and swiss chard), two cuts were taken. In case of intercrop, single crop of beetroot and knol-khol, double crop of lettuce were harvested. Meanwhile in leafy vegetables, two cuts were taken. The yield was calculated as per unit area. The Land Equivalent Ratio was computed as per the formula given below;

LER = L1+L2 = (YI1/YS1) + (YI2/YS2)

L1 and L2 are the LER for individual crops in the experiment, YI1 and YI2 are the individual crop yield in intercropping, where YS1 And YS2 are their yield as sole crop. The yield of intercrops was converted into Broccoli equivalent yield (BEY) as per the prevailing rates in the mandi, y. It was calculated as per the formula given below;

BEY=Economic yield of intercrop in kg X Price per kg of intercrop/Price per kg of Broccoli

The economics of treatments was also worked out based on the prise of vegetable in local market. Wages which are common in Jammu was considered while calculating cost of cultivation.

3. Results

Yield of main and intercrops

Significantly the maximum yield (172.53 q/ha) was obtained in sole Broccoli (Table 1) and was influenced by intercropping systems which was in accordance with prior findings of by Ananda *et al*, (2018). Among intercropping systems, Broccoli + Coriander being at par with Broccoli + Fenugreek recorded higher broccoli yield (163.27 q/ha) which might be due to improved resource sharing as broccoli being long duration crop had the chance to use the nutrients and space effectively thereby increased broccoli yield (Islam *et* al., 2016; Suresha *et* al., 2010; Obadoni *et* al., 2005). The lowest broccoli yield of 50.19 q/ha was recorded in Broccoli + Knol-khol (Table 1) which might be due to negative impact of knol-khol on broccoli. Maximum yield reduction by 73.93% was recorded in Knol-khol when intercropped with Broccoli followed by Fenugreek by 56.61% in Broccoli based intercropping system. In case of Beetroot, Spinach beet, Coriander, Lettuce and Swiss chard, it was recorded 53.65%, 36.88%, 43.55%, 40.74%, 35.50%, respectively, when intercropped with broccoli indicated that sole crop of broccoli had higher yields as compared to intercrop due to increased competition and reduced plant population of Broccoli among intercrop plants (Obedoni *et al.,* 2005; Panwar *et al.,* 2021). Yield of intercrops was higher when grown as sole due to more area but in intercropping system yield of swiss chard, when grown with broccoli, was recorded higher (Table 1).

Table 1. Effect of intercropping on yield of main crop of broccoli and intercrops

Treatment	Yield of broccoli ($q\ ha^{-1}$)	Yield of intercrops ($q\ ha^{-1}$)
Broccoli	172.53	-
Knol-Khol	-	343.40
Beetroot	-	142.90
Spinach beet	-	168.21
Fenugreek	-	102.59
Coriander	-	70.00
Lettuce	-	115.12
Swisschard	-	172.47
Broccoli + Knol-Khol	50.19	89.51
Broccoli + Beetroot	120.43	66.23
Broccoli + Spinach beet	156.54	106.17
Broccoli + Fenugreek	161.11	44.51
Broccoli + Coriander	163.27	39.51
Broccoli + Lettuce	154.81	68.21
Broccoli + Swiss chard	157.84	111.23
SE(m)	2.07	8.83
LSD (0.05)	5.34	25.83

Yield advantage of intercropped broccoli over sole crop

The highest value of LER was recorded with Broccoli + Swiss chard (1.56) followed by the treatment Broccoli + Spinach beet (1.54) and Broccoli + Coriander with LER (1.51). The lowest LER of 0.55 was recorded with Broccoli + Knol-khol (Table 2). The value of LER more than one indicates intercropping advantage over sole cropping whereas lower value depicts that the treatment combination is insolvent and cannot be utilized in intercropping system.The maximum Broccoli equivalent yield (BEY) of 231.99 q/ha was recorded in Broccoli + Swiss chard followed by Broccoli + Lettuce and Broccoli + Coriander with broccoli equivalent yield q/ha 223.02 and 202.78 q/ha, respectively. The minimum BEY of 80.03 q/ha was recorded in treatment Broccoli + Knol-khol (Table 2).

Economics of production

Economic analysis of different broccoli based intercropping system has been presented in Table 3. Cost of cultivation is an index to indicate the amount of funds needed to adopt a promising intercropping system. It was observed that intercropping system requires more money in com comparission to mono cropping system might be due to high input cost. But their combined yield gives more return as compared to mono cropping system. The maximum values for net return, gross return and B:C ratio recorded for treatment Broccoli + Swiss chard (Rs. 695980/ha , Rs. 586413/ha and 6.35, respectively) (Table 3). It was found that all the intercropping treatments were more remunerative than sole treatments. This might be due to increase in system productivity in intercropping system. According to Seren and

Table 2. Effect of intercropping on land use indices i.e., Land Equivalent Ratio and Broccoli Equivalent Yield

Treatment	LER	BEY (q/ha)
Broccoli (sole)	1.00	172.53
Broccoli + Knol-Khol	0.55	80.03
Broccoli + Beetroot	1.16	186.66
Broccoli + Spinach beet	1.54	191.93
Broccoli + Fenugreek	1.37	175.95
Broccoli + Coriander	1.51	202.78
Broccoli + Lettuce	1.49	223.02
Broccoli + Swisschard	1.56	231.99

Price of Broccoli -30 Rs/kg, Knol-khol -10Rs/kg, Beetroot -30Rs/kg, Spinach beet-10Rs/kg, Fenugreek – 10Rs/kg, Coriander – 30Rs/kg, Lettuce – 30Rs/kg and Swiss chard – 20 Rs/kg

Table 3. Effect of intercropping on economics of production

Treatment	Cost of cultivation (Rs. ha^{-1})	Yield (BEY, q ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C Ratio
Broccoli	108941	172.53	517590	408649	4.75
Knol-khol	106173	114.47	343400	237227	3.23
Beetroot	114253	142.90	428700	314447	3.75
Spinach beet	90517.1	56.07	168210	77692.9	1.86
Fenugreek	83522.5	34.20	102590	19067.5	1.23
Coriander	83521.2	70.00	210000	126478.8	2.51
Lettuce	98884.3	115.12	345360	246475.7	3.49
Swiss chard	95584.3	114.98	344940	249355.7	3.61
Broccoli + Knol-Khol	114417	80.03	240080	125663	2.10
Broccoli + Beetroot	129942	186.66	559980	430038	4.31
Broccoli + Spinach beet	109192	191.93	575790	466598	5.27
Broccoli + Fenugreek	111067	175.95	527840	416773	4.75
Broccoli + Coriander	99191.8	202.78	608340	509148.2	6.13
Broccoli + Lettuce	118642	223.02	669060	550418	5.64
Broccoli + Swiss chard	109567	231.99	695980	586413	6.35

Brintha (2009), intercropping occupies large land use hence, provides higher net returns than mono-cropping. The results are in agreement with prior findings of Kumar *et al.* (2014) in okra based intercropping system.

This study indicated that intercropping systems were promising in terms of LER and BEY as compared to mono-cropping system. Among the intercropping system, Broccoli + Swiss chard can be adopted to increase net return and benefit cost ration under agro-climatic conditions of Chatha, Jammu (J&K).

From the present investigation, it can be concluded that Broccoli + Swiss chard recorded highest Broccoli equivalent yield 231.99 q/ha and higher net returns (Rs. 586413/ha) with benefit : cost ratio (6.35). Hence, Broccoli + Swiss intercropping system is more remunerative for higher net returns than cultivating sole broccoli crop.

4. Referances

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