Biological Forum – An International Journal **14(2): 498-502(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Performance of Intercropping under Juvenile Jackfruit Orchard in Sub-Himalayan Terai Region of West Bengal

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(Received 03 February 2022, Accepted 13 April, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Intercropping of vegetable crops in fruit orchard has higher potential to enhance the productivity. Intercropping involves raising of two or more crops simultaneously in proximity. The main goal of intercropping is to obtain higher yield on a given piece of land by effective utilization of resources or ecological processes that would elseways not be used by a single crop. This ensures their suitability for growing as intercrops under fruit orchards. An experiment was conducted in the Instructional Farm of Department of Pomology and Post-Harvest Technology, Uttar Banga Krishi Viswavidyalaya, Pundibari, with an aim to identify the suitable and profitable intercrops and also to evaluate the performance of intercropping under juvenile orchard of jackfruit. An experiment consisting of ten treatments such as jackfruit + cabbage+ amaranthus, jackfruit + cauliflower+ amaranthus, jackfruit + broccoli+ amaranthus, jackfruit + tomato+ amaranthus, jackfruit + brinjal+ amaranthus, jackfruit + palak+ amaranthus, jackfruit + peas+ amaranthus, jackfruit + radish+ amaranthus, jackfruit + cucumber+ amaranthus, Jackfruit (monocrop) to assess the performance of intercropping under juvenile orchard of jackfruit. The results indicated that the increase in juvenile jackfruit plant growth behavior due to intercropping with pea or other intercrops, contained adequate amount of plant nutrients enhanced the growth of the main crop and improvedthe atmospheric nitrogen fixing capacity into the soil and jackfruit + tomato intercropping system showed better performance in terms of yield and economic analysis followed by jackfruit + cauliflower intercropping system. Jackfruit + tomato cropping system has recorded higher B:C ratio (2.86) followed by jackfruit + cauliflower (2.57).

Keywords*:* Juvenile Orchard, Jackfruit, Intercrops, Yield.

INTRODUCTION

Jackfruit (*Artocarpus heterophyllus* Lam) is the most significant fruit in tropical and subtropical areas. The tree can provide many environmental amenities and it can be used as wind break or border planting. In home gardens, the dense canopy of jackfruit can provide shade and long-term timber. The green fruit is eaten as vegetable whereas ripe fruit is consumed fresh due to its flavor and nutritional importance. In India, systematic plantation of jackfruit is very rare. Vegetative propagated trees of jackfruit take 3-4 years for fruiting whereas seedlings take 5-6 years. Jackfruit is planted at a distance of 8 to10 m in both ways as such there is an abundant scope for growing short duration crops during the initial years. Intercropping enhances the production of fruit orchard compared to non-intercropping (Srivastava *et al.,* 2007; Aziz *et al.,* 2008). Okra + marigold + beetroot intercropping system was more profitable followed by sweet corn + tomato intercropping system under commercial crops (Kumari *et al.,* 2022). Intercropping not only generates extra income but it also checks the soil erosion through ground coverage and enhances the physico-chemical condition of the soil. Selection of suitable intercrops for jackfruit orchard to obtain highest return as well as to enhance the fertility status of soil mostly depends on agro-climatic condition of the area. However, there are numerous studies of intercropping models in various fruit crops under diverse agro-climatic condition (Sarkar *et al.,* 2004; Ghosh and Pal, 2010). Global agriculture is obstructed by urbanization, climate change and increasing population. Enhanced soil management practices, diversification of crop, efficient use of water, together with the advancement of suitable crops can lessen some of the adverse effects (Kumari *et al.,* 2022).

Intercropping is also considered helpful in rising demand of the households and increased employment

opportunities to family labours (Ghilotia *et al.,* 2015). It can offer extensive yield benefits as compared to sole cropping (Din *et al.,* 2012). Intercropping with guava is not only done for the generation of an extra profit but it also offers better utilization technique of land through optimum production along with maintaining the health of soil by checking soil erosion (Bhattanagar *et al*., 2007). Intercropping system has various advantages like insurance against failure of base crop, higher gross return per unit area, efficient use of environmental factors (light, water and nutrients), reduction in weed population, intensive utilization of labours throughout the year, protecting soil from erosion, diversity of diet and improvement of socio-economic status of growers. Besides, intercropping also provide greater stability in production as well as help the farmers in maintaining the soil fertility level (Venkateshwarlu, 1990).

The different soil and agro-climatic condition of West Bengal made various intercrops well suited in different fruit-based cropping system. However, information on jackfruit-based intercropping systems is scantly and no report is available in sub-Himalayan terai region of West Bengal. Thus, the study was carried out to find out the suitable intercropping systems under juvenile orchard of jackfruit in Sub-Himalayan terai region of West Bengal.

MATERIAL AND METHODS

The study was conducted at Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal, India, during 2018-19. which falls under eastern sub-Himalayan plains (81°66'73" E longitude and, 28°58'86" N latitude, at an elevation of 42m above MSL). The climate of the region is subtropical with high humidity, high rainfall and prolonged winter. Broadly, there are 2 dominant seasons in a year: long rainy season and dry rabi or extended winter season. The minimum temperature of this region varies from 7.1–8.0°C and maximum temperature is 24.8–32.2°C. The soil is sandy loamy, coarse textured with poor water holding capacity, organic carbon rich and contain higher amount of available nitrogen.

The intercropping experiment was carried out for two consecutive years from 2019 -20 and 2020-21, consisting of ten treatments such as jackfruit + cabbage + amaranthus, jackfruit + cauliflower + amaranthus, jackfruit + broccoli + amaranthus, jackfruit + tomato + amaranthus, jackfruit + brinjal + amaranthus, jackfruit + palak + amaranthus, jackfruit + peas + amaranthus, jackfruit + radish + amaranthus, jackfruit + cucumber + amaranthus, Jackfruit (monocrop) was laid out in RBD (Randomized Block Design) with three replications to evaluate the performance of intercropping under juvenile orchard of jackfruit (6 years old) at 7m × 7m apart. The vegetable intercrops were grown in rabi season and amaranthus crop grown in kharif season. The experimental field was ploughed thoroughly to get fine tilth. Well decomposed farmyard manure @ 10 t/ ha was applied during land preparation. Nutrient management and cultural practices of various crops was followed. The plants were irrigated just after sowing or planting of intercrops. Need based irrigation was given for main crop and intercrops. Plant protection measures were followed as and when required for all crops. The benefit: cost ratio of various cropping models was evaluated based on the cost of cultivation, gross return and net return. The economic assessment was achieved by taking into account the input cost and market price of the produce during the experimentation period.

Economic analysis. System cost of cultivation was calculated by taking into account maintenance cost of one hectare jackfruit and for other systems it was estimated by adding aforesaid cost with the cost of cultivation of intercrop for respective systems. Gross return of each system was estimated by adding the price value obtained by multiplying individual yield of crop to its sales price. Net return from the system was evaluated by subtracting the value of gross return to its cost of cultivation value of respective systems. The B: C (benefit: cost) ratio of each system was calculated by dividing the net returns with total cost of cultivation of respective systems.

RESULTS AND DISCUSSION

Effect of intercrops on growth attributes of the juvenile jackfruit plants. It was noticed from the data presented in Table 1 and 2 that, growing of intercrops lead to better growth behavior of the juvenile jackfruit plants, which may be beneficial for enhancement of soil fertility status of the orchard. Highest plant height after 2 yearswas obtained from jackfruit + peas + amaranthus (5.88 m) followed by jackfruit + tomato + amaranthus (5.69 m) and lowest from the mono cropped jackfruit (4.34 m). The highest leaf length of jackfruit plants was recorded jackfruit + peas + amaranthus (15.67 cm) and lowest from the monocrop jackfruit (12.97 cm). Highest leaf width in jackfruit + peas + amaranthus (9.60 cm) and lowest from the monocrop jackfruit (7.30 cm). Stem diameter was recorded highest from jackfruit + peas + amaranthus (79.97 cm) followed by Jackfruit + Tomato + amaranthus (77.53cm) as compared to the monocrop jackfruit (45.53 cm) and also recorded the growth parameters in terms of percentage increasement after 1st and 2nd year. It was noticed that cultivation of various intercrops, contained adequate amount of plant nutrients enhances the growth of the plant.

Highest plant growth and fruit yield was observed from the jackfruit tree intercropped with cowpea followed by chickpea. Lowest fruit yield was observed from the jackfruit tree where no intercrop was grown. Increased plant growth and fruit yield due to intercropping with chickpea or cowpea or other leguminous intercrops due to the fact that, they have the capacity of fixing atmospheric nitrogen that added to the soil and thus main crop may get additional nitrogen (Laishram and Ghosh, 2017). Similar studies on the positiveeffect of intercropping were done by Swain *et al*. (2012) in mango and Ghosh and Pal (2010) in sweet orange.It has also been supported by other workers that, the intercropping of jackfruit tree with turmeric had increased tree height followed by arvi and suran compared to control (Singh *et al.,* 2016). Intercropping of guava trees with tuber crops improved plant height which might be due to the better floor management of

orchard as confirmed by Singh and Sharma (2016) and better soil nutrition and moisture status as reported by Singh *et al.* (2016).

Effect of cropping system on intercrop yield. The average highest intercrop yield was observed in tomato (28,880 kg/ ha) followed by cauliflower (21,200 kg/ ha) and lowest from the peas (3,400 kg/ ha) has been presented in Table 3. This result might be due to the vegetable crops raised under shade of jackfruit trees show elongation which could be related with higher activity of auxin under shade condition. Hence, plants exhibit tropic response towards sunlight. Thus, the intercrop yield had not been adversely affected by shade of jackfruit trees compared to the normal yield observed in open field. Also, Prasanna (1995) suggested that yield capability of short duration and shallow rooted intercrops was not influenced by perennial trees.

Effect of cropping system on cost of cultivation. The cost of cultivation for raising intercrops has been presented in table 3. The highest expenditure (Rs. 95,712.00/ ha) was obtained from the intercropping of radish followed by cucumber (Rs. 83,770) and lowest was in palak (Rs. 46,755). Vegetables have shown yield reduction when they were grown under fruit orchard canopy but ensure proper orchard management and thus enhance yield and productive life of fruit trees. Hence, these vegetable crops can be regarded as sacrificial crops which enhance the orchard productivity at the cost of their yield. Although, the income generated from orchard due to intercropping of vegetables is additional income for farmers thus net return becomes better.

Effect of cropping system on gross return and net return. Highest gross return (Rs. 2,90,400/ ha) was found from radish closely followed by tomato (Rs. 2,88,800/ ha) and lowest from peas (Rs. 1,19,000/ ha). Highest net return (Rs. 2,13,977/ ha) was found from tomato followed by radish (Rs. 1,94,688/ ha) and lowest from peas (Rs. 61,762/ ha). Although, the income generated due to intercropping of vegetables from orchard is additional for farmers hence net return becomes better. In papaya-based intercropping, Gadre (1997) observed highest net return (17067.02/ ha) and input: output ratio (1:4.76) and confirmed that papaya cultivation for papain with suitable intercrops was economically viable. Highest net return was obtained from jackfruit intercropped with cowpea followed by French bean (Laishram and Ghosh, 2017). In a farmer-based study, Ijaz *et al.,* (2014) was observed that the average higher yield was obtained from Kinnow without intercropping (12454 kg/ ha) than those with intercropping (7492 kg/ ha), but the income generated from the intercrop was more profitable.

Effect of cropping system on benefit: cost (B: C)ratio. Taking into account the total cost and monetary return from the intercrops, it was noticed that jackfruit with tomato gave highest benefit: cost ratio (2.86). The next profitable combination was jackfruit with cauliflower which resulted in benefit: cost ratio of 2.57, which might be because of excellent yield of intercrops from jackfruit without additional management practices under juvenile jackfruit orchard and satisfactory yield of intercrop. Hugar *et al*. (1991) had also supported intercropping of guava plantation with vegetable crops gave higher return per hectare. The estimated cost: benefit ratio acquired from various cropping systems have clearly denoted that the highest cost-benefit ratio of 2.88 was observed. The higher economic benefits have also been noticed from jackfruit-based agroforestry system in several studies such as pineapple (Hasan *et al.,* 2008) and eggplant (Miah *et al.,* 2018; Rahman *et al.,* 2018).

Table 1: Effect of vegetable crops grown as intercrops on plant height and leaf length of jackfruit plants.

Treatments	Intercropping systems	Plant height (m)					Leaf length (cm)				
		Initial height	1st year	2nd year	Percentage increased after 1 year	Percentage increased after 2 years	Initial length	1st year	2nd year	Percentage increased after 1 year	Percentage increased after 2 years
T_1	Jackfruit + cabbage + amaranthus	3.77	4.26	5.26	12.99	39.52	13.41	13.73	13.93	2.38	3.87
T_2	Jackfruit + cauliflower + amaranthus	3.79	4.29	5.34	13.19	40.89	14.01	14.43	14.97	2.99	6.85
T_3	Jackfruit + broccoli + amaranthus	3.69	4.11	5.13	11.38	39.02	13.72	14.03	14.13	2.25	2.98
T_4	Jackfruit + tomato + amaranthus	4.01	4.60	5.69	14.71	41.89	14.62	15.07	15.27	3.07	4.44
T_5	Jackfruit + brinjal + amaranthus	3.99	4.54	5.58	13.78	39.85	13.53	13.93	14.33	2.95	5.91
T_6	Jackfruit + palak + amaranthus	3.24	3.57	4.70	10.18	45.06	12.72	12.97	13.08	1.96	2.83
T_7	Jackfruit + peas + amaranthus	4.02	4.79	5.88	19.15	46.26	15.12	15.60	15.67	3.17	3.63
T_8	Jackfruit + radish + amaranthus	3.35	3.71	4.80	10.74	43.28	12.79	13.07	13.30	2.18	3.98
T_9	Jackfruit + cucumber + amaranthus	3.45	3.84	4.94	11.30	43.18	12.94	13.23	13.63	2.24	5.33
T_{10}	Jackfruit (monocrop)	3.21	3.52	4.34	9.65	35.20	12.66	12.87	12.97	1.65	2.44
SEm (±)		-	7.76	3.20	-	-	-	0.22	0.15	-	-
CD (0.05)		-	23.23	9.59	-	-	-	0.65	0.44	-	-

Table 2: Effect of vegetable crops grown as intercrops on leaf width and stem diameter of jackfruit plants.

Treatments	Intercropping systems	Leaf width (cm)					Stem diameter (cm)				
		Initial width	1st year	2nd year	Percentage increased after 1 year	Percentage increased after 2 years	Initial diameter	1st year	2nd year	Percentage increased after 1 year	Percentage increased after 2 years
T_1	Jackfruit + Cabbage + amaranthus	8.12	8.57	8.63	5.54	6.28	37.05	49.57	67.37	33.79	81.83
T_2	Jackfruit + Cauliflower + amaranthus	8.33	8.67	8.97	4.08	7.68	38.45	55.27	70.8	43.74	84.13
T_3	Jackfruit + Broccoli + amaranthus	8.06	8.37	8.57	3.84	6.32	36.26	40.67	65.3	12.16	80.08
T_4	Jackfruit + Tomato + amaranthus	8.54	8.97	9.30	5.03	8.89	41.24	61.35	77.53	48.76	87.99
T_5	Jackfruit + Brinjal + amaranthus	8.36	8.77	9.10	4.90	8.85	40.65	59.17	73.07	45.56	79.75
T_6	Jackfruit + Palak + amaranthus	7.12	7.47	7.60	4.91	6.74	31.16	31.93	55.87	2.47	79.30
T_7	Jackfruit + Peas + amaranthus	8.76	9.07	9.60	3.53	9.58	42.26	64.65	79.97	52.98	89.23
T_8	Jackfruit + Radish + amaranthus	7.76	7.97	8.27	2.70	6.57	34.12	35.97	59.47	5.42	74.29
T_9	Jackfruit + Cucumber + amaranthus	7.95	8.17	8.43	2.76	6.03	34.46	37.97	62.03	10.18	80.00
T_{10}	Jackfruit (Monocrop)	6.75	6.83	7.30	1.18	8.14	27.12	28.13	45.53	3.72	31.01
	SEm (±)	-	0.11	0.17	-	-	-	0.37	0.84	-	-
	CD (0.05)	-	0.32	0.52	-	-	-	1.11	2.52	-	-

Table 3: Yield and economic analysis of jackfruit based intercropping models (per hectare) (pooled data).

Intercropping systems	Yield (kg/ha)	Selling Price/kg (Rs)	Cost of cultivation (Rs)	Gross return (Rs)	Net return (Rs)	Benefit: cost ratio
Jackfruit + cabbage	16160	10	59379	161600	102221	1.72
Jackfruit + cauliflower	21200	10	59290	212000	152621	2.57
Jackfruit + broccoli	12280	10	59380	122800	63421	1.06
Jackfruit + tomato	28880	10	74823	288800	213977	2.86
Jackfruit + brinjal	19760	10	68963	197600	128637	1.86
Jackfruit + palak	8000	15	46755	120000	73245	1.57
Jackfruit + peas	3400	35	57243	119000	61762	1.08
Jackfruit + radish	19360	15	95712	290400	194688	2.03
Jackfruit + cucumber	9920	20	83770	198400	114630	1.37
Jackfruit + amaranthus	8640	15	48836	129600	80764	1.65
Jackfruit (monocrop)	-	-	-	-	-	-

CONCLUSION

Based on the present study it can be concluded that, under jackfruit based intercropping system, growing of different vegetable intercrops enhances the better growth of juvenile jackfruit trees along with improves the soil fertility status of the orchard. The highest benefit: cost ratio was observed in jackfruit + tomato (2.86), followed by jackfruit + cauliflower (2.57) and jackfruit + radish (2.03). These intercropping models were most suitable strategies for generating employment opportunities, economizing productivity, enhancing economic conditions of the entrepreneurs and farmers, enhancing export, and nutritional security to the people. Moreover, intercropping of short duration vegetable crops in juvenile fruit orchard not only enhance the utilization of resources but also play a crucial role in reducing the risk of crop failure by increasing the net income per unit of area.

FUTURE SCOPE

Jackfruit based intercropping system gives good opportunity to enhance farmers income, better utilization of land and resources. There is need to develop different cropping system under juvenile jackfruit orchards which are remunerative and will be suitable to the Sub-Himalayan Terai region of West Bengal. Further studies shall be done on the development of different intercropping systems and motivate farmers for adoption of recommended cropping systems.

Acknowledgement. The authors gratefully acknowledge to Department of Science and Technology, Government of West Bengal and the authority of Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal, India for providing funds and their continuous support during this research work.
Conflicts of Interest. None.

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How to cite this article: Santhoshkumar G.M., Nilesh Bhowmick and Ashok Choudhury (2022). Performance of Intercropping under Juvenile Jackfruit Orchard in Sub-Himalayan Terai Region of West Bengal. *Biological Forum – An International Journal*, *14*(2): 498-502.