ELSEVIER
The Ecoscan
AN INTERNATIONAL QUARTERLY JOURNAL OF ENVIRONMENTAL SCIENCES

Studies on Feasibility of Intercropping Under Litchi Based Cropping System

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Abstract. Present experiment was conducted consecutively for three years at ICAR-NRC on Litchi, Mushahari, Muzaffarpur (Bihar) to study the impact of tuber crops viz. *Amorphophallus*, turmeric and *colocasia* in litchi based intercropping system. The intercrops were grown in strips between two rows of litchi plants (7-9 years old) leaving the canopy area. Canopy spread and area covered by litchi plants increased gradually and availability of intercropped area decreased with increase in age of plants. All the intercrops performed well with litchi. Yield of litchi fruit grown as sole crop was little bit higher (51.42q/ha) than yield obtained with intercropping. Highest litchi equivalent yield (109.15q/ha), land equivalent ratio (1.83) and price equivalent ratio (1.80) were obtained from litchi + turmeric combination followed by litchi + *Amorphophallus* (96.23 q/ha, 1.71 and 1.59, respectively). Soil pH was slightly decreased from initial value 8.24 to 8.13 after continuous cultivation whereas, electrical conductivity increased slightly. Soil status of available NPK was improved over the period from their initial status. On the basis of economic studies, it is inferred that intercropping of litchi with turmeric could be more productive and remunerative than sole crop.

Keywords: Litchi, Turmeric, *Amorphophallus*, *Colocasia*, Growth attributes, Intercropping

1. Introduction

The continuous increasing pressure on cultivable land for foods crops, because of the huma population load as well as unlimited use under industrial and civil sector, now it is very difficu to put additional area in agriculture and particularly to horticulture sector. This phenomenon is serious threat to not only food grain production in the country and that too at the time when mo and more quality fruit production is required at greater level. The intercropping in diversifie from is a good crop cultivation practice recognized in India. The concept and principals intercropping lead to improve the productivity per unit area and time and also make possib

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to judicious utilization of resources and inputs at cost effective level. In the present scenario of agriculture under changing climatic condition, concept of sustainable integrated production system has emerged as a solution to the problem of reducing agricultural land coupled with shortage of water, high cost of input, labour and other abiotic stresses. The integrated cropping system involves more than one component of agriculture on same piece of land resulted in maximum output in terms of soil health management, yield, biomass production and economic returns. The interaction between the component viz. fruit trees with short duration crops are complex to comprehend and can be classified as above ground (1.5-3.0m) as a fruit crop and below ground more than 2m and surface level (0.75-1.2m) in multi-tier interface. The complementarities/ competitiveness among them for light, space, water and nutrients are the key factor for success of any fruit based cropping system including litchi. Intercropping or mixed cropping has potential to increase total yields above those of mono-cropping using the same resources base [1]. The utilization of nutrient elements under intercropping system must be greater as compared sole system and because of this reason the status of available nutrient varied according to cropping system followed during experimentation [2]. Intercropping with perennial horticulture crops like mango and litchi is also one of the important ways to increase the production, productivity and provide income stability both under assured irrigation condition and limited soil moisture conditions.

Litchi is an evergreen perennial tree and has long gestation period (> 10 years) to reach in flowering and fruiting at economically viable level. Since, litchi is planted in square or rectangular system at 8-10m spacing which provides sufficient vacant space in between 2 rows of litchi plants for cultivation of different intercrops. Utilization of these vacant space (> 80-85% of total area under litchi orchard) for growing intercrops with cereals, oilseeds, pulses, vegetable and flower crops with litchi as main crops has been intensified recently to understand the biological validity of the system by way of possible increase in yield, efficient use of solar energy and better land use resulting in higher net returns [3- 5]. The traditional agriculture aimed at increasing the production through two dimensions viz. expanding the cultivated area and increasing the potential yield per unit area of the crop. The modern agriculture stresses on efficient use of available resources *i.e.* land, solar energy, water and nutrients including soil microbes. As vegetative growth of the litchi plants increases over the year, there is decrease in interspaces and increase in partial shade cover area which leads to problem of light interception on ground. Under these circumstances, choice of growing so many crops as intercrop is very limited and hence, intercropping of shade tolerant tuber crops with litchi orchard can be a suitable option for sustainable production system. The information for wider adoptability of intercropping of shade tolerant vegetable crops with junior bearing litchi orchard with respect to yield, soil nutrient status and economic return is very much lacking in litchi growing belt of the country. In light of the above, the present investigation was undertaken to study the feasibility of intercropping of tuber crops with litchi orchard and to find out the effect of intercrops on the available nutrients (kg ha^{-1}).

2. Materials and Methods

A field experiment was conducted during 2011 to 2014 consecutively for three years at the research farm of ICAR-NRC on Litchi, Mushahari, Muzaffarpur (Bihar). The *Litchi* cv. Shahi was planted in the year 2005 at a spacing of 8.25m x 8.25m accommodating 144 plants per ha.

Standard cultural practices were followed to grow the litchi crops as described by Kumar *et al.* [5]. The intercrops were grown in between two rows of 7-9 years old litchi orchard leaving the canopy area of litchi. Intercrops viz. Amorphophallus (*Amorphophallus paeoniifolius*) var. Gajendra, turmeric (*Curcuma longa*) var. Rajendra Sonia, Colocasia (*Colocasia esculenta*)) var. Lal Gauriya was sown as per the schedule of planting season (Table 1). Recommended agronomic practices were adopted for raising different intercrops as suggested by Chadha [6]. The experimental field was sandy loam in texture, alkaline in reaction with low to medium in fertility status. The observation on plant spread and subsequent area covered by litchi including yield were recorded every year from selected plant. Yield of intercrops, area available for intercropping and actual area utilized for intercrops were also recorded. Various physical and chemical parameters like soil pH, EC, organic carbon, available N P K of the experimental field were analyzed as per standard procedure before start of the experiment and every year after harvest of the crops. Observations on growth, yield components of litchi and intercrops were recorded at harvest. Litchi equivalent yield (LEY) was calculated by considering the prices of both the crops using following formulae:

$$\text{Litchi Equivalent Yield (kg/ha)} = \frac{\text{Litchi yield (kg/ha)} + \text{Intercrop yield (kg/ha)x Price (Rs./kg)}}{\text{Litchi Price (Rs./kg)}}$$

Land equivalent ratio (LER) was calculated using the formula as given by Mead and Willey [7]: LER = Yl/Sl + Yt/St, Where Yl and Yt are the respective yields of litchi and tuber crop in intercropping and Sl and St are the respective yields of litchi and tuber crop in sole cropping. Price equivalent ratio (PER) was calculated on the basis of cumulative return of intercrops divided by average return of sole crops. Cumulative return derived as sum of return of main as well as intercrops grown in combination while, average return derived as per the average of returns obtained from main and intercrops grown, separately. Yield proportion of litchi was calculated on the basis of LER of litchi divided by sum of LER of litchi and intercrop.

Table 1. Planting season, spacing, seed rate and seed size of different intercrops

Crops	Planting time	Spacing (cm)	Seed rate (q/ha)	Seed size (g)
Amorphophallus	15-20th April	75x75	80-100	500-600
Turmeric	20-25th April	20x75	15-18	20-25
Colocasia (Arvi)	20-25th April	20x75	15-18	20-25

3. Results and Discussion

3.1 *Canopy coverage and space availability*

Data on area occupied by litchi plants and space available for intercrops over the period of 10 years had been recorded from first year to 10th year growth of the litchi plant (Table 2). Results revealed that the canopy spread and area covered by litchi plants were increased gradually whereas, availability of area for taking intercrops was decreased with increase in age of the litchi plants (Fig. 1). Similar finding was also observed by Kumar *et al.* [5] in litchi based cropping system. Canopy spread per plant ranged from 0.5 x 0.5m in first year to 5.44 x 5.59m in 10th year. Similarly, area occupied by litchi/ha basis varied from 36.0m^2 in first year to 7378.98m^2 in 10th year of litchi planting. Thus, the substantially large area 7237.67m^2, 6825.84m^2, 6151.40m^2

and 5621.02m^2 was available during 7, 8, 9 and 10th year of litchi plantation in one hectare area. However, actual area utilized through strip intercropping during 7, 8 and 9th year were 4744.0m^2, 4372.0m^2 and 3796m^2, respectively. Percentage of area occupied by litchi plants were 27.62, 31.74, 38.49 and area available for intercrops cultivation were 72.38, 68.26, 61.51 during 7th, 8th and 9th year, respectively.

3.2 *Yield performance of litchi and intercrops*

Yield of litchi fruit, amorphophallus, turmeric and colocasia grown as sole crop as well as intercrops has been presented in Table 3 and 4. Data revealed that most of the crops taken as sole crop performed better over intercrops. The fruit yield of litchi was increased with increase in age of the plant under sole and intercrops both. However, the yield of amorphophallus, turmeric and colocasia was marginally decreased from first year to third year. Yield reduction in intercropping could be associated to inter-specific compaction for nutrients, moisture and space [8]. Pooled yield of litchi fruit grown as sole crop (Table 3) was little bit higher (51.42q/ha) than taken as intercrop with amorphophallus (49.25q/ha), turmeric (50.67q/ha) and colocasia (50.21q/ha). Similarly the sole crop yield of amorphophallus (178.44q/ha), turmeric (172.69q/ha) and colocasia (149.28q/ha) was substantially higher than intercrop yield with their respective values 134.30, 146.21 and 108.98 q/ha (Table 4). The lower yield under intercrop

Table 2. Area occupied by litchi plants and availability of space for intercrops over the period of 10 years

Canopy spread/plant (m)	Area occupied by litchi/ha (m^2)	Total area available for intercrops/ha (m^2)	Actual intercrop area /ha (m^2) row-wise	Area occupied by litchi/ha (%)	Total area available for intercrops/ha (%)
0.5x0.5	36	9964	9400	0.36	99.64
0.8x0.8	92.16	9907.84	9040	0.92	99.08
1.2x1.2	207.36	9792.64	8560	2.07	97.93
2.2x2.2	696.96	9303.04	7360	6.97	93.03
3.20x3.30	1520.64	8479.36	6100	15.2	84.79
4.20x4.30	2600.64	7399.36	4900	26	74
4.34x4.42	2762.32	7237.67	4744	27.62	72.38
4.68x4.71	3174.16	6825.84	4372	31.74	68.26
5.12x5.22	3848.6	6151.4	3796	38.49	61.51
5.44x5.59	4378.98	5621.02	3382	43.79	56.21

Table 3. Year-wise sole crop yield under litchi based cropping system

Crop	Yield (q/ha)			
	2011-12	2012-13	2013-14	Pooled
Litchi	33.43	50.88	69.96	51.42
Amorphophallus	182.44	180.62	172.26	178.44
Turmeric	175.56	172.64	169.88	172.69
Colocasia	157.36	149.12	141.35	149.28

Table 4. Year-wise yield of different intercrops under litchi based cropping system

Crop components	Crops	Yield (q/ha)			
		2011-12	2012-13	2013-14	Pooled
Litchi + *Amorphophalus*	Litchi	31.29	49.73	66.72	49.25
	Amorphophallus	138.11	136.27	128.52	134.3
Litchi+ Turmeric	Litchi	32.56	48.96	70.48	50.67
	Turmeric	156.42	144.63	137.57	146.21
Litchi+ *Colocasia*	Litchi	36.15	49.24	65.23	50.21
	Colocasia	109.22	111.26	106.47	108.98

Table 5. Yield, land equivalent ratio (LER), price equivalent ratio (PER) and yield proportion as influenced by intercropping of tuber crops with litchi (Pooled data of 3 years)

Intercropping Component	Yield (q/ha)	LERs	Total LER	Litchi equivalent yield (q/ha)	PER	Yield proportion of litchi
Litchi	49.25	0.96	1.71	96.23	1.59	0.56
Amorphophallus	134.3	0.75				
Litchi	50.67	0.99	1.83	109.15	1.8	0.54
Turmeric	146.21	0.85				
Litchi	50.21	0.97	1.71	88.26	1.55	0.57
Colocasia	108.98	0.73				

LER: land equivalent ratio, PER: Price equivalent ratio

Table 6. Soil pH, EC and soil nutrient status of experimental plots

Parameters	Initial	2011-12	2012-13	2013-14	Soil status
Soil pH	8.24	8.22	8.2	8.13	Static
EC (dsm^{-1})	0.08	0.09	0.12	0.15	Static
Organic carbon (%)	0.39	0.4	0.41	0.41	Low
Av. Nitrogen (kg/ha)	91.38	138.12	133.48	146.33	Medium
Av. P_2O_5 (kg/ha)	15.37	16.38	19.33	25.22	Medium
Av. K_2O (kg/ha)	109	112	129	134	Medium

might be due to the shading effect of the litchi plant which leads to lower the photosynthetic activity of intercrops taken besides, competition for soil moisture, nutrient availability and their uptake. Similar types of observations have also been reported by Mandal *et al.* [9] in maize based intercropping system with groundnut and soybean.

Land equivalent ratio (LER) calculated from different intercropping system was always higher from sole crop (Table 5), thus land equivalent ratio of all intercrop showed advantage of yield. The highest LER of 1.83 was obtained under litchi + turmeric combination *i.e.* 0.83 times more area is required to get the same produce in their monoculture treatment. This may be due to use of better resources like space, sunlight, water, nutrition etc. similar advantage of total yield of intercrops has been reported by Prasad *et al.* [10] in mango+ tuber crop and Singh *et al.* [11] for radish-cabbage-sweet paper-onion. Singh *et al.* [12] also reported advantage of intercropping of tuber crops with litchi orchard.

The highest litchi equivalent yield (109.15q/ha) was obtained from litchi with turmeric combination followed by litchi with amorphophallus (96.23q/ha) and litchi with colocasia (88.26q/ha). All intercropping component showed more litchi equivalent yield (LEY) than sole litchi yield. Price equivalent ratio (PER) refers to the relative monetary advantage per unit area in intercropping. The highest PER (1.80) was calculated from litchi with turmeric combination followed by litchi with amorphophallus (1.59) and litchi with colocasia (1.55). This result proved the fact that litchi with tuber crop intercropping was more profitable than monocropping of litchi. These findings are in agreement with the report obtained by Mandal *et al.* [9]. Among the intercrop combination, turmeric cultivation with litchi was more profitable than amorphophallus and colocasia.

3.3 *Nutrient status of the soil*

Various physical and chemical soil parameters like soil pH, EC, organic carbon, available NPK of the experimental field were analyzed (Table 6) before start of the experiment and every year after harvest of the crops. The results revealed that soil pH was slightly decreased from initial value 8.24 to 8.13 after continuous cultivation up to 3 years. Similarly, Electrical conductivity (EC) also showed slight increasing trend over the years. Organic carbon (OC)

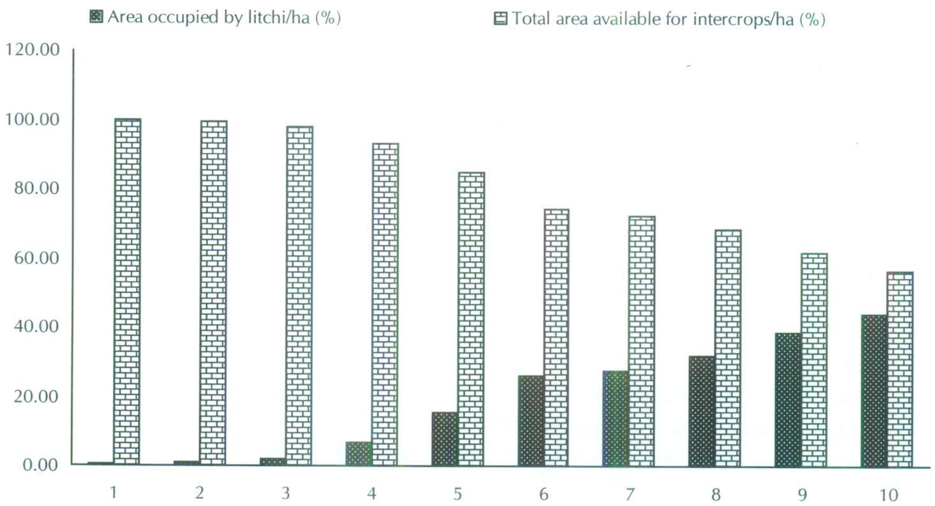

Figure 1. Area covered by Litchi plants and area available for intercrops

content of the experimental field was marginally improved with respect to initial soil analysis (Fig. 2). However, status of available NPK showed the substantial improvement over the period under study. The initial N content was 91.38kg/ha, P (15.37kg/ha) and K (109.0kg/ha) which were increased to 146.33, 25.22, 134.00kg/ ha respectively, over the period of three years of experimentation (Fig. 3). These results are in agreement with the findings of [13, 14]. Improvement in physical properties and nutrient status of the soil might be due to continuous intercropping and application of organic manures, fertilizers and litter fall of litchi leaves. The soil status of Na is expected to increase which influenced the soil reaction *i.e.* decrease in soil pH and simultaneously increase in EC. The increase in Ca salt content due to removal of Na ions from exchange complex resulted in increase of Ca salts and P over the period of intercropping and cultural practices.

Canopy spread and area covered by litchi plants increased gradually and availability of intercropped area decreased with increase in age of plants. Highest litchi equivalent yield (109.15q/ha), land equivalent ratio (1.83) and price equivalent ratio (1.80) were obtained from litchi + turmeric combination. Soil status of available NPK was improved over the period from their initial status. Litchi with tuber crop intercropping found more profitable than monocropping and among the intercrops, cultivation of turmeric as intercrop in litchi orchard could be more profitable than amorphophallus and colocasia under sub tropics condition.

5. AKNOWLEDGEMENT

The authors acknowledge the ATMA (Agriculture Technology Management Agency), Muzaffarpur, Bihar for providing financial support to conduct the experiments.

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