Performance of papaya in the litchi based multilayered Agroforestry system

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Abstract: A field experiment was conducted to investigate the performance of papaya and ginger grown as understorey crop under litchi at different distance on the yield and yield contributing characters at BADC farm, Dinajpur during April to December 2004. Two varieties of papaya (Shahi=V_1 and Rachi=V_2) and a local variety of ginger were grown at four different distances from litchi tree namely D_1=Control/outside the litchi canopy (100% PAR), D_2= 1.5m distance (25-35% PAR), D_3= 3m distance (55-65%PAR) and D_4= 4.5m distance (80-90%PAR). Among the two papaya varieties Shahi produced the highest yield (19.96 t/ha) due to the increasing of fruit number/plant, fruit weight, fruit diameter, fruit length, cavity length, cavity diameter and flesh thickness. Different distance level from litchi tree showed the significant effect on the yield and yield contributing parameters of papaya variety due to mostly varing light intensity. In 100% PAR level (Control) produced the highest fruit weight/plant (19.67 kg/plant) followed by 4.5m distance yield (18.44 kg/plant), 3m distance yield (16.25 kg/plant) and the lowest yield was obtained from 1.5m distance (3.97 kg/plant). On the other hand, the interaction effect between variety and different distance level exhibited non-significant effect on most of the yield contributing parameters of papaya and D_1V_1 treatment combination produced the highest yield (20.11 kg/plant) while D_2V_2 produced the lowest yield (3.73 kg/plant) of papaya. As an undestroried crop ginger contribute at 5.08 t/ha yield in the litchi based multilayered Agroforestry system. Therefore, it may be stated that Shahi variety of papaya is better than Rachi and multistoried Agroforestry system is more beneficial than sole production system.

Keywords: Papaya variety, %PAR level, multistoried Agroforestry system, yield and yield contributing parameters.

Introduction

Bangladesh is an agro-based country which is situated in the North-Eastern part of South Asia with a tropical to sub-tropical climate. The country has only 8.29 million ha of arable land is to feed 134.3 million people (BBS, 2003). This limited land resources are engaged in producing minimum food requirements for the people. The requirements of fruits per day per capita are 85 g. Whereas the availability is only 30-35 g. The fruits are important source of vitamins and minerals moreover, fruits are very costly.

Therefore, the majority of people of Bangladesh can not afford to buy them. Papaya (*Carica papaya*) is one of the leading fruit crops of Bangladesh comprising nearly 2% of the total fruit production of this country (Anonymous 1995). It is also used as vegetable and is available year round in the local market. The severe gap between the production and demands of papaya fruit is increasing day by day and only 47% requirement of fruits are met up from local production. Papaya as a quick growing fruit can play an important role to overcomes this situation.

On the other hand Ginger (*Zingiber officinale*) is one of the most important spice crops of Bangladesh and the total production of ginger is 43000 Metric tons in an area of 8000 ha (BBS, 2003). Under multistoried agroforestry system ginger is compatible crop due to their shade loving nature and easily grown habit in all homesteads. There are many commercial and non-commercial litchi orchards in Dinajpur region of Bangladesh, which is being used as monoculture practice (sole litchi). There is a great scope to bring these orchards under intensive cultivation like multilayered Agroforestry system. Moreover, no scientific research was done on litchi based multilayered production in this region. For this reason, a study was undertaken to investigate the yield and yield attributes of two papaya varieties and ginger under litchi orchards and also assess the suitability of litchi + papaya + ginger based multilayered Agroforestry production system.

Materials and Methods

The research work was carried out at the Bangladesh Agriculture Development Corporation (BADC) farm, Chehelghagi, Dinajpur district during the period from April to December 2004 under the upland condition. The experiment site is situated between $25°13$ latitude and $88°23$ longitude at the elevation of 40 m above from the sea level belonging to the Agro-ecological zone of old Himalayan piedmont plain area.

The experiment was conducted by factorial experiment in a split plot design with three replications involving four different distance (% PAR level) from litchi tree and two papaya varieties using recommended rate of fertilizer for papaya (BARI, 1999).

Factor A: Different distance (D) (Main plot)

D_1 = Open field (outside the tree canopy) allowing 100% PAR

D_2 = 1.5 m distance from the tree base allowing (25-35% PAR)

D_3 = 3.0 m distance from the tree base allowing (55-65% PAR)

D_4 = 4.5 m distance from the tree base allowing (85-95% PAR)

Factor B: Papaya varieties (V) (Sub-plot).

V_1 = Shahi

V_2 = Ranchi

The selected land area in litchi orchard was prepared properly and each plot (9 m x 9 m) possess a litchi tree in the centre were made at 15 m row to row spacing. Healthy and uniform (height of 15-20 cm having 5-6 leaves) seedlings of two local variety papaya were transplanted to the main field on 14 April 2004 and at the same time local variety of ginger (Zhizome) was grown between the two papaya rows. Harvesting of the papaya fruit was done on different days depending on their maturity and data were recorded on number of fruit per plant, weight of fruit, diameter of fruit, length of fruit, cavity length, cavity diameter, flesh thickness, total soluble solids. Yield per plant and yield per hectare for papaya and only total yield for ginger. Data on various yield and yield contributing characters of papaya were statistically analyzed and treatments means were compared by Duncan's Multiple Range Test (DMRT).

Results and Discussion

Number of fruits per plant

The number of fruit per plant due to the effects of papaya variety and distance from litchi base was affected significantly. The highest number of fruit (17.25) per plant was recorded from Shahi while Ranchi produced (16.16) fruit per plant (Table 1). Among the different distance the highest number of fruits per plant was produced (20.16) from D_4 (4.5 m distance from tree base) and the lowest results (7.0) was obtained in D_2 (1.5 m distance form tree base) (Table 2). On the other hand, with full sunlight condition control produced the highest (21.66) number of fruits per plant compare to all distances. The interaction effect between the varieties and different distance on number of fruits per plant was found non-significant. The maximum number of fruits per plant (21.00) was observed in D_4V_1 and the minimum result (6.66) obtained from D_2V_2 (Table -3). The result indicated that different light level affects the fruit formation. Similarly Veerannah et $al.$ (1982) reported that the number of fruits per plants was varied in different varieties of papaya due to difference in light intensity.

Fruits weight

The highest fruit weight (830.83 g) was obtained in Shahi and the lowest (818.91g) was found in Ranchi variety (Table - 1). Among the different distance from litchi tree, the maximum fruit weight (914.16g) was obtained from D_1 (Out side the canopy /100%PAR level) followed by D_4 (908.33g) and the minimum fruit weight was produced by D_2 (574.16g). The result revealed that the fruit weight gradually increased by the increasing effect of light condition (Table 2). The

interaction effect between the variety and distance level showed non-significant variations. The maximum and the lowest fruit weight was produced by D_1V_1 (920.00g) and D_4V_2 (556.00g) respectively (Table 3).

Fruit diameter and length

The maximum fruit diameter (10.99cm) was obtained from Shahi and fruit length was (13.55cm) found in Rabchi variety (Table 1). Among the different distance level the highest fruit diameter and length (12.2 cm and 18.72 cm) was obtained from D_1 while the lowest result (8.75 cm and 14.89 cm) was produced from D_2 (Table 2). Similarly Singh and Sirohi (1977) reported that the fruit diameter of papaya varieties varies in different agro-ecological conditions. The interaction effect of different distance/PAR levels and papaya varieties on fruit diameter and length was found to be statistically non-significant. However, the maximum fruit diameter and length (12.03 cm and 18.93 cm) was obtained from D_4V_1 and D_1V_2 respectively (Table 3). The lowest fruit diameter and length (8.66 cm and 14.86 cm) produced from D_2V_2 and D_2V_1 respectively.

Cavity length and diameter

The lowest cavity length and diameter (13.08 cm and 7.63 cm) was found in Shahi and Ranchi variety while the highest result (13.55 cm and 7.77 cm) obtained from Ranchi and Shahi variety respectively (Table 1). The result indicated that cavity length and diameter were more or less similar for the both variety. Out of four distance level, the maximum cavity length and diameter (14.76 cm and 8.18 cm) was produced by D_1 followed by D_4 (table 2). The lowest result (10.93 cm and 6.98 cm) was

Table 1: Different fruit characteristics of papaya as affected by litchi tree

Variety	Fruit no./plant	Fruit wt. (gm)	Fruit diameter (cm)	Fruit length (cm)	Cavity length (cm)	Cavity diameter (cm)	Flesh thickness (cm)	TSS (%)	Yield kg/plant
Shahi	17.25a	830.8a	10.99a	17.25b	13.08b	7.77a	2.97a	13.35	15.14
Ranchi	16.16b	818.91b	10.85b	17.56a	13.55a	7.63b	2.87b	13.64	14.03
Level of Significance	**	*	*	*	*	*	*	NS	**

Table 2 Effect of distance on different fruit characteristics

Distance	Fruit no./plant	Fruit wt. (gm)	Fruit diameter (cm)	Fruit length (cm)	Cavity length (cm)	Cavity diameter (cm)	Flesh thickness (cm)	TSS (%)	Yield kg/plant
D_1	21.66a	914.16a	12.2a	18.72a	14.76a	8.18a	2.55a	13.75	19.67a
D_2	7.00d	574.16b	8.75c	14.89b	10.93c	6.98c	2.05c	13.20	3.97d
D_3	18.00c	902.83a	10.83b	17.63a	13.16b	7.65b	2.21b	13.36	16.25c
D_4	20.16b	908.33a	11.91a	18.39a	14.42a	8.00a	2.48a	13.66	18.44b
Level of Significance	**	*	*	*	*	*	*	NS	**

obtained from D_2. The interaction effect of variety and different distance level on cavity length and diameter were found to be non-significant while the highest (14.97 cm and 8.26 cm) result was found in D_1V_2 and D_1V_1 and the lowest cavity length and diameter (10.89 cm and 6.86 cm) was produced in D_2V_1 and D_2V_2 respectively (Table 3).

Flesh thickness

Flesh thickness of papaya fruit is one of the most important parameter for good quality papaya and of the two varieties Shahi produced the better (2.97 cm) flesh thickness than Ranchi (2.87 cm) (Table 1). Among the four distance level D_1 produced (2.55 cm) showed the highest flesh thickness followed by D_4 (2.48 cm) and the lowest result (2.05 cm) was obtained from D_2(Table 2). The interaction effect between papaya variety and different distance level on flesh thickness showed no-significant variation. The highest and lowest (2.60 cm and 2.00 cm)

flesh thickness of papaya produced by D_1V_1 and $D2V_2$ respectively (Table 3). The result indicated that increasing of shade level can subsequently decrease the papaya flesh thickness.

Total Soluble Solid (TSS)

In respect of TSS the varieties, distance levels and their interaction effect showed non-significant variation. Of the two varieties the highest TSS (13.64 %) was produced by Ranchi (Table 1). Among the four distance level, the highest and lowest TSS (13.75 % and 13.66 %) was obtained from D_1 and D_4 respectively (Table 2). The interaction effect of papaya varieties and different distance level on TSS was the highest (13.76 %) in D_4V_1 and the lowest result (13.20 %) was found in D_2V_1 which was statistically identical to D_2V_2 and D_3V_1 (Table 3).

Table 3 Interaction effect of varieties and distance on different fruit characteristics

Treatment combination	Fruit no./plant	Fruit wt. (gm)	Fruit diameter (cm)	Fruit length (cm)	Cavity length (cm)	Cavity diameter (cm)	Flesh thickness (cm)	TSS (%)	Yield kg/plant
D_1V_1	22.00	920.00	12.00	18.52	14.55	8.26	2.60	13.30	20.11
D_1V_2	21.33	901.66	11.95	18.93	14.97	8.10	2.50	14.20	19.23
D_2V_1	7.33	583.33	8.83	14.86	10.89	7.10	2.10	13.20	4.22
D_2V_2	6.66	556.00	8.66	14.93	10.97	6.86	2.00	13.20	3.73
D_3V_1	18.66	905.00	10.90	17.53	12.76	7.70	2.26	13.33	16.89
D_3V_2	17.33	900.66	10.76	17.73	13.57	7.60	2.16	13.40	15.61
D_4V_1	21.00	915.00	12.03	18.10	14.13	8.03	2.53	13.76	19.32
D_4V_2	19.33	908.33	11.80	18.68	14.72	7.96	2.43	13.56	17.55
Level of Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same latter(s) in a column did not differ significantly

** = 1% level of significant (DMRT test)
** = 5% level of significant (DMRT test)
NS = Non-significant

V_1 = Shahi, V_2 = Ranchi
D_1 = Control, 100% PAR level
D_2 = 1.5 m distance and 25-35% PAR level
D_3 = 3.0 m distance and 55-65% PAR level
D_4 = 4.5 m distance and 85-95% PAR level

Yield per plant

The highest yield per plant (15.14 kg) was found in Shahi and the lowest yield per plant (14.03 kg) was obtained from Ranchi variety. Out of four distance level, the highest and lowest yield per plant (19.67 kg and 18.44 kg) was produced in D_1 and D_4 respectively (Table 2). The interaction effect of papaya variety and distance level on yield per plant was found to be non-significant and the highest and lowest yield per plant (20.11 kg and 3.73 kg) was obtained from D_1V_1 and D_2V_2 respectively (Table 3). The result showed that out of two varieties Shahi is the best in respect of yield per plant and the shade level affect the yield of papaya significantly. Similar type of result was found by Taleb (2003) to determine the performance of vegetables under multilayered Agroforestry system.

Yield of different components of the Multistoried Agroforestry System

In the open field (100% PAR) i.e. out side the multilayered system the Shahi variety of papaya produced 67.28 t/ha and in multilayered system it produced 29.96 t/ha papaya while the Ranchi produced 62.35 t/ha and 27.20 t/ha in open and multilayered system respectively. In case of Ginger the open and multilayered system yield was 9.08 t/ha and 20.03 t/ha respectively. On the other hand the litchi produced the similar type of yield both in open and multilayered system (2.65 t/ha and 2.68 t/ha) but slightly higher in multilayered system (Figure 1).
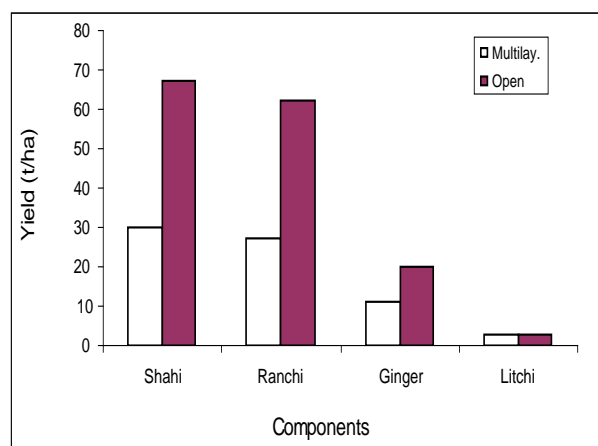

Figure1: Yield performance of papaya varieties, Ginger and Litchi.

Due to proper intercultural operation and nutrient cycling in the multilayered system, litchi plat

received more beneficial effects and it was responsible for litchi higher yield.

The result of the present experiment clearly indicated that the parameter were significantly influenced by the two papaya varieties and more or less all the parameters attained highest value in Shahi variety. In case of different distance level maximum parameters showed highest value in the 100% PAR level (D_1) and 1.5m distance from the litchi tree (D_2) (i.e. nearest distance from litchi tree) showed the lowest result. In the interaction effect between the varieties and distance levels on the yield and yield contributing parameters of the papaya indicated the non-significant variation. Though the 100% PAR level yield of both papaya and ginger were higher than multilayered yield but if we considered the total yield of multilayered production system it would be more beneficial and economically feasible. More over multilayered production system can properly utilize the land and nutrient of the production area. In a limited resources country the multilayered production system can play a significant contribution of the multiple component yield and

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economic condition of the farmers. Finally from this experiment it could be concluded that the owner/farmer of the litchi orchard can successfully introduced multilayered production system in their orchard with combination of Litchi + Papaya + Ginger and it will be more beneficial and environmentally sound than mono production system.

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