

Screening of Potato Varieties under Litchi Based Agroforestry System

M. M. Rahman^{1*}, M. S. Bari¹, M. S. Rahman¹, M. A. Ginnah² and M. H. Rahman¹

¹Department of Agroforestry and Environment, Hajee Mohammad Danesh Science and Technology University, Dinajpur- 5200, Bangladesh.

²Department of Agriculture Extension, Upazila Agriculture, Ministry of Agriculture, Dhaka, Bangladesh.

Authors' contributions

This work was carried out in collaboration between all authors. Author MMR performed the field experiments, statistical analysis, wrote the protocol and the first draft of the manuscript. Authors MSB and MSR designed the study. Authors MAG and MHR managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEA/2016/28695

Editor(s):

(1) Suleyman Korkut, Duzce University, Department of Forest Industrial Engineering, Division of Wood Mechanic and Technology, Turkey.

Reviewers:

(1) Richard A. Rodríguez Padrón, University of Republic, Uruguay.

(2) Edgar Iván Sánchez Bernal, Institute of Ecology, Universidad del Mar, Mexico.

(3) Surendra Singh Bargali, Kumaun University, Nainital- 263002, India.

Complete Peer review History: <http://www.sciencedomain.org/review-history/16325>

Original Research Article

Received 31st July 2016
Accepted 1st September 2016
Published 24th September 2016

ABSTRACT

Aims: To evaluate the performance of eight potato varieties and identify the best variety under litchi based Agroforestry system.

Study Design: The treatments were laid out with two factors RCBD following three replications.

Place and Duration of Study: Study was carried out at Agroforestry Research Farm, Hajee Mohammad Danesh Science and Technology University, Dinajpur during November 2014 to March 2015.

Methodology: There are two factors, factor A was two production systems; S₁= Litchi + potato and S₂=Potato sole cropping, another factor B was eight potato varieties; V₁=Diamond, V₂= Cardinal V₃=Asterix, V₄=Carage, V₅=Lady Rosetta, V₆=Granula, V₇=Raza and V₈=4.26R. Data are collected on plant height, leaf length, leaf breath, no. of leaf per shoot, no. of shoot per hill and yield ton/ha.

*Corresponding author: E-mail: mijanurag@gmail.com;

Results: The result of the experiment revealed that there was a significant effect of different variety and production systems on the growth and yield contributing characters of potato. Significant effect of eight potato varieties and production system was found on the plant height, leaf length, leaf breath, no. of leaf per shoot, no. of shoot per hill and yield. The highest tuber yield (18.88 tha^{-1}) was recorded in Lady Rosetta potato variety whereas the lowest tuber yield (12.29 tha^{-1}) was recorded in Diamond.

Conclusion: The suitability of the cultivation of different potato variety under litchi based Agroforestry systems may be ranked as Lady Rosetta > Granula > Asterix > Carage > Raza > 4.26 R > Cardinal > Diamond.

Keywords: Potato; litchi; suitability; agroforestry system; varieties; screening; sole cropping.

1. INTRODUCTION

Bangladesh is one of the densely populated countries of the world having a population of 152.25 million in the area of 147570 sq. Km and growth rate is 1.37% per annum [1]. The population growth of Bangladesh and greater affluence exert pressures to convert forests to agricultural, industrial or residential land. Critical situation, increasing demand for food, fodder and timber can be met through traditional and non-traditional agroforestry. It is well known fact [2,3,4,5,6] away out to practice agriculture without deteriorating agro-ecosystem services while maintaining or improving productivity, stability or in other words sustainability. Potato (*Solanum tuberosum* L.) is an important vegetable crop of solanaceae family, which is originated in the Andes near the border of Peru and Bolivia in South America [7] has been growing in Bangladesh as an important vegetable crop predominantly in the winter season. During 2013-14, the production of potato was 8950024MT from an area of 462032ha which is 4.03% higher than previous year and average yield was 19.371 MTha^{-1} [8]. The litchi (*Litchi chinensis*) is a delicious, juicy fruit of excellent quality. It is a very popular fruit in our country. It is an evergreen tree and a perfect multipurpose tree. It grows well all over Bangladesh especially in the northern part of the country. Total production of litchi is 43767 m. ton and total production area under garden is 5789 acres, average yield per fruit bearing tree is 49 kg [9]. On the other hand, the minimum dietary requirement of fruit per day per capita is 85 g, whereas the availability is only 30-35 g in Bangladesh. Though fruits are important source of vitamin and minerals, the availability and consumption of fruits in Bangladesh are much less than it should be. As a result, fruits are very costly in the country and majority of people can't afford to buy them and is being suffering from malnutrition. Therefore, production of potato in

association with litchi tree may be an ideal combination of two high value crops. Scientific research is needed for investigating interaction effects of Litchi-Potato production system. Moreover, an appropriate potato variety should be identified in order to get maximum benefit from litchi-potato based agroforestry system. Considering the above circumstances a study was conducted in order to screening out suitable potato variety for cultivation at the floor of litchi orchard.

2. MATERIALS AND METHODS

2.1 Experimental Site Description

The experimental site was selected in the existing litchi orchard of the Agroforestry & Environment Research Farm, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh. The geographical location of the site was between $25^{\circ} 13'$ latitude and $88^{\circ} 23'$ longitude. The soil texture was sandy loam in nature. The soil P^H was 5.1.

2.2 Experimental Design and Crop Husbandry

The experiment was laid out following a two factorial Randomized Complete Block Design (RCBD) with three replications. Total number of experimental plot was 48. The size of each unit plot was $2\text{m} \times 2\text{m} = 4\text{m}^2$. Among the two factors, factor A was two production systems; S_1 =Litchi + potato and S_2 =Potato on sole cropping. Another factor B was eight potato varieties; V_1 = Diamond, V_2 =Cardinal V_3 = Asterix, V_4 = Carage V_5 = Lady Rosetta, V_6 = Granula, V_7 = Raza and V_8 = 4.26 R. So there were 16 treatments combinations and these were; S_1V_1 = Litchi + Diamond, S_1V_2 = Litchi + Cardinal, S_1V_3 = Litchi + Asterix S_1V_4 = Litchi + Carage, S_1V_5 = Litchi + Lady Rosetta, S_1V_6 = Litchi + Granula, S_1V_7 = Litchi + Raza. S_1V_8 = Litchi + 4.26 R, S_2V_1 = Diamond sole cropping, S_2V_2 = Cardinal sole cropping,

S₂V₃ = Asterix sole cropping, S₂V₄ = Carage sole cropping, S₂V₅ = Lady Rosetta sole cropping, S₂V₆ = sole cropping, S₂V₇ = Raza sole cropping and S₂V₈ = 4.26 R sole cropping. Seed potato tubers were collected from Bangladesh Agricultural Development Corporation (BADC) Domar, Nilphamari. The age of the litchi trees were five years with spacing of 8m × 8m. The litchi variety was China-3. Recommended doses of fertilizers were used as Urea (N@135 kg /ha), TSP (P₂ O₅ @30 kg /ha), MP (K₂ O@90 kg /ha), Gypsum (S@10 kg /ha), Zinc Sulfate (Zn @2 kg /ha), Borax (B @1.5 kg /ha), Cowdung (5 ton/ha). Potato variety and intercultural operations were done as and when necessary to keep the crop weed free and to pulverize the soil. Irrigation was given three times at 30, 40 and 50 DAP, respectively.

2.3 Data Collection

The heights were measured from the ground level to the tip of the longest shoot at an interval of 15 days starting from 30, 45 and 60 DAP. The length of the leaf was obtained with the help of centimeter scale at 30, 45 and 60 DAP. The breadth of the leaf was obtained with the help of centimeter scale at 30, 45 and 60 DAP. Number of shoots per hill⁻¹ was recorded with at an interval of 15 days starting from 30, 45 and 60 DAP. Number of tubers hill⁻¹ was recorded at the time of final harvest. It was recorded as the average of the 10 plants selected at random at harvest from each unit plot. Weight of tubers hill⁻¹ recorded at the time of final harvest. Yield of tubers was recorded from the harvested tubers of all plants of each plot including the sample plants. The yield of tuber plot⁻¹ was converted to the yield per hectare. Net return usually means the profit of the enterprises. Net return was calculated by deducting the total cost of production from the gross return.

$$\text{Net return} = \text{Gross return (Tk.ha}^{-1}\text{)} - \text{Total cost of production (Tk.ha}^{-1}\text{)}.$$

Benefit-cost ratio is the ratio of gross return with total cost of production. It was calculating by using the following formula.

$$\text{Benefit-cost ratio} = \frac{\text{Gross return (Tk.ha}^{-1}\text{)}}{\text{Total cost of production (Tk.ha}^{-1}\text{)}}.$$

2.4 Data Analysis

Data were statistically analyzed using the "Analysis of variance" (ANOVA) technique with

the help of computer package MSTAT-C. The mean differences were adjudged by Duncan's Multiple Range Test (DMRT) [10].

3. RESULTS

3.1 Main Effect of Variety on Growth and Yield of Potato

The tallest plant (35.53 cm, 63.97 cm, 84.35 cm at 30 DAP, 45 DAP, 60 DAP, respectively) was recorded from the variety of Lady Rosetta (V₅) which is significantly followed by the variety of Carage (V₄) whereas the shortest plant (29.19 cm, 49.87 cm, 58.73 cm at 30 DAP, 45 DAP, 60 DAP, respectively) was observed from Diamond (V₁) which is significantly followed by the variety of Granula (V₆), Raza (V₇) (Fig. 1). The longest leaf (17.27 cm, 20.86 cm, 21.82 cm at 30 DAP, 45 DAP, 60 DAP, respectively) was recorded from the variety Lady Rosetta (V₅) which is significantly followed by the variety of Granula (V₆), Carage (V₄), 4.26R (V₈) and Raza (V₇) whereas the shortest leaf (13.03 cm, 16.19 cm, 16.82 cm at 30 DAP, 45 DAP, 60 DAP, respectively) was observed from Asterix (V₃) (Table 1). Again, the widest leaf (10.70 cm, 11.87 cm, 12.45 cm at 30 DAP, 45 DAP, 60 DAP, respectively) was recorded from the variety Lady Rosetta (V₅) which is significantly followed by the variety of Carage (V₄), Asterix (V₃) and minimum breadth of leaf (9.40 cm, 10.80 cm, 11.68 cm at 30 DAP, 45 DAP, 60 DAP, respectively) was observed from Diamond (V₁) (Table 1). On the other hand, the maximum number of leaves per shoot (10.12, 15.47, 17.69 at 30 DAP, 45 DAP, 60 DAP, respectively) was recorded from the variety Lady Rosetta (V₅) and the minimum number of leaves per shoot (8.86, 12.33, 13.49 at 30 DAP, 45 DAP, 60 DAP, respectively) was observed from Diamond (V₁) (Table 1). Again, the maximum number of shoot hill⁻¹ (6.26) was recorded from the variety Lady Rosetta (V₅) which is significantly followed by the variety of Granula (V₆), Carage (V₄), respectively whereas minimum number of shoot hill⁻¹ (3.16) was observed from Diamond (V₁) (Fig. 2). Again, the maximum number of tuber hill⁻¹ (8.70) was recorded in Lady Rosetta (V₅) which is significantly followed by the variety of Granula (V₆), Asterix (V₃), respectively and the minimum number of tuber hill⁻¹ (5.35) was found in Diamond (V₁) (Table 2). Consequently, the maximum weight of tuber per hill (385.61 g) was recorded in Lady Rosetta (V₅) which is significantly followed by the variety of Granula

(V₆), Asterix (V₃), respectively whereas minimum weight of tuber per hill (283.10 g) was recorded from the variety Diamond (V₁) (Table 2). Similarly, the highest tuber yield plot⁻¹(7.55 kg) was recorded in Lady Rosetta (V₅) which is significantly followed by the variety of Granula (V₆), Asterix (V₃), respectively. On the other

hand, the lowest tuber yield per plot (4.91 kg) was recorded in Diamond (V₁) (Table 2). Again, the highest tuber yield (18.88 t/ha) was recorded in Lady Rosetta (V₅) followed by V₁ (17.67 t/ha), V₃ (17.50 t/ha) and V₇ (14.29 t/ha), respectively. The lowest tuber yield (12.29 t/ha) was recorded in Diamond (V₁) (Table 2).

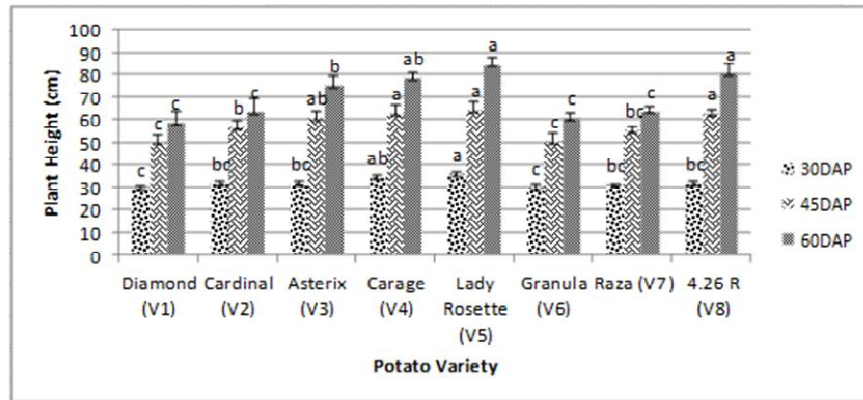


Fig. 1. Main effect of on plant height of potato variety

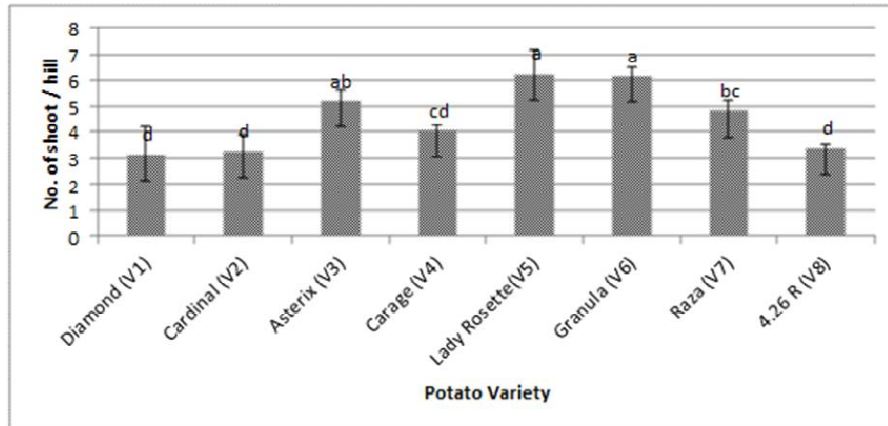


Fig. 2. Main effect of variety on no. of shoot/hill of potato

Table 1. Main effect of variety on the growth parameters of potato

Treatments (variety)	Leaf length (cm)			Leaf breath (cm)			No. of leaf per shoot		
	30DAP	45DAP	60DAP	30DAP	45DAP	60DAP	30DAP	45DAP	60DAP
Diamond (V ₁)	13.68b	16.67b	17.05c	9.40c	10.80 b	11.68 a	8.86a	12.33c	13.49c
Cardinal (V ₂)	13.48b	16.41b	16.88c	9.76b	11.00 b	12.02 a	9.03a	14.27ab	15.82bc
Asterix (V ₃)	13.03c	16.19c	16.82c	10.12ab	11.13ab	12.38 a	9.11a	14.13ab	17.08ab
Carage (V ₄)	15.65a	19.60a	20.11b	10.27ab	11.27ab	11.95 a	9.88a	14.47ab	17.50a
Lady Rosetta (V ₅)	17.27a	20.86a	21.82a	10.70 a	11.87a	12.45 a	10.12a	15.47a	17.69a
Granula (V ₆)	16.02a	19.66a	20.03b	9.90bc	10.93 b	11.82 a	9.54aa	14.28ab	16.42b
Raza (V ₇)	16.78a	20.40a	20.62ab	9.65bc	11.58ab	12.40 a	9.81a	13.48bc	16.92ab
4.26 R (V ₈)	15.90a	19.17a	19.87b	9.71bc	11.28ab	11.97 a	9.40a	14.90ab	17.50a
CV (%)	10.65	7.72	5.52	4.88	5.48	13.25	13.73	9.26	6.79

In a column, figures having similar letter(s) do not differ significantly whereas figures bearing different letter(s) differ significantly (as per DMRT)

Table 2. Main effect of variety on the yield and yield attributing characters of potato

Treatments (variety)	No. of tuber/hill	Wt. of tuber (gm/hill)	Total wt. of tuber (kg/plot)	Yield (ton/ha)
Diamond (V ₁)	5.35c	283.10d	4.91d	12.29d
Cardinal (V ₂)	5.58bc	284.00d	5.03cd	12.58cd
Asterix (V ₃)	7.48ab	363.36ab	7.00abc	17.50abc
Carage (V ₄)	6.76bc	312.70bc	5.85abcd	14.63abcd
Lady Rosetta (V ₅)	8.70a	385.61a	7.55a	18.88a
Granula (V ₆)	7.85ab	365.15ab	7.10ab	17.67ab
Raza (V ₇)	6.36bc	301.60bcd	5.71abcd	14.29abcd
4.26 R (V ₈)	6.38bc	296.50bcd	5.03cd	13.63bcd
CV (%)	20.86	19.85	25.17	25.13

In a column, figures having similar letter(s) do not differ significantly whereas figures bearing different letter(s) differ significantly (as per DMRT)

3.2 Main Effect of Production System on Growth and Yield of Potato

The tallest plant (32.53 cm, 58.92 cm, 77.04 cm at 30 DAP, 45 DAP, 60 DAP, respectively) was observed in litchi+potato based Agroforestry system (S₁) whereas the shortest plant was observed (30.92cm, 56.35 cm, 64.17 cm at 30 DAP, 45 DAP, 60 DAP, respectively) in sole cropping of potato (S₂) (Fig. 3). Consequently, the longest leaf length of potato (16.75 cm, 19.11 cm, 19.47 cm at 30 DAP, 45 DAP, 60 DAP, respectively) was observed in sole cropping of potato (S₂) whereas the shortest leaf length of potato (13.70 cm, 18.12 cm, 18.82 cm) was observed in litchi+potato based Agroforestry system (S₁) (Table 3). Similarly, the widest leaf (10.23 cm, 11.40 cm, 11.90 cm at 30 DAP, 45 DAP, 60 DAP, respectively) was observed in litchi+potato based Agroforestry system (S₁) whereas leaf with minimum breadth (9.64 cm, 11.07 cm, 11.76 cm at 30 DAP, 45 DAP, 60 DAP, respectively) was observed in sole cropping of potato (S₂) (Table 3). Similarly, the maximum number of leaves (9.83, 14.35, 17.20 at 30 DAP, 45 DAP, 60 DAP, respectively) was observed in litchi+potato based Agroforestry system (S₁) whereas the minimum number of

leaves (9.12, 13.98, 15.51 at 30 DAP, 45 DAP, 60 DAP, respectively) was observed in sole cropping of potato (S₂) (Table 3). Again, the maximum number of shoots per hill (4.86) was recorded in sole cropping of potato (S₂). However, the minimum number of shoots (4.23) per plant of potato was recorded in litchi+potato based Agroforestry system (S₁) (Fig. 4). Again, the maximum number of tuber hill⁻¹ (7.18) was recorded in sole cropping of potato (S₂). In opposition, the minimum number of tuber hill⁻¹ (6.19) was found in Litchi+potato based Agroforestry system (S₁) (Table 4). On the other hand, the maximum weight of tuber per hill (384.75 g) was observed in sole cropping of potato (S₂) and the minimum weight of tuber per hill (194.87g) was recorded in Litchi+potato based Agroforestry system (S₁) (Table 4). Again, the highest tuber yield per plot (8.77 kg) was recorded in sole cropping of potato (S₂). The lowest tuber yield (3.38 kg) was recorded in Litchi+potato based Agroforestry system (S₁) (Table 4). Finally, the highest yield was found (21.94 ton/ha) in sole cropping of potato (S₂) and the lowest yield (8.43 t/ha) was found in Litchi+potato based Agroforestry system (S₁) (Table 4).

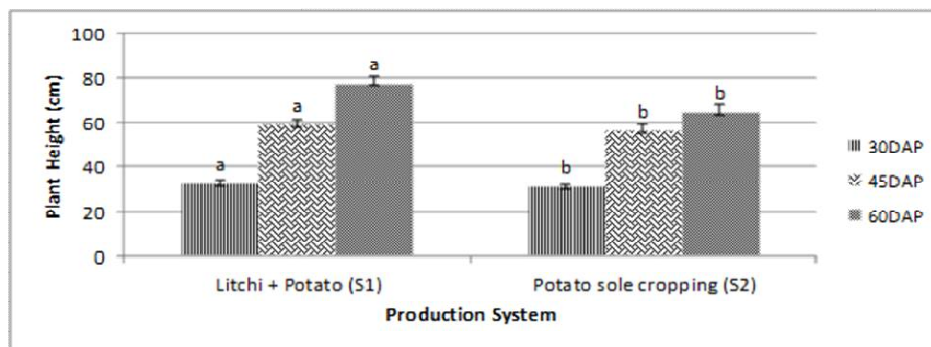


Fig. 3. Main effect of production system on plant height of potato

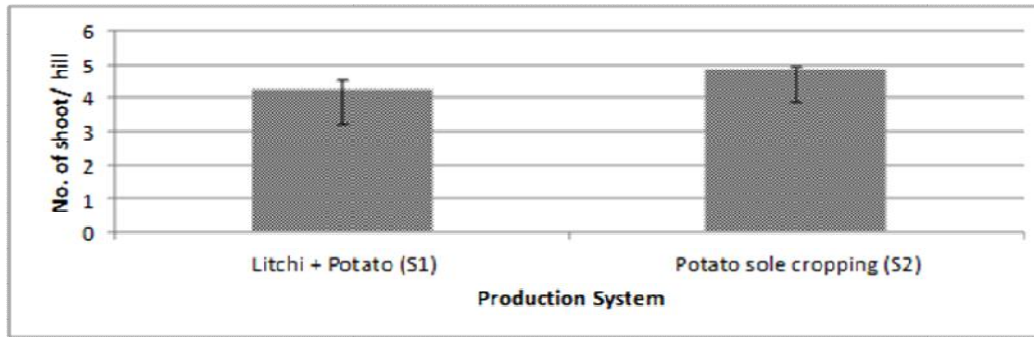


Fig. 4. Main effect of production system on no. of shoot/hill of potato

Table 3. Main effect of production system on the growth parameters of potato under litchi orchard

Treatments (production system)	Leaf length (cm)			Leaf breath (cm)			No. of leaf per shoot		
	30DAP	45DAP	60DAP	30DAP	45DAP	60DAP	30DAP	45DAP	60DAP
Litchi + Potato (S ₁)	13.70b	18.12b	18.82b	10.23a	11.40a	11.90a	9.83a	14.35a	17.20a
Potato sole cropping (S ₂)	16.75a	19.11a	19.47a	9.64 b	11.07a	11.76a	9.12a	13.98b	15.51b
CV (%)	10.65	7.72	5.52	4.88	5.48	13.25	13.73	9.26	6.79

In a column, figures having similar letter(s) do not differ significantly where as figures bearing different letter(s) differ significantly (as per DMRT)

Table 4. Main effect of production system on the yield and yield attributing characters of potato under litchi orchard

Treatments (production system)	No. of tuber/hill	Wt. of tuber (gm/hill)	Total wt. of tuber (kg/plot)	Yield(ton/ha)
Litchi + Potato (S ₁)	6.19b	194.87b	3.38b	8.43b
Potato sole cropping (S ₂)	7.18a	384.75a	8.77a	21.94a
CV (%)	20.86	19.85	25.17	25.13

In a column, figures having similar letter(s) do not differ significantly where as figures bearing different letter(s) differ significantly (as per DMRT)

3.3 Interaction Effect of Variety and Production System on the Growth and Yield of Potato

The tallest plant of potato (37.27 cm, 66.77 cm, 91.27 cm at 30 DAP, 45 DAP, 60 DAP, respectively) was recorded in S₁V₅ (Litchi + Lady Rosetta) which is significantly followed by S₁V₄ (Litchi+Carage) and the shortest plant of potato (27.52 cm, 45.88 cm, 54.83 cm at 30 DAP, 45 DAP, 60 DAP, respectively) was recorded in S₂V₁ (Sole cropping of Diamond) (Fig. 5) Similarly, the longest leaf length of potato (18.73 cm, 21.57 cm, 21.93 cm at 30 DAP, 45 DAP, 60 DAP, respectively) was recorded in S₂V₅ (Lady Rosetta Sole Cropping) which is significantly followed by S₁V₇ (Litchi+Raza) and the shortest leaf of potato (10.95 cm, 15.32 cm, 16.43 cm at 30 DAP, 45 DAP, 60 DAP, respectively) was

recorded in S₁V₁ (Litchi + Diamond) which followed by S₁V₃ (Litchi + Diamond) and S₁V₂ (Litchi + Cardinal), respectively (Table 5). Consequently, the widest leaf of potato (11.27 cm, 12.33 cm, 21.93 cm at 30 DAP, 45 DAP, 60 DAP, respectively) was recorded in S₁V₅ (Litchi + Lady Rosetta) and the leaf with minimum breadth (9.20 cm, 10.57 cm, 16.43 cm at 30 DAP, 45 DAP, 60 DAP, respectively) was recorded in S₂V₁ (Diamond Sole Cropping) which is followed by S₂V₇ (Raza sole cropping), S₂V₈ (4.26 R sole cropping), S₁V₁ (Litchi + Diamond) and S₂V₆ (sole cropping Granula) (Table 5). Similarly, the maximum number of leaves (10.63, 15.80, 19.50 at 30 DAP, 45 DAP, 60 DAP, respectively) was recorded in S₁V₅ (Litchi + Lady Rosetta) and minimum number of leaves (8.00, 12.07, 13.00 at 30 DAP, 45 DAP, 60 DAP, respectively) was recorded in S₂V₁ (Diamond

Sole Cropping) (Table 5). Again, the maximum number of shoots per plant (7.00) was recorded in S₂V₅ (Lady Rosetta sole cropping) which is significantly followed by S₂V₆ (sole cropping Granula) and the minimum number of shoots (2.867) per hill of potato was recorded in S₁V₁ (Litchi + Diamond) treatment combination (Fig. 6). The maximum number of tuber (8.93) was recorded in S₂V₅ (Lady Rosetta Sole Cropping) which was statistically identical with S₂V₆, S₂V₃, S₂V₂, S₂V₇, S₁V₅ respectively and the minimum number of tuber (4.90) was recorded in S₁V₁ (Litchi + Diamond) which is identical with S₁V₄, S₁V₂, S₁V₆ and S₁V₇ treatment combination (Table 6). Again, the maximum weight of tuber per hill (406.70 g) was in S₂V₅ (Lady Rosetta

Sole Cropping) treatment combination and the minimum weight of tuber (190.80 g) was recorded in S₁V₁ (Litchi + Diamond) treatment combination (Table 6). Again, the highest tuber yield (10.90 kgplot⁻¹) was recorded in S₂V₅ (Lady Rosetta Sole Cropping) treatment combination whereas the lowest tuber yield (2.87 kg plot⁻¹) was recorded in S₁V₁ (Litchi + Diamond) treatment combination (Table 6). In case of per hectare the highest tuber yield (27.25 t/ha) was recorded in S₂V₅ (Lady Rosetta Sole Cropping) treatment combination whereas the lowest tuber yield (6.25 t/ha) was recorded in S₁V₁ (Litchi+Diamond) treatment combination (Table 6).

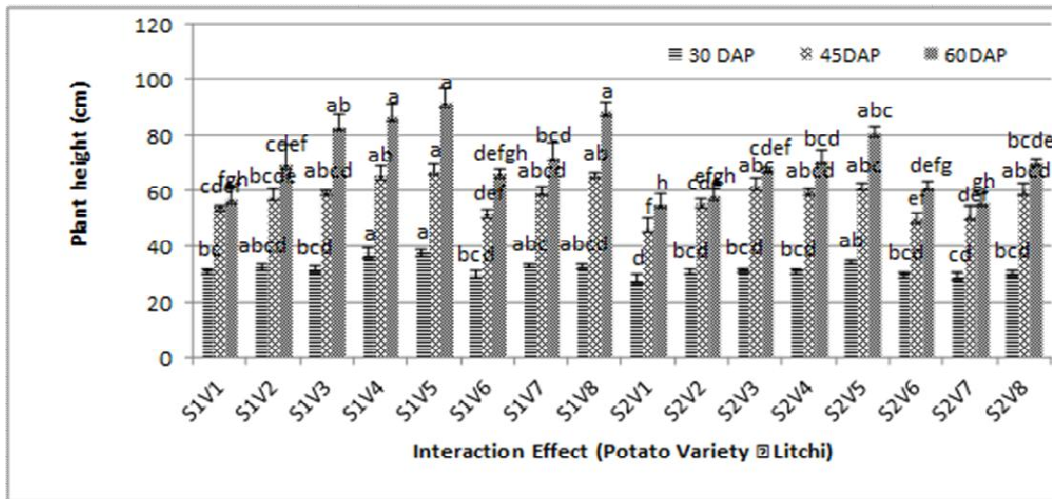


Fig. 5. Interaction effect of production system and potato variety on plant height of potato

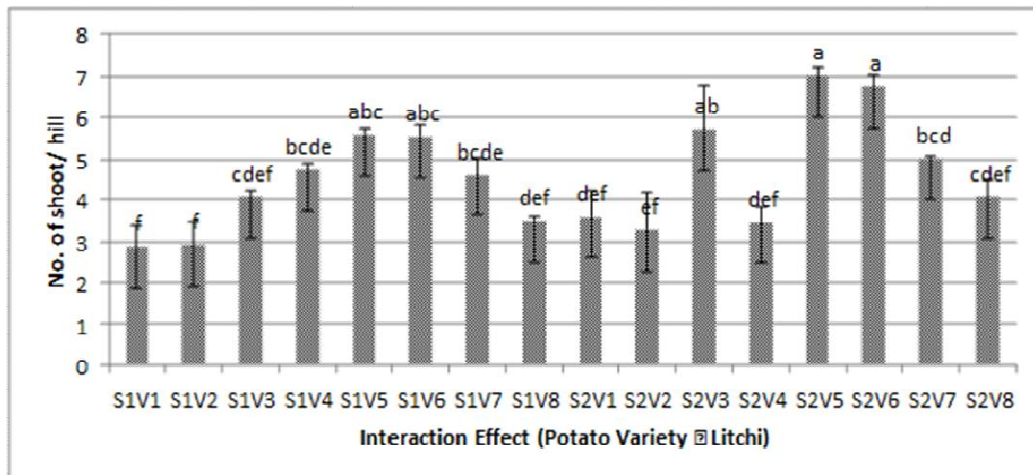


Fig. 6. Interaction effect of production system and potato variety on n. of shoot/hill of potato

Table 5. Interaction effect of variety and production system on the growth parameters of potato

Treatments	Leaf length (cm)			Leaf breath (cm)			No. of leaf per shoot		
	30DAP	45DAP	60DAP	30DAP	45DAP	60DAP	30DAP	45DAP	60DAP
S ₁ V ₁	10.95g	15.32f	16.43d	9.46cde	11.17abc	11.33ab	10.01ab	13.83abcd	18.10ab
S ₁ V ₂	12.58efg	15.98ef	16.63d	9.63bcde	10.90c	12.10ab	10.37ab	14.60abcd	17.17bcd
S ₁ V ₃	11.37fg	16.58d	17.03d	10.37bc	11.20abc	12.50a	9.30ab	13.87abcd	17.83abcd
S ₁ V ₄	14.92cde	19.73ab	20.12abc	10.50ab	11.27abc	11.29ab	10.10ab	14.20abcd	17.87abc
S ₁ V ₅	15.30bcde	20.15ab	21.70a	11.27a	12.33a	12.83a	10.63a	15.80a	19.50a
S ₁ V ₆	14.13def	19.28abcd	19.53bc	10.33bc	11.39abc	12.43a	8.47ab	13.60bc	13.83fg
S ₁ V ₇	15.82abcd	19.77ab	19.97abc	10.10bcde	12.17ab	12.67a	10.07ab	13.17bcd	15.70def
S ₁ V ₈	14.53de	18.21bcde	19.20c	10.23bcd	11.43abc	12.07ab	9.67ab	14.33abcd	17.60abcd
S ₂ V ₁	16.00abcd	16.77def	17.07d	9.20e	10.57c	10.59c	8.00b	12.07d	13.00g
S ₂ V ₂	14.37de	16.83cdef	17.13d	9.90bcde	11.10bc	11.93ab	9.87ab	13.93abcd	14.47efg
S ₂ V ₃	15.10cde	17.05cdef	17.20d	9.87bcde	11.07bc	12.27ab	8.93ab	14.40abcd	16.33bcde
S ₂ V ₄	16.38abcd	19.47abc	20.10abc	10.03bcde	11.27abc	12.06ab	9.67ab	14.73abc	17.13bcd
S ₂ V ₅	18.73a	21.57a	21.93a	10.13bcde	11.00bc	12.07ab	9.07ab	15.14abc	17.40bcd
S ₂ V ₆	17.90abc	20.03ab	20.53abc	9.47cde	10.87c	11.20ab	9.27ab	12.60cd	15.73cde
S ₂ V ₇	18.27ab	21.03a	21.27ab	9.22e	11.40abc	12.13ab	9.00ab	13.80abcd	14.13fg
S ₂ V ₈	17.27abcd	20.13ab	20.53abc	9.33de	11.13abc	11.87ab	9.13ab	15.47ab	16.87cdef
CV (%)	10.65	7.72	5.52	4.88	5.48	13.25	13.73	9.26	6.79

In a column, figures having similar letter(s) do not differ significantly where as figures bearing different letter(s) differ significantly (as per DMRT)

Table 6. Interaction effect of variety and production system on the yield and yield attributing characters of potato

Treatments	No. of tuber/hill	Wt. of tuber (gm/hill)	Total wt. of tuber (kg/plot)	Yield (ton/ha)
S ₁ V ₁	4.90c	190.80b	2.87e	6.25e
S ₁ V ₂	5.80bc	194.00b	3.13e	7.08e
S ₁ V ₃	6.10bc	197.50b	3.83e	9.58e
S ₁ V ₄	5.10c	204.30b	3.80e	9.33e
S ₁ V ₅	6.93abc	217.00b	4.20de	10.50de
S ₁ V ₆	6.03bc	197.20b	3.87e	9.67e
S ₁ V ₇	6.00bc	174.50b	2.83e	7.83e
S ₁ V ₈	6.43abc	183.70b	2.48e	7.17e
S ₂ V ₁	6.07bc	368.70a	7.20c	18.00c
S ₂ V ₂	7.07abc	374.00a	6.70cd	16.75cd
S ₂ V ₃	8.33ab	404.30a	10.17ab	25.42ab
S ₂ V ₄	6.47abc	365.00a	7.83bc	21.00abc
S ₂ V ₅	8.93a	406.70a	10.90a	27.25a
S ₂ V ₆	8.47ab	381.30a	10.40ab	26.00ab
S ₂ V ₇	7.60abc	391.30a	8.60abc	21.50abc
S ₂ V ₈	6.73abc	386.70a	8.40abc	19.58bc
CV (%)	20.86	19.85	25.17	25.13

In a column, figures having similar letter(s) do not differ significantly whereas figures bearing different letter(s) differ significantly (as per DMRT)

3.4 Economic Analysis

The values in Table 7 indicate that the total cost of production was maximum (136202 Tk./ha) in Litchi + potato based Agroforestry system (S₁) whereas the minimum cost of production (130390 Tk./ha) was recorded from the sole cropping of potato (S₂). The values in Table 7 also indicate that the highest value of gross return (476850 Tk. /ha) was obtained from Litchi + potato based Agroforestry system (S₁). On the other hand, the lowest value of gross return (329100Tk. /ha) was obtained

from sole cropping of potato (S₂). So, the highest benefit-cost ratio (3.50) was recorded from Litchi + potato based Agroforestry system (S₁) whereas the lowest benefit-cost ratio (2.52) was observed in sole cropping of potato (S₂).

4. DISCUSSION

The research revealed that the highest plant height, leaf length, leaf breath, no. of leaf per shoot, no. of shoot per hill, no. of tuber per hill and yield were found on lady rosetta variety of

Table 7. Economics analysis of potato production under Litchi based Agroforestry system (ha⁻¹year⁻¹)

Production system	Outcome (Tk./ha)		Total cost of production (Tk./ha)	Gross return (Tk./ha)	Net return (Tk./ha)	BCR
	Litchi	Potato				
Litchi + Potato (S ₁)	350400	126450	136202	476850	340648	3.50
Potato sole cropping (S ₂)		329100	130390	329100	198710	2.52

Note: Potato 15 Tk. /kg, Litchi tree 8 year, 400 litchi/tree, 4 Tk. /litchi, Numbers of Litchi tree 219/ha

potato under open condition. It may be due to that, this variety may have high efficiency of using space, air, water & sunlight. It also may have high genetic vigor than other variety. The research also revealed that the highest plant height, leaf length, leaf breath, no. of leaf per shoot, no. of shoot per hill, no. of tuber per hill and yield were found on lady rosetta variety of potato under litchi tree. It may be due to that lady rosetta variety of potato remains more competitive growth capability than other variety under litchi orchard. These result followed by Abbasi et al. [11] who observed that Lady Rosetta show higher physical attributes, tuber firmness and specific gravity, maximum dry matter and starch contents. Munira et al. [12] proved that in salinity condition Lady Rosetta shows best results. The research reported that, plant grown in low light levels was found to be more apical dominant than those grown in high light environment resulting in taller plants under shade [13]. The shortest leaf length was observed in sole cropping of potato. This might be attributed due to the situation of cellular expansion and cell division of leaves under shaded condition [14]. The maximum number of leaves was observed in litchi+potato based Agroforestry system. These results are similar to many researchers [15,16] reported that temperature profoundly influences the growth and development of the potato canopy, leaf appearance, expansion, and senescence, leaf orientation and physiological. The leaf-level photosynthetic rate also varies with temperature; air temperatures at 23°C and above increase the number of axillary branches and the leaf appearance and senescence rates [17]. This finding was in agreement with the findings of [18] who stated that, cooler temperatures promote lower number of total leaf and numbers of branches. The highest yield was found in sole cropping of potato and the lowest yield was found in Litchi+potato based Agroforestry system because more sun light gave more photosynthesis produced more carbohydrates accumulated in potato tuber. Corroboratory

results from [19] reported that the main growth and yield attributing character responsible for lower yield under poplar were number of tuber and weight of tuber. The result is in agreement with the findings of [20] who found the lowest amount of potato yield under kalakoroi + potato based Agroforestry system. It may be due to minimum rate of photosynthesis, which results in lower amount of food materials deposited in the tuber. The highest gross return as well as benefit-cost ratio was observed from Litchi + potato based Agroforestry system rather than sole cropping of potato. The findings may be due to that in case of Agroforestry system more output was obtained as two crops produce more biological yield than single cropping.

5. CONCLUSION

The findings of the present investigation indicate that diversification of farming system and growing potato as ground layers crops in litchi tree orchard is a viable option for increasing income of farmers. One potato variety like Lady Rosetta has been grown successfully as intercrops in the floor of litchi tree orchard. From the results and foregoing discussion, the suitability of the cultivation of different potato variety under litchi based Agroforestry systems may be ranked as Lady Rosetta > Granula > Asterix > Carage > Raza > 4.26 R > Cardinal > Diamond.

ACKNOWLEDGEMENTS

I deeply expressed cordial thanks to National Science and Technology (NST) under the Ministry of Science and Technology (MoST), 'The People' s Republic of Bangladesh, for funding of this experiment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. BBS. Statistical Pocket Book of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Govt. of Peoples' Republic of Bangladesh; 2013.
2. Bargali SS, Singh SP, Pandya KS. Effects of *Acacia nilotica* on gram crop in a traditional agroforestry system of Chhattisgarh plains. *International Journal of Ecology and Environmental Sciences*. 2004;30(4):363-368.
3. Bargali SS, Kiran Bargali, Lalji Singh, Ghosh L, Lakhera ML. *Acacia nilotica* based traditional agroforestry system: Effect on paddy crop and management. *Current Science*. 2009;96(4):581-587.
4. Pandey K, Bargali SS, Kolhe SS. Adoption of technology by rural women in rice based agroecosystem. *International Rice Research Notes*. 2011;36:1-4.
5. Padalia K, Kiran Bargali, Bargali SS. How does traditional home-gardens support ethnomedicinal values in Kumaun Himalayan bhabhar belt, India? *African Journal of Traditional, Complementary & Alternative Medicines*. 2015;12(6):100-112.
6. Parihaar RS, Kiran Bargali, Bargali SS. Status of an indigenous agroforestry system: A case study in Kumaun Himalaya, India. *Indian Journal of Agricultural Sciences*. 2015;85(3):442-447.
7. Rowe, Randall C. Potato health management. Dept. of Plant Pathology, Univ. of Wooster, Ohio, U.S.A. 1993;178.
8. BBS. Statistical pocket book of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Govt. of Peoples' Republic of Bangladesh; 2014.
9. BBS. Statistical Pocket Book of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Govt. of Peoples' Republic of Bangladesh; 2007.
10. Gomez KA, Gomez AA. Statistical procedures for agricultural research. (2nd eds) John Wiley and Sons. Inc., New York. 1984;680.
11. Abbasi KS, Masud T, Gulfranz M, Ali S, Imran M. Physico-chemical, functional and processing attributes of some potato varieties grown in Pakistan. *African J. of Biotechnology*. 2011;10(84):19570-19579.
12. Munira S, Hossain MM, Zakaria M, Ahmed JU, Islam MM. Evaluation of potato varieties against salinity stress in Bangladesh. *International J. of Plant & Soil Science*. 2015;6(2):73-81.
13. Hillman JR. Apical dominance, In: Wilking, M. B. (ed). *Advanced plant physiology*. Pitman, London. 1984;127-184.
14. Schoch PG. Effects of shading on structural characteristics of the leaf and yield fruit in *Capsicum annum* L. *J. Amer. Soc. Hort. Sci.* 1972;97(4):461-464.
15. Kirk WW, Marshall B. The influence of temperature on leaf development and growth in potatoes in controlled environments. *Ann. Appl. Biol.* 1992;120: 511–525.
16. Ng N, Loomis RS. Simulation of growth and yield of the potato crop. *Simulation Monogr. Ser. Pudoc, Wageningen, the Netherlands*; 1984.
17. Manrique LA, Bartholomew DP, Ewing EE. Growth and yield performance of several potato clones grown at three elevations in Hawaii: I. Plant morphology. *Crop Sci.* 1989;29:363–370.
18. Benoit GR, Grant WJ, Devine OJ. Potato top growth as influenced by day–night temperature differences. *J. Agron.* 1986; 78:264–269.
19. Nandal DPS, Hooda MS. Production potentials of some agricultural crops under different Spacings of poplar. *Indian J. Agrofor.* 2005;7(1):16-20.
20. Malik MS, Surendran C, Kailasham K. Predicting growth of *Eucalyptus globulus* under Agroforestry plantation. *Indian J. For.* 2005;7(1):57-61.

© 2016 Rahman et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
 The peer review history for this paper can be accessed here:
<http://sciencedomain.org/review-history/16325>