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BIODIVERSITY AND INTERCROPS OF CITRUS SPECIES AT SREEMANGAL UPAZILA UNDER MOULVIBAZAR DISTRICT OF BANGLADESH

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ABSTRACT

Citrus biodiversity is decreasing day by day although citrus is a major fruit crop in Sylhet region. Hence, a study was conducted at Sreemangal upazila of Moulvibazar district during September 2015 to June 2016 to determine the biodiversity of citrus species and intercrops in citrus orchard. Data were collected from three villages of Sreemangal upazila through face to face interview of 60 respondents and field observation. Eighty percent respondents opined that acid lime was the dominant citrus species followed by zinger lime (75%). But field observation indicated that 100% farmers were cultivating elachilebu followed by zinger lime (75%) and acid lime (45%). High diversity (H'= 0.85) of citrus species was observed ranging from 0.80 (Bisamoni) to 0.93 (Doluchara). Total 25 kinds of annual and perennial fruits, vegetables, spices, timbers and ornamental plants were intercropped in citrus orchard, among which chili was the highest (58.33%) followed by papaya (50%) and banana (40%). About 82% farmers opined that the availability of lemon was the highest. Rough lemon (66.67%) was the highest as rarely cultivated species followed by Orange (55%). Lemon (21.67%) was the highest risk as endangered citrus followed by Sweet lime (20%). Lime (31.67%) was the highest as critically endangered position. Citrus leaf miner was the most serious problem as opined by 34.67% respondents which was also observed in the field. Die back, citrus canker and sunburn were the highest disease infestation as opined by 20% of the respondents while field observation noticed that 30% citrus orchards were affected by canker. Disease and insect pests were the major problems causing genetic erosion of citrus. Training should be provided to the farmers on citrus orchard management and importance of citrus biodiversity by GO and NGOs to conserve citrus biodiversity at the farm level.

Keywords: Biodiversity, citrus, conservation, genetic erosion, intercrop

Introduction

Citrus belongs to the family Rutaceae. The genus citrus has 17 species distributed throughout the tropical and temperate regions (Chutia *et al*. 2009). All commercially important citrus species were believed to originate in Southeast Asia (Janick *et al.*1981, Whiteside *et al.* 1988) which has greater varietal diversity than anywhere in the world (McPhee 1967). Citrus is currently grown throughout the world, particularly well in areas where rainfall or irrigation is sufficient to sustain growth, and freezing conditions are not severe enough to kill the tree (Whiteside *et al.* 1988).

The citrus production in Bangladesh is gradually increasing over the years. According to FAO, Bangladesh ranked the 52nd position in the world contributing about 0.1% of total citrus production (FAO 2016). Since 2014, Citrus production in Bangladesh has been growing at 1.4% per year (https://www.nationmaster.com/nmx/timeseries/bangladesh-citrus-production). About 1,38,064 metric tons of citrus fruits were produced in the country during 2016-17 from 21000 hectares of land (BBS 2017). The high demand of citrus fruits exists in both domestic and overseas market. Now a days, Bangladesh is exporting citrus to UAE, UK, EU, Germany, France and Netherlands. The main exportable citrus fruits are lemons and limes like Zinger lime, Lemon, Citron, Acid lime, and Large-winged orange (Anon. 2013). Greater Sylhet region has diversified ecosystems like hills, hillocks, haors and plain lands and rich in citrus biodiversity.The major citrus growing areas in Sylhet division are Rajnagar, Baralekha, Kamalganj, Sreemangal, Kulaura, and Juri Upazilas under Moulvibazar district (AEZ 22, 29). Bahubol and Chunarughat upazilas of Hobigonj district (AEZ 19, 21, 22); Jaintapur, Gowainghat and Beanibazar upazila of Sylhet district (AEZ 20, 22, 29) comprising of 74% area and 84% production of Sylhet division and 13.3% area and 9.79% production of Bangladesh, respectively (BBS 2017).

The atmosphere and soil condition of Sreemangal upazila under Moulvibazar district are congenial for the growth and development of citrus fruits. Citrus cultivation was being practiced by the people in these areas from time immemorial, though the practice was not commercial basis. Recently, some of the farmers are cultivating citrus commercially. Several types of citrus fruits with variable size, shape, color, scent and use etc. are found in Sreemangal upazila under Moulvibazar district. Due to human intervention indigenous citrus biodiversity having medicinal and therapeutic values are being extinct and thus citrus biodiversity is decreasing with time. A little research was conducted at Jaintapur upazila on citrus biodiversity by Roy *et al*. (2014) who reported that some of the indigenous citrus species like, kotlebu, sulanglebu, kolombulebu (lime) and tuna lebu were going to extinct due to disease and insect pest infestation. However, there is no well documented systematic research on indigenous citrus biodiversity and their production system in greater Sylhet region. Keeping this view in mind the present study was undertaken to observe the diversity of citrus species and intercrops being practiced with citrus by the farmers in Sreemangal upazila.

Materials and Methods

The study was conducted during September 2015 to June 2016 at Sreemangal upazilla in Moulvibazar district. Sixty farmers having citrus orchards from three villages like, Doluchara, Bisamoni and Radhanagar under Sreemangal upazila of Moulvibazar district were used as sample farmers.

The primary data were collected by (i) direct observation; (ii) face to face interview and (iii) record kept by the farmers. Data were collected through farm visit and personal interviewing with a purposive sample of 60 households. The head of the households were interviewed with the use of an informal and semi-structured questionnaire. Information on available citrus species (past and present), causes of extinction and intercrops were collected. Twenty citrus farmers were selected as respondents from each of the villages from the selected upazila. The data obtained from farmers' opinion were cross-checked and compared with the data of *in-situ* observation in the farmers' field.

Collected data were analyzed by using Microsoft Excel software. The Shannon-Weaver Diversity Index (H′) was used to measure the existing citrus species diversity. The H′ ranges from 0 to 1, where 1 indicates the maximum diversity. The higher the diversity index, the more diverse the population. The H′ values ≥ 0.75 indicates the high diversity, H′= 0.50-0.75 indicates moderate diversity and H′ ≤0.50 indicates the low diversity (Jamago 2000). Shannon-Weaver Diversity Index (H′) was calculated by using the following formula of Yu Li *et al.* (1996):

$$H' = \sum_{i=1}^{n} [\frac{\text{PixLog(Pi)}}{\text{Log(N)}}]$$

Where, P_i is the proportion of the total number of entries belonging to the i^{th} class and n is the number of phenotypic classes of plant species. N is the number of phenotypic classes. The H′ for each of the village and plant species practiced as intercrops was calculated by using Microsoft Excel. All possible causes of genetic erosion of citrus biodiversity were documented. The citrus farmers and orchards were selected with the help of BARI scientists and DAE personnel along with progressive farmers in the study areas.

Results and Discussion

A total of 15 citrus species were found in study area. Eighty percent respondents opined that kagzilebu (acid lime) was the dominant citrus species in the study area followed by adazamir (75%), elachilebu (lemon) (50%) and batabilebu (pummel) (48.33%). On the contrary, during field visit it was observed that 100% farmers were cultivating elachilebu (lemon) followed by adazamir (zinger lime) (75%), batabilebu (pummel) (48.33%) and kagzilebu (acid lime) (45%) (Table 1).

The average high diversity (H'= 0.85) of citrus species was found in the study area. The diversity of citrus species in the study area ranged from 0.80-0.93. Among the studied villages, Doluchara had the highest citrus species diversity (H'=0.93) and the lowest (H'=0.80) in Bisamoni (Figure 1).

Farmers' opined that most importance for citrus species conservation was related to food item as fruit and salad or pickle (90%) followed by subsistence family income (80%), soil erosion control (77%) and boundary plants (75%). Only 25% of the farmers responded that the citrus fruits could be used as medicinal purpose, though most of them were not concerned about that. Yet most of the respondents evaluated the citrus as being "less important"

Table 1. Citrus species in Sreemangal upazila of Moulvibazar district during 2015-16

Common/ Local name	English name	Scientific name	Existing in Farmers' field (%)	
			Farmers' opinion	Field Observation
Kagzilebu	Acid lime	*Citrus aurantifolia*	80.0	45.00
Ada jamir	Zinger lime	*Citrus assamensis*	75.0	75.00
Elachilebu	Lemon	*Citrus limon*	50.0	100.00
Batabilebu	Pummelo/ Shaddock	*Citrus grandis*	48.33	48.33
Kata jamir/Kata lebu	Citronelle/ Rough lemon	*Citrus jambhiri*	35.0	35.0
Zara lebu	Citron	*Citrus medica*	28.33	23.33
Karun jamir	Indian lemon	*Citrus aurantium*	0	0.00
China lebu	Chinese lemon/Sylhet lime/ Gandharaj lemon	*Citrus limonia*	20	15.00
Komolalebu	Orange	*Citrus reticulata*	15	8.33
Sorbatilebu	Sweet lime	*Citrus limetta*	15	10.00
Malta	Sweet orange	*Citrus sinensis*	15	6.67
Kolombolebu	Lime	*Citrus sp*	7.5	10.00
Satkara	Large-winged orange	*Citrus macroptera*	5	3.33
Deshi/ Gotha lebu	Lemon	*Citrus limon*	3.33	10.00
Patilebu	Lemon	*Citrus limon*	0	0.00

Total sum over 100% due to the multiple responses received from same farmer.

as a means of source of medicinal plants (41%) followed by fire wood and others (30%) (Table 2). So, it appears that there is still lack of knowledge in these two categories. Therefore, institutional training programs are necessary to facilitate improvement of knowledge of the respondents in the study area.

A total of 25 kinds of annual and perennial like, fruit trees, timbers, vegetables, narcotics and ornamentals were intercropped in citrus orchard. Among them fruit species (8) ranked the top followed by vegetables (4) and ornamentals (4). The average diversity index of intercrops was 0.68. Low to high diversity of intercropped plant species (H'= 0.24-0.76) was observed in citrus orchard.

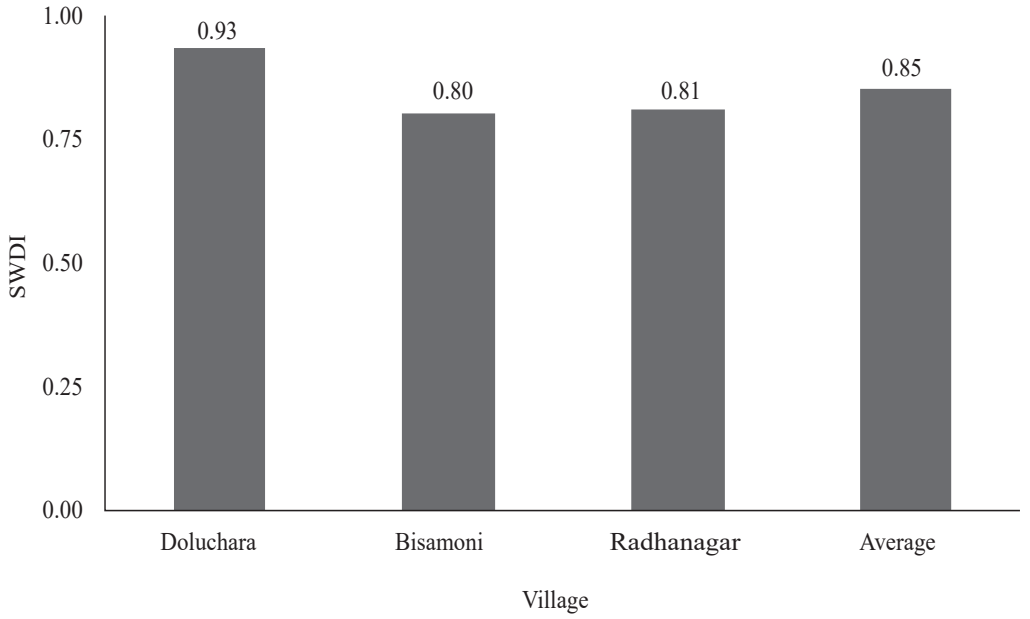


Figure 1. Shannon-Weaver Diversity Indices (SWDI) of citrus species at different villages of Sreemangal upazila under Moulvibazar district during 2015-16.

Table 2. Importance of citrus species conservation as opined by the respondents (%) in Sreemangal upazila of Moulvibazar district

Items	Very important	Less important	Not important
Salad/pickle and fruit	90	10	0
Subsistence family income	80	15	5
Soil erosion control	77	13	10
Boundary plants	75	25	0
Ornamental, spiritual and other purpose	60	30	10
Firewood	50	30	20
Medicinal value	25	41	34

Among the intercrops the biodiversity of fruit species was the highest (H'= 0.76) followed by ornamentals and vegetables (H'= 0.76 and 0.55 respectively) (Table 3).

Mostly chili (58.33%) was intercropped in citrus orchard followed by papaya (50%), banana (40%), ginger (33.33%), areca nut and sponge gourd (25%), pineapple and betel leaf (20%). Most of the annuals and perennials were intercropped in citrus orchard for home consumption and more income (Table 4). Uddin *et al*. (2005) reported that fruits, vegetables and other enterprises were practiced as intercrops with coconuts in the Philippines as commercial purpose. Fernandez (2002) reported that the incomes from coconut farm were much higher when the farmers intercrop coconut with food and cash crops under a technique that was called coconut based farming system (CBFS). The survey of CBFS indicated that 16 kinds of annuals and perennials were suitable for intercropping which included fruit trees, vegetables and other crops. The findings of Fernandez (2002) and Uddin *et al*. (2005) corroborate the present findings. Intercropping of other fruits and vegetables with citrus as commercial purpose might be called citrus based farming system (CBFS) in Sylhet region.

About 82% farmers opined that elachilebu (lemon) was the highest in readily available condition followed by adajamir (zinger lime) (71.33%), zaralebu (citron) (66.67%), batabilebu (pummelo) and kagzilebu (acid lime) (63.33%). Most of the farmers opined that kata zamir (rough lemon) (66.67%) was the highest in rarely available condition followed by komola (orange) (58.33%) and satkora (large winged orange) (55%). Deshi lebu (lemon) (21.67%) was the highest in endangered position followed by sorbati lebu (sweet lime) (20%). Kolombo lebu (lime) (31.67%) was the highest in critically endangered position followed by pati lebu (23.33%) (Table 5). The present finding is supported by Roy *et al*. (2014).

Several reasons were responsible for the genetic erosion of citrus species. Twenty percent farmers opined that diseases and pest infestation were main reasons behind citrus species erosion followed by poor market price (10%)) (Table 6) which is also supported by Roy *et al*. (2014).

Nine problems were identified as the constraints of citrus cultivation (Table 7). Infestation of insect pest and diseases ranked the first as perceived by the respondents. The government and non-government organization should

Table 3. Plant biodiversity maintained as intercrops in citrus orchard at Sreemangal upazila of Moulvibazar district

Plant type	No. of species	RA (%)	SWDI
Fruit	8	32	0.76
Vegetable	4	16	0.55
Ornamentals	4	16	0.56
Spices	3	12	0.40
Narcotics	2	8	0.30
Timber	2	8	0.24
Field crops and other plants	2	8	0.30
Total= 7	25	100	0.68

Table 4. Major intercrops maintained in citrus orchard at Sreemangal upazila of Moulvibazar district

Intercrops	Practiced by the farmers (%)		
	No	Percent	Reason
Vegetable and spices			
Chili (Naga morich)	35	58.33	Home consumption and more income
Ginger	20	33.33	Home consumption and more income
Sponge gourd	15	25	Home consumption
Cucurbits (Ridge gourd)	10	16.67	Home consumption
Country bean	6	10	Home consumption
Turmeric	6	10	Home consumption and more income
Fruit plants			
Papaya	30	50	Home consumption and more income
Banana	24	40	Home consumption and more income
Pineapple	12	20	Home consumption and more income
Jackfruit	9	15	Home consumption and more income
Mango	6	10	Home consumption and more income
Litchi	6	10	Home consumption and more income
Narcotic plants			
Areca nut	15	25	Home consumption and more income
Betel leaf	12	20	Home consumption and more income
Timber tree			
Acacia	10	16.67	Home consumption and more income
Total intercrops	15		

Total sum over 100% due to the multiple responses received from same farmer.

provide training for the farmers to solve these problems. Lack of credit facilities ranked the second highest problem in citrus cultivation which could be solved by providing loan to the farmers. Irrigation facility problem due to lack of electricity supply ranked the third highest problem which could be solved by providing electricity supply for the power pump in the study area. Ndung *et al.* (2010) conducted a case study on citrus farming in Kwale District, Kenya and the authors reported that the farmers experienced a number of constraints among which diseases and poor marketing system were ranked the highest. Roy *et al*. (2014) reported that disease and insect pest infestation was ranked the highest followed by environmental problem for genetic erosion of citrus species at Jaintapurupazila. The present finding was corroborated to the findings of Ndung *et al.* (2010) and Roy *et al*. (2014).

Twenty percent farmers opined that die back, citrus canker and sunburn were the highest disease infestation caused loss in citrus cultivation followed by citrus gummosis and leaf rust (10% each). While citrus canker was the highest (30%) followed by die back (25%) noticed through direct field visit (Table 8). Department of Agricultural Extension (2010) reported that die-back, citrus greening, scab, gummosis and citrus canker were important diseases for citrus in Jaintapur upazila. Roy *et al*. (2014) also found the highest infestation of die back in citrus at Jaintapur upazila of Sylhet district. The present findings corroborate the findings of DAE (2010) and Roy *et al*. (2014).

The highest insect infestation was citrus leaf miner (34.67%) followed by bark and stem borer (18.33%). While, direct field visit noticed that citrus leaf miner infestation was highest (80%) followed by mealy bug (45%) (Table 8). Department of Agricultural Extension (2010) reported that citrus leaf miner infestation was the highest followed by leaf roller and bark and stem borer of citrus in Jaintapur upazila. Similarly Roy *et al*. (2014) reported 21.67% leaf miner and 18.33% bark and stem borer problem in the same area which corroborates the present findings.

Although numerous problems were identified in the farmars' field for citrus cultivation respondents had different opinion about the interest of maintaining citrus in

Table 5. Conservation level of different citrus species at Sreemangal upazila of Moulvibazar district

Species	Farmers' opinion (%) on Conservation level									
	Safe		Lower Risk			Threatened			Ex	NR
	RA	Rare	LC	NT	CD	VU	EN	CR		
Elachilebu	81.6	19.3								
Ada jamir	80	20								
Zara lebu	71.3	10.3	10							8.3
Batabilebu	66.6	33.3								
Kagzilebu	63.3	30.6				6.0				
Satkara	35	55				10				
Komola	25	58.3				10	6.6			
Kata jamir	25	66.6				8.3				
Deshilebu	25					30	21.6	6.6		16.6
Chinese Komola	20		25.6							54.3
Katacharalebu	15	33								52
Patilebu	10					13.3	18.3	23.3		
Kurunjamir			38.3			23.3	10.6			28.6
Sorbatilebu						6.6	20	15		57.3
Kolombolebu						0	11.6	31.6	28.3	
Kotlebu			8.3							91.6
Sulanglebu										100
Tuna lebu			33.3							66.6
Total	12	9	5	0	0	8	6	4	1	9

RA-Readily available, LC-Least Concerned, NT-Near Threatened, CD- Conservation Dependent, VU-Vulnerable, EN-Endangered, CR-Critically endangered, EX-Extinct, NR-No response. Total sum over 100% due to the multiple responses received from same farmer.

Table 6. Causes of reduction of citrus species at Sreemangal upazila of Moulvibazar district

Causes of genetic erosion	Farmers' Opinion	
	Frequency	Percent
Diseases and pest infestation	12	20.0
Diseases and pest infestation, inadequate demand & poor market price.	6	10.0
Poor market price	6	10.0
Less interest	5	8.3
Unavailability of land	5	8.3
Poor yield & inadequate demand	4	6.6
Soil erosion	4	6.6
Environmental problem	4	6.6
Diseases and pest infestation, cutting down of citrus plants during construction of house & die after maturity.	4	6.6
Cutting down citrus plants for construction of house	4	6.6
Replacement through other field crops	2	3.3
Cutting down old/unproductive plants	2	3.3
Do not bear fruit	2	3.6
Replacement through other fruit crops	0	0
Total	60	100.0

Table 7. Problem faced by the respondents during citrus cultivation at Sreemangal upazila of Moulvibazar district

Problem faced by the respondents	Ranking	Farmer's expectation
Infestation of insect pest and diseases	1	Providing training on management of insect pest and diseases
Lack of credit facilities	2	Providing credit loan at lower rate of interest
Drought/Irrigation facilities during dry period	3	Supply electricity for operating the power pump
Quality planting materials of citrus species	4	Providing good quality planting materials /sapling in proper time
Death of citrus trees before/after being maturity	5	Providing training through the execution of Govt. and non Govt. organization
Unavailability of quality pesticides	6	Chemicals require to treatment plants should be economical and available
Difficulties in marketing system of product	7	Improve marketing communications channel and controlling middlemen syndicate
Difficulties in post-harvest processing of product	8	Providing training on post-harvest operation
Lower price of the product	9	Providing subsidy by the Government
Technical knowledge & training	10	Providing training on citrus cultivation
Soil erosion	11	Providing training on management (prevention/control) of soil erosion
Lack of electricity for irrigation pump	12	Providing electricity through PDB for irrigation pump
High price of input like fertilizers and pesticides	13	Availability of citrus production input at lower price
Don't bear fruit in some plants	14	Suggest management package and supply quality sapling

Table 8. Disease and Insect pest infestation in citrus plants at Sreemangal upazila of Moulvibazar district

Disease and Insect	Farmers' opinion (%)	Field Observation (%)
Disease		
Die back	20	25
Gummosis	13.33	5
Citrus canker	20	30
Scab	6.67	15
Leaf rust	10	10
Sun burn	20	15
No responses	10	-
Insect		
Citrus leaf miner	34.67	80
Bark and stem borer	18.33	15
Leaf roller	10.0	25
Lemon butterfly	8.3	34.33
Orange bug	8.3	10
Aphid	6.7	25.50
Mealy bug	6.7	45
Scale insect	5.0	15
Termite	5.0	10
No response	10.0	

Total sum over 100% due to the multiple responses received from same farmer.

their farm. Half of them opined that they were interested in maintaining citrus orchard because of soil/land suitability (50%) for citrus growing followed by high yield and more income (25%) (Table 9).

Conclusion

A total of 15 citrus species and 25 kinds of annual and perennial fruits, vegetables, spices, timbers and ornamental plants were intercropped in citrus orchard of Sreemangal Upazila. Elachilebu (lemon) was the highest in readily available condition and Kolombolebu (orange) was the highest in critically endangered position. Infestation of disease and insect pest, lack of irrigation facility and lack of electricity supply were the major problems in citrus cultivation which were remarkable reasons for citrus species reduction. Providing training on insect pest management, irrigation facility and incentives to the farmers could help in conserving the biodiversity of citrus.

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Table 9. Reasons for farmers interest in maintaining citrus in their farm

Causes of interest	Farmers' perception		
	Frequency	Percent	Ranking
Soil/Land suitable for citrus	30	50	1
High yield and profitable/more income	15	25.0	2
Don't want to change their ancestors' establishment/occupation	5	8.33	3
Personal satisfaction	5	8.33	3
Year round production and longevity for the benefit	2	3.33	4
Lower maintenance cost	1	1.67	5
Environment suitable for citrus	1	1.67	5
Lack of money for other crops	1	1.67	5

Total sum over 100% due to the multiple responses received from same farmer.

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