Key Factors Affecting Citrus Production in Chhukha District of Bhutan

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Abstract

This study aimed to identify the key factors affecting citrus production in the district and recommend interventions to enhance production. Primary data were obtained from 99 households exclusively of citrus growers and eight extension workers using semi structured interview form. Results of the growers indicated lack of key management practices namely chemical fertilizer application, irrigation practices and non-use of plant protection chemicals against the important pests and diseases and steep orchard topography as the key factors. Extension workers' perspectives showed consistent results where the lack of fertilizer use irrigation practice, pest and disease control practices and the steep orchard topography as the key factors. In addition, all of extension agents claimed citrus greening was the principle cause of citrus quick decline. Citrus greening was part of the problem; productions were easily overwhelmed by fruit fly; trunk borer; powdery mildew and old orchards. Practical education programs through study tours, field days, demonstrations and trainings are necessary to enhance knowledge and skills of extension agents and the farmers. Signature intervention and approaches of central authorities are required to guide extension services related to choice of right promotion and adoption of technologies and changing the perception of clients about the sustainable and productive livelihood practices on citriculture.

Keywords: Citrus Production; Extension services; Factors affecting; Citrus management Practices

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Introduction

Bhutan is endowed with wide range of agro ecological zones, a natural resource base for the production of a variety of horticultural crops (Joshi & Gurung, 2009). Citrus is among the most important horticultural crops cultivated over 5618 hectares (Department of Agriculture, 2016) in 17 of 20 districts of Bhutan (Dorji, Lakey, Chophel, Dorji, & Tamang, 2016). Of the varieties of citrus cultivated in the country, mandarin is the only type commercially cultivated. Thus, native Bhutanese refer citrus to mandarins (*Citrus recticulanta* Blanco), valued for source of livelihood for over 60 percent of the rural population (Joshi & Gurung, 2009).

Citrus contributes to the Bhutan's economy through revenue, employment opportunities and foreign exchange. Bhutan exported citrus worth *Ngultrum* (Nu.) 439.1 million and reported its production at 42,700 metric tons (mt) (Ministry of Agriculture and Forest, 2016). Development of transport infrastructure, road net-works and trade relations with the neighboring countries of India and Bangladesh, provides added opportunity to increasing citrus production to a broader economic scale (Ministry of Economic Affairs, 2015). However, citrus industry in Bhutan is constrained by the lack of improved management practices and dominated by traditional system of management (Dorji et al., 2016). Similarly, Neuhoff, Tashi, Rahmann, and Denich (2014), stated that Bhutanese agriculture is marked by smallholder and primitive farming practices. The nature of this unfavorable production environment results in low yield and high production costs, thus poor competitiveness. Thus, they suggest common constraints of low agricultural productivity is a result of low soil fertility and other factors such as labor shortage, low quality seed, poor management practices, lack of techniques and knowledge , and poor infrastructure.

Chhukha is one of the six largest citrus districts in the country (Joshi & Gurung, 2009). According to Dr. Thinley, National Plant Protection Centre, Simtokha (personal communication, September 13, 2016), citrus in the district is declining particularly in areas below an elevation of 1500 meters. The decline is most severe in Bongo, Lower Darla, Lokchina, Phuntsholing and Sampheling. On the other hand, Bhutan government is on constant effort both through international support and at its own capacity to maintaining citrus industry as the national subject (Ministry of Agriculture and Forest, 2013). In the face of declining yield problems, the paucity of information calls for more research studies particularly confined to localized situations such as Chhukha district. This study attempts to determine key factors affecting citrus production in Chhukha district and suggest field of interventions based on the findings.

Nevertheless, this study is anticipated to contribute with information for anyone in pursuit, the quest for knowledge and use of the information

Materials and Methods

Study Area and Sampling

The sampling frame of the study was citrus growers in five of 11 *gewogs* (blocks) in Chhukha district namely Bongo, Darla, Lokchina, Phuntsholing and Sampheling *gewogs.* List of citrus growers were asked from respective block Extension Officers. Sample size of 99 households was determined by using Arkin's sampling technique (Arkin, 1974). For better sample composition, growers' population was categorized into small, medium and large groups having 20–100 trees, 100–300 trees and 301 or more trees respectively from which proportionate samples were drawn using simple random sampling technique.

$$n = \frac{P(1-P)}{(SE/t)^2 + P\{\frac{1-P}{N}\}}$$

Where, n = Sample size, N = Total Population, P = Proportion in the population (.95)
SE = Standard error (.04), t = testing statistical value (1.96)

Research Tool

The research instrument for the grower respondents involved semi structured interview comprised of baseline information on household characteristics of the citrus growers, orchard information, management practices, challenges faced in citrus production and recommendation. Similarly, for extension agents of the respective blocks selected for study site involved semi structured questionnaires comprised of production trend of citrus, problems and challenges faced in citrus production and their recommendations.

Data Collection

Interview forms were pretested on non sample citrus farmers to gain firsthand experience and pursue required corrections. Vast majority of the district farmers cannot speak and read English thus; face to face interview in local languages was carried out. Data from block agricultural extension agents were collected online by mailing the questionnaires to the respective extension agents. The general description of sample respondents as obtained from interview data were reported in Table 1.

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Table 1 General description of respondents in categories by orchards size

	Characteristics	Category of orchards		
		Small	Medium	Large
1	Average labor force (person)	3.3	3.3	3.78
2	Respondents gender(n=99			
	Female	16	14	11
	Male	32	9	17
3	No. of trees	42 (<100)	27 (101-300)	16 (≥301)
4	Literacy level of respondents			
	Lower secondary	4	1	5
	Upper secondary	1	-	-
	Primary school	6	4	1
5	Labor force by age (n=388)			
	15–64 years (%)	42	18	26
	65 years and older (%)	7	5	3

Data Analysis

Descriptive statistics were used to characterize socio economic information, adoption of management practices and various responses of the growers and extension agents. The statistical package for social science (SPSS) version 24 and Microsoft excel spreadsheet was used to analyze the data. Chi-square tests of independence were used to investigate association between production trend and various factors. The results of the analysis were presented in tables and graphs.

Results and Discussion

Factors Affecting Citrus Production Based on Respondents' Data

Chi-square tests of independence in Table 2 present results of association between production trend and 22 different factors. The test results showed significant association between production trend and the lack of key management practices namely lack of use of chemical fertilizers ($\square^2$ (1) = 23.740, p = .000), lack of irrigation practices ($\square^2$ (1) = 11.121, p = .001) and lake of use of plant protection chemicals against the important pest and diseases indicated by constant responses. Rugged topography and altitude of the orchards also accounted major challenge faced by citrus farmers in the district ($\square^2$ (1) = 4.021, p = .045).

Table 2 Factors affecting citrus production from growers' context

Factors	Production trend (n=99)			
	χ^2	df	*p*	Phi
Fertilizers application	23.740	1	.000*	-.490
FYM application	1.633	1	.201	-.128
Powdery Mildew	.026	1	.873	-.016
Fruit drop problem	.805	1	.370	-.090
Pest and disease control	Constant data, no use of PP chemical			
Greening problem	1.272	1	.259	-.113
Training received	.116	1	.733	-.034
Extension visit	1.633	1	.201	-.128
Illiteracy	.583	1	.445	.077
Irrigation	11.121	1	.001*	-.335
Steep orchard land	4.021	1	.045*	.203
Tree age 1–9	.096	1	.756	-.031
Tree age 10–20	.662	1	.416	-.082
Tree age 21–30	.517	1	.472	.072
Tree age 31–50	.454	1	.501	.068
Tree age ≥ 50 years	.179	1	.672	.043
Orchard perished	.737	1	.390	-.086
Certified seedling	.911	1	.34	.096
Buy local seedlings	1.389	1	.239	.118
Produce own seedlings	.116	1	.733	-.034
Government promotion	.423	1	.515	-.065
Orchard layout pattern	.336	2	.845	.058

* $p < .05$

Factors Affecting Citrus Production from Extension Agents' Perspectives

Concern over extreme decline in citrus production was common amongst extension agents. As presented in figure 1, results of the extension perspectives on factors affecting citrus production showed that citrus greening disease (100%), Chinese citrus fly *Bactrocera minax* (Enderlein, Diptera and Tephrrtidae) (100%) and trunk borer (50%) were major citrus plant pathological and entomological problems responsible for citrus quick decline in the district.

The lack of fertilizer application (100%); irrigation (88%) and non use of plant protection chemicals against the most devastating pest and diseases (88%) were reported to be the key management practices devoid in large majority of the growers. Steep orchard topography (75%), orchard abandonment (88%) and the old citrus orchards (88%) appeared to be the added problems affecting production.

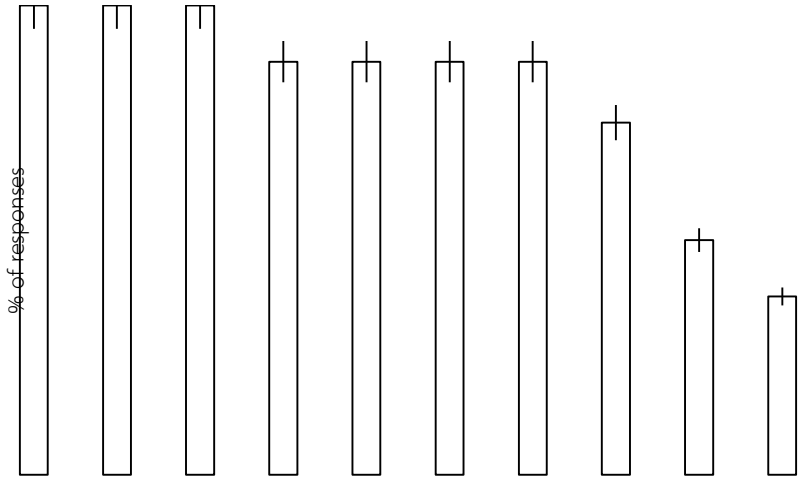

Figure 1 Factors affecting citrus production from extension workers' perspectives

The findings from this study suggest four major factors affecting citrus production in Chhukha district. (i) Citrus greening disease as the cause of citrus quick decline (ii) Acute problem of citrus fruit fly and trunk borer (iii) Predominantly steep topographical features of the orchard lands (iv) Lack of key management practices namely lack of fertilizer application, irrigation and the lack of pathological and entomological control practices particularly non use of pesticides against the important citrus pest and diseases. Each of these factors is discussed with supporting evidence in the following.

Possible measures to increase citrus production would be augmenting the areas of production, the quality and quantity of fruits produced. However, perished and abandoned orchards indicated one core reason for declining citrus production in the district. The ratio of the existing number of trees to those that have perished was 19852:9842.The accelerated decline in trees over the years was a common concern of the growers. Figure 2 shows the total number of citrus trees under existing and perished group. Over 33 percent of the total citrus trees had perished due to the greening disease in the district so far.

In figure 2, the number of abandoned trees was separated from those that have died since abandoned trees are a major source of pests and diseases to the managed orchards thus, suggesting measures. In terms of area coverage those perished citrus trees easily cover over 82 acres of citrus orchard. Estimates indicated that the total acreage of perished trees has the potential to produce over 142 mt of citrus fruit annually under current management conditions, a dramatic reduction in production annually.

Growers were observed familiar with consequences of any further venture in expensive management practices could result in negative economic return and thus, management were limited to what was affordable within their pool of resources. The most affordable cultural practices were rough mowing, removal of loranthus and application of animal manure through animal tethering or use of farm yard manure (FYM). As a matter of fact that perplex scenario of citrus trees continuing to plummet with majority of the orchards, the concept of economic threshold virtually forms central to their move in deciding any improved management practices recommended by their extension agents.

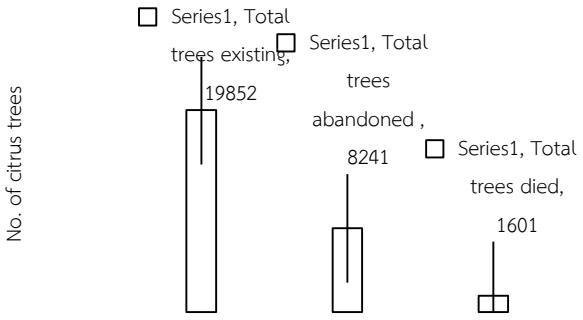

Figure 2 Total existing, abandoned and perished citrus trees

Analysis showed eight challenges of citrus production faced by the growers (figure 3). Citrus greening was the colossal problem affecting citrus production even from the growers' own knowledge as technically claimed by extension agents. Concerns were major among all the growers but makes sense unless the adoption of scientific management practices are ensured. The future of Chhukha citrus depends on a breakthrough in the fight against greening disease through adoption of improved management practices by growers and strict policy support of the government particularly in legislative control, eradication and replacement of infected plants and control of vectors. Chinese citrus fly *Bactrocera minax* (Enderlein, Diptera

and Tephrrtidae), trunk borer and powdery mildew remain problems unaddressed. The damage due to the fruit fly was reported anywhere between 30–50 percent.

Steep land topography was indicated as the single most limiting factors affecting the adoption of technologies not only in citriculture but agriculture in general. It is beyond technical and financial capability of the growers to construct contour-trench or terracing systems of orcharding, thus, soils are exposed to rapid surface erosion making it a poor nutrient reserve in the soil for plants' growth and development. None of the growers claimed to have used counter pattern of orchard layout and was practically not observed.

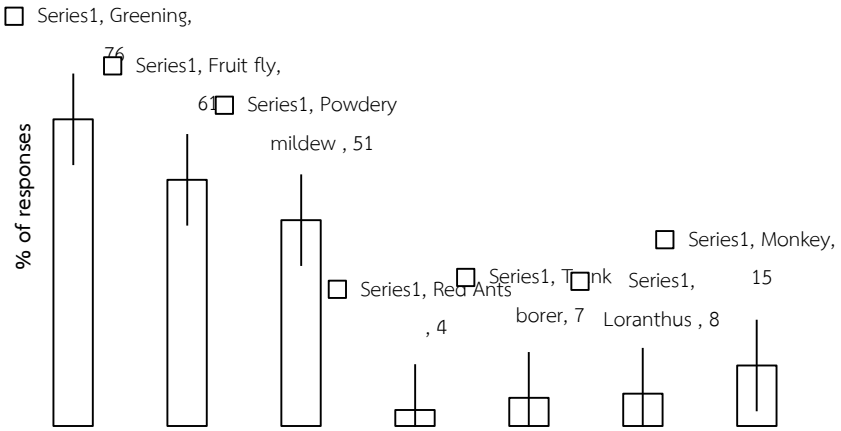

Figure 3 Common problems of citrus production faced by citrus growers

Largely 64 percent of the growers categorized their citrus orchards located on steep slope. Sample measurements indicated slopes greater than 25 degree were what most growers referred to this category and orchards as steep as 45 degree or more were seen. The adverse impact of steep orchard topography is not only the bottleneck for operation of technical management practices, but also soil are infertile with low soil organic matter content and low in calcium and magnesium (Soil Fertility Unit, 2008). Growers claimed they were neither aware nor recommended for feasibility of the orchard lands. In consequence, the growers must use their own judgment in designing and handling their groves referred to as traditional method.

Soil fertility factors, conditions and drainage play an important influence on citrus tree health, quantity and quality of citrus fruits (Alva & Tucker, 1999). The only concept of management to the vast majority of growers exclusively refers to providing orchards a rough mowing once or twice a year. Other aspects of key management are missing. Soil fertility factor is one key management aspects completely unaddressed. This takes a revisit to previously described steep orchards as one major constraint. Soils on steeply sloped lands are poor in

organic and inorganic particles which contain a reserve of nutrients in organic and inorganic form (Soil Fertility Unit, 2008). Added to the poor soil condition of steep nature of the orchard topography is the growers' deliberate use of traditional soil fertility management systems based on the inefficient use of animal manure .This delivers primary explanation for the low productivity of citrus farming in the district. It is the kind of harvest one would expect from such soil lacking supplementary nutrition over a long period of time. Practices in amount of FYM used in a year deviated from one to five kilogram, five to ten kilogram (kg) per trees to no use of FYM at all as shown in figure 4. Application timing of FYM showed larger segregation as well.

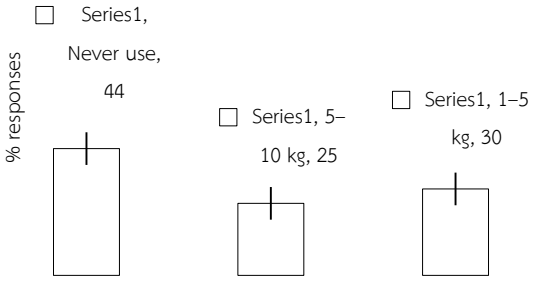

Figure 4 Annual use of FYM in kg/tree irrespective of tree age.

Farmers did not overlook the use of chemical fertilizers. Lack of techniques, knowledge and unavailability were the primary reasons for ignoring their use. Growers claimed to have used chemical fertilizers but, encouraged continuity failed as the result of a good initial impact. Analysis identified seven principle causes of hindering use of chemical fertilizers (Figure 5). One surprising result was the killing of trees by fertilizers, thus there is a need for more demonstration on the judicial use and benefits of chemical fertilizers.

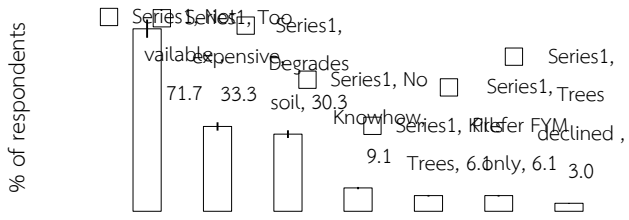

Figure 5 Respondents' reasons for not using chemical fertilizers by citrus growers

Irrigation in citrus groves was largely dependent on seasonal rainfall and knowledge of improved water management practices was limited in majority. Endeavors in improved weed and pest control, pruning, and fertilization do not result in higher yields if irrigation is not satisfactory. It is only when all other management practices are combined with good irrigation management can the growers realize the benefits fully (Boman, Levy, & Parsons, 1999). The respondents suggested supplementary irrigation if practiced would be anywhere from November to April since there was a little or no rain fall during these periods. Ninety six percent of the growers never irrigate their citrus trees although 47.5 percent understand irrigation to be the most important aspect of cultural practices. Lack of water source, techniques, knowledge and equipments were the main reasons claimed. Citrus canopy management (CCM) was observed a focused research-extension intervention which is good but it's a part of the practices. To encourage planning and practices, integrated canopy management in citrus production (ICCM) is felt an appropriate tweak over CCM. ICCM must involve integration of key management practices including integrated vegetation management (IVM) in citrus production put forth by (Tucker & Singh, 1999) which involves the selection, integration, and implementation of effective vegetation management strategies in the light of ecological, sociological, economic and environmental consequences.

Conclusion and Recommendations

Citrus production in Chhukha district was reported an extreme decline over the years. Extension agents technically claimed citrus greening to be the principal cause of production decline. The productions from existing orchards were easily overwhelmed by lack of key management practices namely non use of plant protection chemicals against economic pest and diseases, irrigation, chemical fertilizers and the two major citrus pest, citrus fruit flies and trunk borers. Steep geographical terrain of the orchards is one hidden factors which hinders adoption of management technologies. Lack of knowledge and awareness in growers and poor approaches in extension services were the main cause of failure in technology adoption.

Approach to convinced adoption of recommended orchard design through development of land development guidelines specific to citrus orchards was seen as the first step in developing a successful citriculture. Options for rain water harvesting should be explored where water sources are lacking and demonstrations on high efficiency irrigation system are the better ways to get the message on benefits of improved irrigation practices.

The establishment of real-time demonstration and model orchards in complete package of practices is needed to foster adoption of improved technologies. Research and extension linkage should be revitalized and enhanced to put collective and specialized knowledge to practical use through effective communication and team work. There is an urgent need for signature approaches from central authorities for technical improvement and providing better control mechanism of citrus greening disease.

Abandoned illegal orchards established in government land were reported to be the potential source of pest and diseases. Growers and Extensions suggested initiating ways to destroying these abandoned ownerless citrus trees. Developing practical educational program both for farmers and extension agents must include trainings, demonstrations, field days, study tours, supply of equipments and improved facilities. Quality of improved propagation materials supplied under promotional program should be checked and improved. CCM is intensively being promoted by research and extension workers to boost production. ICCM is a suitable replacement in fostering government authorities to planning and implementation of key management practices for effective and efficient result than the CCM alone

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