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Factors Contributing to Citrus Mandarin Yield Decline in Dewathang Geog under Samdrup Jongkhar Dzongkhag

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Abstract

A study was conducted to determine the factors responsible for yield decline observed in *Citrus reticulata* Blanco (locally known as citrus mandarin) in Dewathang Geog under Samdrup Jongkhar Dzongkhag. Seventy two farmers were randomly selected and interviewed using a structured questionnaire survey. Twenty eight composite soil samples were collected from 14 different citrus mandarin orchards to evaluate soil nutrients. The Chinese fruit fly and the green stink bug were the major causes of fruit drop, causing significant yield loss in 97% of the orchards. Citrus greening disease has completely destroyed three orchards and was observed in 35% of the remaining orchards, posing a serious threat. About 82% of the citrus seedlings were propagated from backyard nurseries, which may have led to the supply of poor planting materials. Majority (86%) of the growers only applied farm yard manure, which may have contributed to the low soil nutrient contents recorded in the orchards. These growers do not practice proper management practices such as pruning, basin making, and spacing. Considering the poor management practices and low soil nutrient status, there is a need to train the citrus growers in soil fertility and good orchard management.

Key words: Citrus, Dewathang, poor management, soil nutrients, yield decline

Introduction

Citrus reticulata Blanco is an important fruit crop grown worldwide. The global average in citrus production was about 70 million metric tonnes (MT) in 2011; with Brazil producing 20 million MT, followed by the USA with 8 million MT, and lowest production by Djibouti with 4 MT (FAO, 2013).

In Bhutan, *Citrus reticulata* Blanco and its cultivars are commonly known as "citrus mandarin" and they are primary source of income for many small farm families. Citrus mandarin is grown in the warm temperate and subtropical regions in 17 *Dzongkhags* (districts). They are generally cultivated on sloping terrains, under poor or limited management practices (Tashi, 2007). *C. reticulata* is the single dominant cultivar and is a leading export commodity in Bhutan with a total volume of 18,372 MT exported to India and Bangladesh in 2012 (BAFRA, 2012).

There are about 3.12 million citrus mandarin trees being grown in the country, of which 1.72 million are bearing fruits and producing about 70,000 MT of citrus mandarin fruits. Samdrup Jongkhar Dzongkhag produced about five percent (3,500 MT) of the total nationwide production ranking seventh by volume in 2011. Citrus productivity has been erratic and declining from 2007 onwards in almost all the *Geogs* (blocks) within the Dzongkhag. The production increased to 7,481 MT in 2006 from 4,614 MT in 2004, but it dropped to 2,842 MT in 2011. Dewathang Geog produced approximately 252 MT of citrus mandarin in 2007 from 11,133 trees. In 2010, the total number of fruit bearing trees had increased to 15,575 but production had decreased to 105 MT. The average yield dropped from 23 kg/tree in 2004 to 7 kg/tree in 2010 (DOA, 2011). This issue of fluctuating citrus mandarin yield, despite the increased number of fruit bearing trees in Dewathang, was raised as a great concern during the 10th Five Year Plan (FYP) mid-term review meeting in 2010. Similar trends have been observed in other Geogs as well.

Studies conducted from other parts of the world have found that yield differences are caused by

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various isolated or combined factors. These factors are not confined to one locality or condition, but differ from region to region depending on geographic and climatic conditions as well as the quality of management practice. Major causes of yield decline are citrus greening, physiological disorders, and nutrient deficiency in Pakistan and Thailand (Vichitrananda, 1998; Batool *et al.*, 2007; Javed *et al.*, 2007), low soil fertility in China (Fang *et al.*, 2010), and lack of planting material, pest and disease, top soil erosion, and poor nutrient management in Meghalaya, India (Srivastava *et al.*, n.d.). In Bhutan, a study carried out by Connellan *et al*. (2007) indicated several possible factors affecting citrus mandarin production. The study, however, was not specific to Dewathang Geog. In the absence of a study conducted at the Geog level, the Geog administration was not able to develop commodity focused plans. The lack of research has also impeded extension personnel from initiating capacity development programmes for the farmers. This study was therefore undertaken to determine the factors responsible for the yield decline of citrus mandarin in Dewathang Geog. It is expected that the findings of the study would be used as the basis for citrus rehabilitation programmes, contributing substantially to improving rural livelihoods.

Materials and Method

The study was conducted in Dewathang Geog under Samdrup Jongkhar Dzongkhag in southeastern Bhutan. The Geog shares its border with Assam, India to the south. It has an area of 174.88 km^2 with a population of about 3,091 people (Census data, 2013). Out of 98 citrus growers in the Geog, 78 growers (80%) were randomly selected for interviews.

From the 78 citrus mandarin growers selected, only 72 were interviewed using a structured questionnaire survey, as 6 growers were not available for the interview. The questionnaire consisted of three parts: Part I consisted of basic information about the orchard (number of trees, location of orchard, production etc.); Part II consisted of symptoms and causes of yield decline (source of seedling, pest, disease etc.), and Part III consisted of the farmer's perceptions about declining yield and production constraints. The questionnaire was pretested and revised before the actual survey. Data on management practices, such as planting distance, basin making, fencing, pest related problems, greening disease vector, and orchard sanitation were collected by directly visiting the orchards. The interviews were conducted during January and February of 2013.

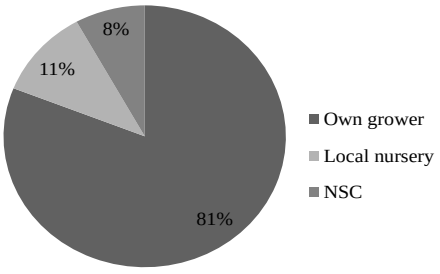

Figure 1. Different sources of planting materials used by farmers

Soil samples were randomly collected from 14 orchards in December, 2012. Samples were collected from 5 – 10 sub samples at 0 – 20 cm and 20 – 40 cm depth using a soil auger. Bulked samples (composite) were analysed for soil pH (1:1.25 soil: water), cation exchange capacity (CEC) (Ammonium acetate extraction at pH 7), organic Carbon (C) (Walkley and Black method), total Nitrogen (N) (Semi micro Kjeldahl method), available Phosphorus (P) (Bray method), available Potassium (K) ($CaCl_2$ extraction), exchangeable Ca and Mg (Ammonium acetate extraction at pH 7). Soil texture was determined by the feel method.

Rainfall and temperature data of the study area were obtained from the Department of Hydrometeorology. These data were used to interpret the rainfall pattern and temperature regime of the study area.

Data analyses were done using SPSS Ver. 16. Pearson correlation, Pearson's chi-square test, and one sample *t*-test were conducted.

Results and Discussion

Current situation of citrus orchard

In the study area, 50% of the respondents were small scale citrus growers owning less than 100 trees, while the rest were commercial growers owning more than 100 trees. Bangtsho village had the highest number (4,844) of citrus mandarin trees, while Khorpam village had the lowest (222 trees). Total number of households growing citrus mandarin reduced to 11 at Reshore village due to coal mining pollution.

Factors affecting yield

Citrus greening disease was the major factor causing the decline in citrus production in Martang, Chenary,

and Bangtsho villages in the study area. About 35% of citrus orchards were affected by greening disease. Greening disease already wiped out three orchards completely and had started to damage the remaining trees in the partially affected orchards. Almost 83% of the growers were not aware of greening disease and had left the trees unattended. As discussed by Batool *et al.* (2007), these trees may harbour the greening vector and spread the disease to unaffected orchards if left unattended. About 100 million trees were affected by greening disease worldwide which led to Nepal, with similar agro-ecological zones to that of Bhutan, abandoning citrus cultivation all together (Budathoki and Pradhanang, 1992).

About 97% of the farmers had the problem of fruit drops and more than 90% of the production was lost to fruit drops caused by the green stink bug and fruit fly. The level of loss varied from less than 30% to more than 50% (Figure 1). This is in agreement with the study conducted in Bhutan by Connellan *et al.* (2007). Results showed that none of the growers disposed the dropped fruits to reduce the spread of fruit fly. Use of insecticide was minimal due to religious stigma and prevailing policies toward conversion to organic agriculture. Most of the farmers (81%) raised seedlings on their own.

About 11% procured seedlings from a local nursery and 8% used high quality planting materials purchased from the National Seed Centre (NSC) (Figure 2). Seedlings raised in backyard nurseries were generally of poorer quality, which were affected with insect infestation and insufficient nutrients. Due to the use of low quality seedlings, most of the existing orchards had weak tree stands. Similar findings were reported by Connellan *et al.* (2007) who found that the majority of farmers raised seedlings in their backyards for cultivation. This was either due to easy access to locally raised seedlings or due to higher cost and difficult access to grafted seedlings.

The study revealed that orchards were generally not managed properly (Table 1). The majority of growers (81%) did not prune, 61% of the growers did not prepare basins, and 64% did not maintain required spacing. Overall orchard management was found to be poor, and as reported by Singh *et al.* (2008), most trees were left to nature's care, resulting in yield decline.

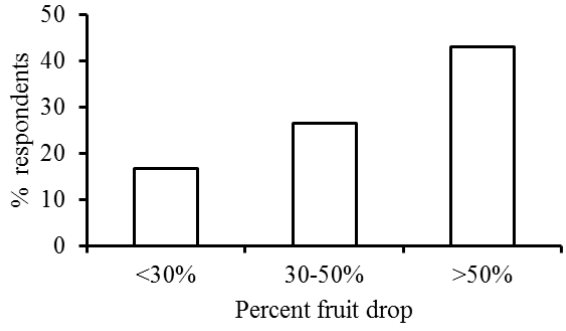

Figure 2. Percent fruit drop due to fruit fly and stink bug attack

Sixty four percent of the farmers did not follow proper spacing standards. It was observed that in some cases the trees were planted far apart, indicating sub-optimal use of land, while in other orchards, the trees were overcrowded, thereby affecting fruit quality, attracting more pests and diseases. Such observations indicate the lack of technical knowledge in orchard management by the farmers.

The majority (95%) of respondents did not irrigate their trees and only 5% of the growers irrigated their orchards occasionally using a hosepipe extended from their drinking water tap. Water sources were limited, insufficient even for the regular supply of drinking water. This restrained the growers from irrigating their citrus trees during the peak dry season. Orchards located away from houses did not have adequate soil moisture, causing the citrus trees to have shrivelled leaves. Such conditions have adverse effects on fruit yield; as shrivelled leaves produce less carbohydrate (Zekri, 2011) and insufficient water affects the tree's ability to uptake nutrients.

Table 1. Orchard management activities carried out by the growers

Management practices	Responses	
	Yes	No
Basin making	39	61
Fencing	28	72
Pruning	19	81
Removed *Loranthus*	94	6
Proper spacing	36	64

The optimum rainfall requirement for citrus mandarin is said to be 700 mm per year (Citrus Production Manual, 2008). While the lack of irrigation posed a problem during the dry season, the total annual rainfall received in the study area from 2004 to 2012 exceeded the total water requirement (Figure 3).

Rainfall was fairly distributed throughout the growing seasons with the least rainfall in January, gradually increasing from April to July (1,646 mm), followed by a gradual decline thereafter. Monthly

rainfall should provide the necessary moisture required during critical growing stages viz. floral initiation (December – January), pollination (March – April), and fruiting (May – October). However, due to the lack of daily rainfall data, details of weather patterns could not be examined during the critical growth stages. Such information is critical in order to assess the drought incidences which caused 5 – 10% loss in yield as reported by 17% of the growers.

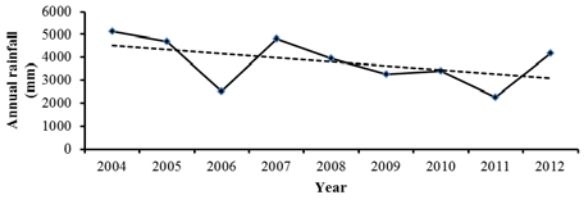

Figure 3. Monthly rainfall from year 2004 to 2012 (Source: Department of Hydrometeorology)

Among the 17,600 trees in the study area, 50% (8,768) were above 20 years of age. This is beyond the optimal production age of 10 – 20 years (Connellan *et al.*, 2007). Only 21% (3,625) of the existing citrus mandarin trees were of optimal production age. During the last 10 years, the number of productive trees has reduced by half. This would have also contributed to the decline in production. Only 29% (5,007) of trees were young, not yet bearing fruits, indicating that yield would remain the same during the next 10 years. This signifies that there is need for a major plantation programme in order to increase production.

The majority (86%) of growers used farmyard manure (FYM) in their orchards. Most growers (72%) applied 1 – 10 kg FYM per tree and the rest (28%) applied 11 – 20 kg FYM per tree. The average FYM applied per tree was lower than the minimum requirement of 20 kg FYM per tree for trees above 12 years of age (Connellan *et al*., 2010). This implies that the yield is also affected by insufficient nutrient application.

Some growers (14%) did not apply FYM to their citrus trees as they were unable to transport FYM long distances to their orchards, and limited possession of FYM due to small number of cattle. However, the Pearson chi square test showed that there was no association between the distance of orchard location and FYM application ($X^2(1) = .138$, $p > .05$). This indicates that it was not due to distance that led to less FYM application but rather due to negligence or ignorance of the farmers. According to Srivatava (2013), application of synthetic fertilisers gives higher yield compared to production solely using FYM. None of the growers used synthetic fertilisers mainly due to the lack of availability (8%), high cost (2%), soil degradation (8%), or by choice (82%).

Soil pH ranged from 5.5 to 6.5 in 64% of the orchards and 96% of the orchards had medium (2 – 5%) to high (> 5%) soil organic matter (OM) content. The CEC of the soils in most (82%) citrus orchards ranged from medium (15 – 25 meq per 100 g) to high (25 – 40 meq per 100 g). These values showed potential for retaining and supplying nutrients to the crops. Base saturation for 63% of the orchards was very low (< 30%) to low (30 – 50%), indicating an availability of very low exchangeable nutrients in the soil for plant uptake, with 37% having medium (50 – 70%) to high (> 70%) levels of saturation.

When compared to the Heckman Response Curve (2006), 83% of the surveyed orchards had major soil nutrient deficits. Reported causes include removal of major nutrients through crop harvest, soil erosion and surface runoff as well as leaching, and the lack of soil management practices to replenish the nutrients lost. Only 12% of the orchards were found to have optimum nutrient levels. About 6% of the orchards had more than optimal levels of nutrients, which could also have adverse effects as excess nutrients could become toxic to plants, limiting vital nutrient uptake (Figure 4).

Soil in the study area had light to medium texture consisting mainly of sandy clay loam (32%), sandy loam (29%), and loam (21%). Although the soil texture was found to be suitable for mandarin cultivation, soils in Chenary, Domphu, Martang, and Rikhey villages contained lots of gravels, which might affect the nutrient and water holding capacities of the soil.

In the study area, the maximum mean temperature was 27 ^{0}C in 2004 and 20 ^{0}C in 2012. Minimum mean temperature remained around 15 ^{0}C over the years. The annual mean temperature for the consecutive nine years was within a favourable range (20 – 28 ^{0}C) recommended in the Citrus Production Manual (2008).

Although the lowest recorded temperature (5.5 ^{0}C) was slightly below the acceptable range, the mandarins were able to tolerate the cold as the temperature did not go below freezing point (Citrus Production Manual, 2008). Low temperatures during the winter cause cold stress, leading to enhanced floral induction (Zekri, 2011).

Ninety seven percent of the growers mentioned pest (mainly fruit fly and green stink bug) and 83% mentioned low soil fertility as their main causes for yield decline (Table 2). This was followed by poor planting materials (82%), lack of tree management (51%), aging trees (50%), and greening disease

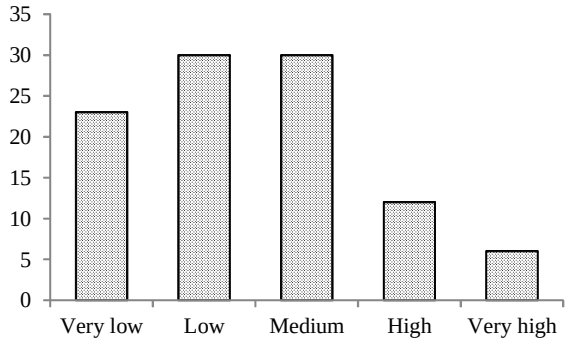

Figure 4. Nutrient content levels of sampled orchards

(35%). About 95% of the growers do not irrigate their citrus trees and depends on rainfall for soil moisture.

Production constraints

The growers did not provide adequate management and control measures to increase the citrus mandarin yield (Figure 5). About 46% of the growers were constrained by labour shortage to carry out required orchard management activities. Available farm labour constituted of two to three household members, mostly elderly parents looking after the household and farm. The other family members were either students, government employees, or were employed outside the farm.

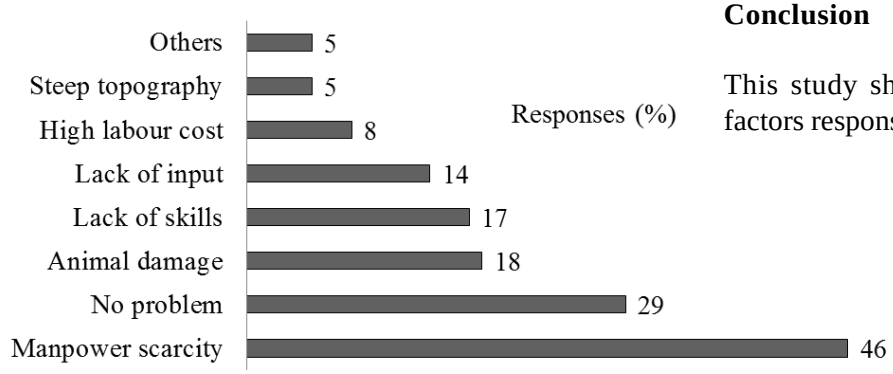

Figure 5. Production constraints limiting citrus production activities

Animal damage was also mentioned as one of the causes for yield loss. Cattle were more destructive than wild elephants for young fruit bearing trees. In addition, the growers reported that they lacked proper management skills which prevented them from carrying out regular maintenance activities and implement pest and disease control measures. These unskilled farmers have not received any training from the regular extension services. Lack of proper pruning equipment, such as secateurs and saws, made the growers use inappropriate tools such as knives, and not having the right tools led to orchards being unmanaged.

Few growers (5%) reported additional challenges such as gravelly soils being hard to work with, guarding orchards from robbers, and weed management. Some growers (29%) reported that they did not face any problems in managing their orchards. These, however, were affluent farmers who could hire labour, and had manageable orchard sizes. About 8% of the respondents, including those who did not maintain their orchards, considered labour cost as becoming unreasonably high (Figure 5).

Conclusion

This study showed that there are several factors responsible for yield decline in citrus mandarin in Dewathang Geog. Fruit drop caused by the green stink bug and citrus fruit fly was one of the major factors, accounting for as high as 50% yield loss. Proper pest management is urgently required, which still remains unaddressed. Similarly, greening disease, if unchecked, could destroy all the citrus mandarin orchards in the Geog within the next few years. In order to sustain the mandarin production in the study area, immediate control measures and research to develop better varieties are urgently needed. The majority of orchards were found to be deficient in major soil nutrients. Lack of irrigation was another

Table 2. Factors responsible for yield decline in the study area

Factors	Responses	Remarks
Fruit fly and green stink bug	97	Caused fruit drop
Trunk borer	80	Only 49 trees died
Lack of irrigation	95	Did not irrigate
Low soil fertility	83	Deficient in macro nutrients
Poor nutrient management	43	Not using nutrient supplements
Poor planting materials	82	Poor quality backyard nursery
Lack of proper tree management	51	Overall management practices
Orchard age	50	Above 20 years
Greening disease	35	Rate of infection rise

limiting factor in citrus production in the study area. Priority should be given, firstly, to manage the fruit fly, green stink bug, and greening disease. Secondly, there should be soil nutrient build-up programmes and training on canopy management techniques, followed by the provision of drip irrigation facilities. The present study did not look at the effects of regional infrastructure and industrial development on crop production, however, it would be worthwhile to look at the impact of industrial emission from factories as well as dust pollution from nearby roads on the citrus mandarin production in the study area. Soil moisture availability using detailed monthly rainfall is also critical in order to understand the effect of rainfall pattern on citrus mandarin yield.

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