Assessment of the Potential to Improve Pre- and Post-harvest Processes in Mango Production in Southern Shan State, Myanmar

การประเมินศักยภาพในการปรับปรุงกระบวนการก่อนและหลังการเก็บเกี่ยวในการผลิตมะม่วงในรัฐฉานตอนใต้ประเทศพม่า

Johannes Mueller[1*], Matthias Plewa[2], Vicha Sardsud[3] and Wolfram Spreer[4]
โจฮันเนส มึลล์เลอร์[1*] มัทธิอัส เพลวา[2] วิชชา สอาดสุด[3] และ วูลแฟรม สเปรียร์[4]

[1]*Department of Highland Agriculture and Natural Resources, Faculty of Agriculture, Chiang Mai University, Chiang Mai 50200, Thailand*
[1]*ภาควิชาเกษตรที่สูงและทรัพยากรธรรมชาติ คณะเกษตรศาสตร์ มหาวิทยาลัยเชียงใหม่ จ. เชียงใหม่ 50200*
[2]*Gesellschaft für International Zusammenarbeit (GIZ) GmbH, Yangon, Myanmar*
[3]*135/50 Ban Chao Far, Hang Dong District, Chiang Mai 50230, Thailand*
[3]*135/50 หมู่บ้านชาวฟ้า ต. หนองควาย อ. หางดง จ. เชียงใหม่ 50230*
[4]*Department of Agricultural Engineering in the Tropics and Subtropics, Faculty of Agricultural Engineering, University of Hohenheim, Stuttgart, Germany*
**Corresponding author: Email: mueller_joh@hotmail.de*

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บทคัดย่อ: มะม่วง (*Mangifera indica* L.) นับว่าเป็นไม้ผลที่มีบทบาทสำคัญต่อการเกษตรโดยเฉพาะอย่างยิ่งการผลิตผลไม้ในประเทศพม่า และยังมีแนวโน้มว่ามะม่วงจะสามารถเติบโตสร้างมูลค่าอีกมากในตลาดสากล อย่างไรก็ตามการพัฒนาผลผลิตทั้งทางด้านปริมาณและคุณภาพมีความสำคัญอย่างยิ่งต่อเกษตรกรเพื่อที่จะให้ทันต่อการเติบโตของตลาดที่จะเกิดขึ้น งานวิจัยนี้มีจุดประสงค์เพื่อศึกษาสภาพที่เป็นอยู่ในปัจจุบันของทั้งกระบวนการจัดการก่อนและหลังการเก็บเกี่ยวมะม่วงในรัฐฉาน ประเทศพม่าและแนวทางในการปรับปรุงให้ดีขึ้นโดยใช้งานวิจัยเชิงสำรวจในเชิงปริมาณ โดยศึกษากับกลุ่มตัวอย่างเกษตรกรผู้ปลูกมะม่วงจำนวน 114 ราย จาก 7 พื้นที่เพาะปลูกในรัฐฉาน ประเทศพม่า นำข้อมูลที่ได้มาวิเคราะห์เชิงคุณภาพโดยกระบวนการทางสถิติ (ค่าความถี่ ค่าเฉลี่ย ค่าการกระจาย) รวมถึงการสัมภาษณ์เพิ่มเติมอีก 5 ครั้ง เพื่อความเข้าใจที่มากขึ้นในเรื่องกระบวนการผลิตและความท้าทายในการพัฒนาสำหรับผลผลิตในรัฐฉาน ผลของการวิจัยแสดงให้เห็นว่าแม้สวนผลไม้ในรัฐฉานจะมีเทคนิคการจัดการที่ทันสมัย แต่การพัฒนาคุณภาพและปริมาณเพื่อนำออกสู่ตลาดยังต้องการ การจัดการความรู้และการฝึกอบรม เกี่ยวกับเทคนิคการจัดการก่อนการเก็บเกี่ยว เช่น การให้ปุ๋ย การให้น้ำ การกำจัดโรคและแมลงเป็นต้น ยิ่งไปกว่านั้นปัจจัยการผลิตและเทคโนโลยีใหม่ ๆ ควรได้รับการพัฒนาเพิ่มมากขึ้น กระบวนการหลังการเก็บเกี่ยวในรัฐฉานยังอยู่ในระยะขั้นต้น ทำให้มีการสูญเสียผลผลิตจำนวนมาก เกษตรกรจำนวนมากมีความสนใจเรื่องการส่งออก การสร้างโรงคัดบรรจุ ระบบคัดบรรจุ และห้องคัดบรรจุที่สะอาดเป็นความต้องการอย่างเร่งด่วนและเป็นเงื่อนไขในการรักษาคุณภาพมะม่วงหลังจากเก็บเกี่ยว

คำสำคัญ: มะม่วง คุณภาพผลไม้ เทคนิคการดูแลสวนไม้ผล โรงคัดบรรจุ รัฐฉาน (พม่า)

Abstract: Mango (*Mangifera indica* L.) plays a central role among horticultural fruit crops in Myanmar and is believed to have a potential on high value in international markets. The aim of the study was to assess the status quo of current pre- and post-harvesting processes in mango orchards in the Shan State, Myanmar, and the potentials for their improvement. An exploratory research approach was applied, drawing on a quantitative research among 114 mango farmers in 7 mango growing zones in the Shan State, Myanmar. The quantitative baseline data was analyzed using standard statistical methods (frequency, mean and dispersion of scores). Additionally, five semi-structured interviews have been conducted to allow a better contextual understanding of the various aspects of mango production and challenges in the Shan State. The results indicated that in spite of advanced orchard management techniques in the Shan State, improving fruit quality and amount of marketable fruits requires providing knowledge and training on pre-harvest management techniques such as fertilization, irrigation and insect and pest management. Moreover, the availability of inputs and technology needs to be improved. Post-harvest handling of mangos is presently at an early stage of development resulting in high post-harvest losses. However, as farmers have a strong interest in exporting, installing full packing-house sequences or as intermediate solution, hygienic field packing houses, are an important precondition to maintain mango quality after harvest.

Keywords: Mango, fruit quality, orchard management techniques, packing-house, Shan State (Myanmar)

Introduction

Mango (*Mangifera indica* L.), native to South- and South-East Asia, is widely cultivated in the tropics and subtropics and plays a major role for local consumption and (inter-)national trade. Commercial mango production takes place in more than 87 countries whereas India, Thailand and Indonesia being the major producing countries (Sivakumar *et al*., 2011; FAOSTAT, 2015). Despite of an increasing share of land dedicated to horticultural production in Myanmar (for mango: central (Mandalay) and eastern Myanmar (Shan State) (Myo, 2009)), international trade and trade within ASEAN countries develops slowly with Myanmar and Singapore being responsible for less than 0.1% of Mango export (Myat, 2012; FAOSTAT, 2015). The Mekong Institute attributes the differences in mango export to differences in *"quality and safety of ASEAN-produced fruits due to the wide diversity of systems, infrastructure, resources and capacities in the region"* (Mekong Institute, 2013a). Currently most of the mango trade of Myanmar takes place at relatively low prices with China by (road) border trade as no certificates are required (Ksoll *et al*., 2013). Myat (2012) provides a wide-ranging study focusing on hindrances and opportunities in the downstream mango supply chain in Myanmar. He found that low fruit quality and missing the Good Agricultural Practice (GAP) standards represent major hindrances for mango export (Myat, 2012). A recent report from the Mekong Institute underlines these findings as well (Mekong Institute, 2013b).

The Southern Shan State represents a promising area for mango production. Due to the late maturity, mangos can be sold at comparatively high market prices as late season mangos. However, to identify levers to improve mango production, data about mango production and post-harvest activities in the region are necessary. Currently, statistical data

is hardly available and difficult to collect in a widespread area with deficient infrastructure. In this situation, the application of new ways of data acquisition and interpretation is necessary. Exploratory, qualitative research designs promise, in particular in early stages of a research process, a sufficient degree of contextual and conceptual flexibility to gain insights, refine problems and ideas and gather explanations (Fritz, 1995). For qualitative research, Mayring (2000) suggests a content analysis model with stringent claims towards validity and reliability. His method provides a seamless traceability due to the inherent systematic and high documentation requirements.

The present study consists of a quantitative baseline study and a qualitative research approach to explore and explain the quantitative results in more detail. Using a combination of both, quantitative and qualitative data aimed at balancing the limitations of each type of data collection and improving the validity of the findings.

Materials and Methods

The overall objective of this research was to analyze current pre- and post-harvest management techniques to produce mango in the Shan State, Myanmar and to identify levers to improve fruit quality. In this study, quantitative and qualitative data collection was carried out.

The quantitative baseline data on mango production in Southern Shan State has been collected by the team from Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) (GIZ project 2012.2451.8-001.00 “Capacity Strengthening for Private Sector Development“ (2013-2016)). From February 2014 to May 2014, 114 mango farmers in the growing zones Taunggyi, Yatsauk, Pindaya, Nyang Shwe and Siasai were interviewed by a partially standardized questionnaire covering mango farm characteristics, pre- and post-harvest management practices and market/logistical data. The data have been analyzed using standard statistical methods to show absolute and relative frequencies, mean values and dispersion of scores. At two locations, namely Yatsawk and Taunggyi, seasonal calendars have been elaborated in two open group interviews with 20 mango farmers, each. The major on-farm activities related to the production of Sein Ta Lone mangos have been listed.

In addition to the quantitative farmer survey, a further qualitative research has been conducted to allow a better contextual understanding of the various aspects of mango production and challenges in the Shan State, Myanmar. From November, 2015 - March, 2016 five semi-structured interviews have been conducted with experts in mango production, post-harvest management and value chain development in Thailand and Myanmar. The questionnaire was designed as a non-standardized guided interview to allow the interviewees enough room for answers.

The raised qualitative data was analyzed according to Mayring’s sequential content analysis model illustrated in Figure 1 (Mayring, 2000). GAP-Guidelines concerning fruit quality (Sareen, 2014; Footan *et al*., 2017) and scientific studies about mango production and post-harvest handling provided a sound basis for the establishment of categories to analyze pre-harvest and post-harvest management processes in mango production in Myanmar. As pre-harvest processes; planting material, fertilizer and soil additives, irrigation, insect and pest management, harvesting and handling and orchard management were identified. Post-harvest processes refer to a packing-house sequence that

includes in general the following activities: Sorting, grading, postharvest treatments (desapping, hot water treatment (HWT), vapor heat treatment (VHT)), packing and labeling, transportation, temperature and storage conditions (Sivakumar *et al*., 2011). As the next step, all interviews were broken down to text passages. The text passages were then assigned to the identified categories (pre- and postharvest processes) using category definitions and coding rules. For text passages, which could not be assigned to certain categories, new categories were established and the interview material was revised again. Therefore, categories are developed, revised, adapted and controlled iteratively. During the last phase of the process, the qualitative method allows an interpretation of the results and generates a systematic and wide spectrum of opinions (Figure 1). In particular, this rule system makes the approach of Mayring comprehensible and traceable (Mayring, 2000).

The results of the qualitative study were re-presented and discussed with the interview partners to ensure that the text passages and interpretation by the author are correct. On the other hand, the results of the qualitative study were used to confirm and open-up the findings from the quantitative survey. Thus, the qualitative findings were triangulated and have been cross-checked.

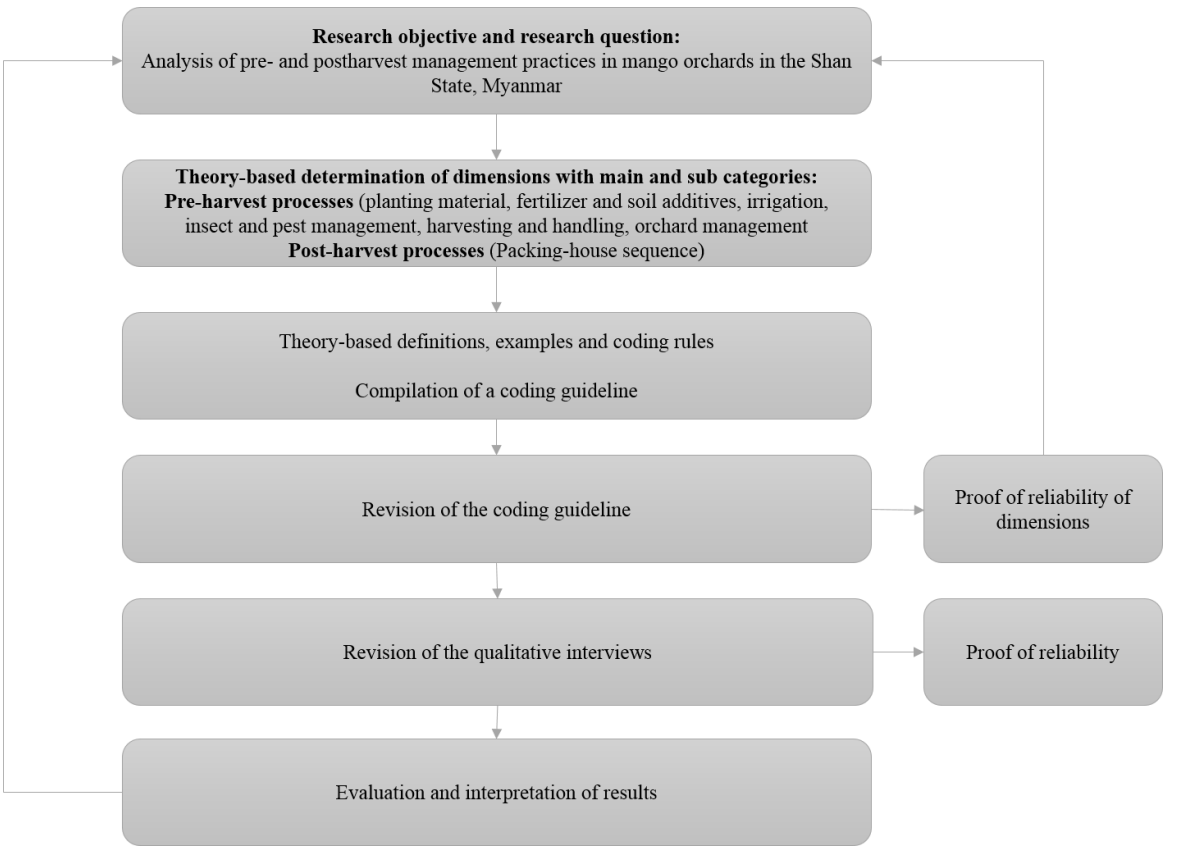

Figure 1. Content Analysis according to Mayring (deductive method) (own, adapted from Mayring, 2000)

Results

Mango orchards characteristics in the Shan State, Myanmar

Currently, mangos are cultivated on a total area of 5332 hectares in seven mango growing zones in the Shan State. The different growing zones are Yatsawk (2833 hectares), Taunggyi (1295 hectares), Pindaya (405 hectares), Nyang Shwe (182 hectares), Siasai (132 hectares) and Hopone (60 hectares) (Plewa, 2016).

The interviews of 114 farmers in the different growing zones show, that the majority of mango orchards in Southern Shan State can be characterized as small orchards with mangos being cultivated on less than 4 hectares (69.2%), and medium sized orchards with mangos being cultivated between 4 -16 hectares (28.9%) (Figure 2).

The average age of the mango trees in the orchards is between 6 and 10 years with an average yield of 0,48 tons per hectare in 2013. In Yatsawk, the largest growing area in the Shan State, Myanmar average yields were the highest (1 ton per hectare) and lowest in Si Sai (0.25 tons per hectare). Most of the farmers grow maize (28%) or rice (16%) and to a minor extent vegetables (10%) as additional crops besides mango. 7.1% grow no other crops besides mango.

Seasonal calendars

Based on group interviews of each 20 farmers, two seasonal calendars for the locations of Yatsawk (Figure 3) and Taunggyi (Figure 4) have been elaborated. From the seasonal calendars, it can be seen, that farmers in Southern Shan State generally apply most of the management methods of modern mango production, such as scheduled pest and disease control, bagging, pruning and weed management. However, due to the method of the group interview it was not possible to determine percentages of farmers that follow these production steps.

Current farm management practices

Concerning mango orchard management techniques, the findings indicate that almost half of the farmers (48.2%) possess an own mango tree nursery whereby seeds come from Han Myint Mo, Taunggyi, Yatsawk or Mandalay and are sown in plastic bags, foliar and pesticides are sprayed and

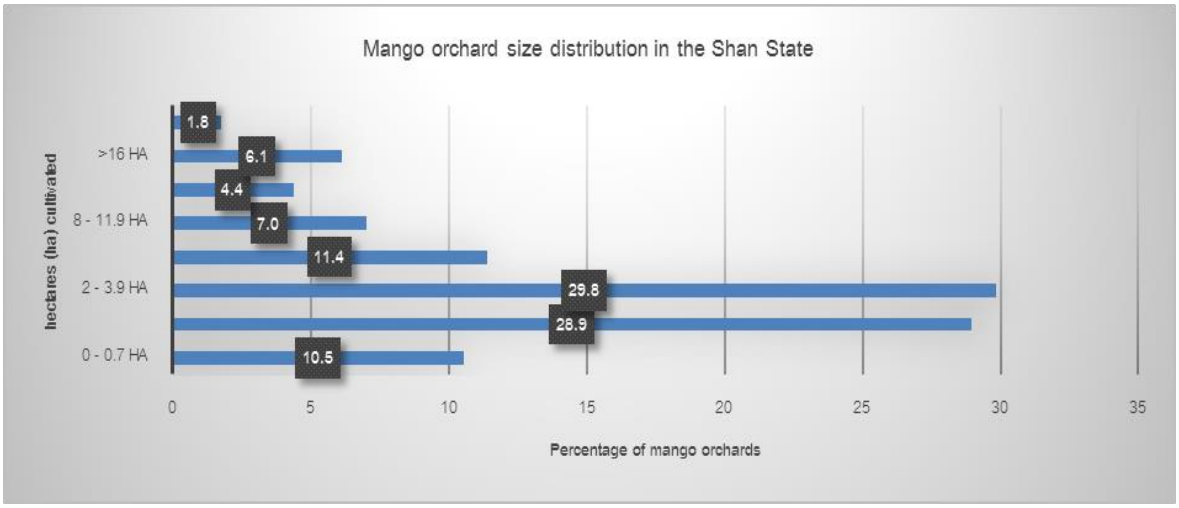

Figure 2. Mango orchard size distribution

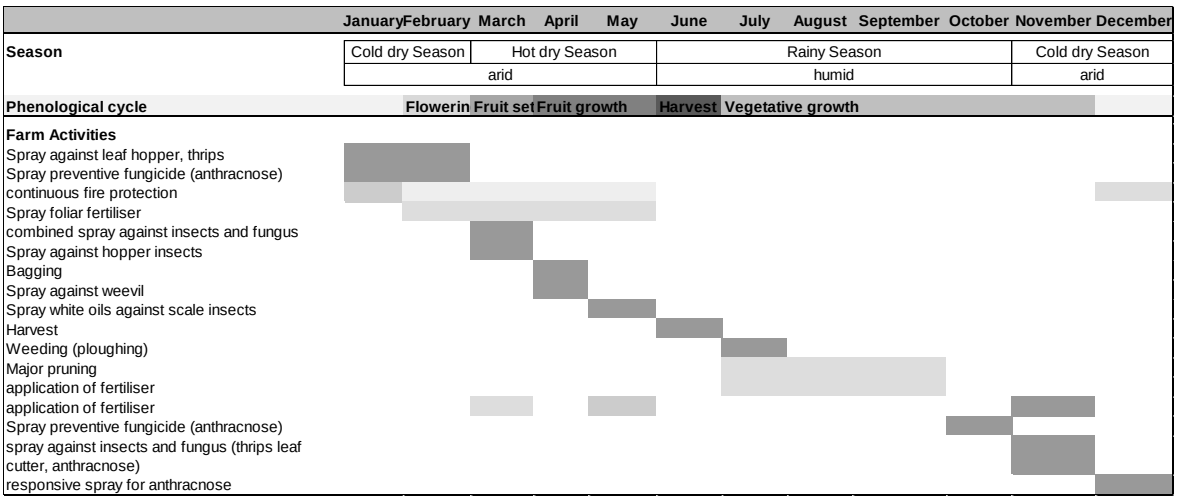

Figure 3. Seasonal calendar for on farm activities related to the production of Sein Ta Lone mangos in Yatsawk

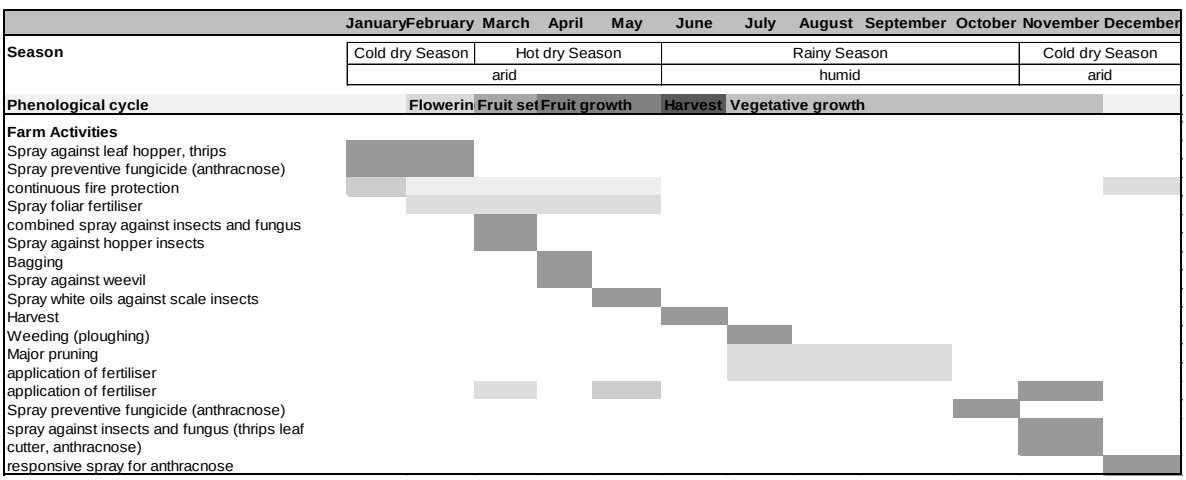

Figure 4. Seasonal calendar for on farm activities related to the production of Sein Ta Lone mangos in Taunggyi

plants are later transplanted. Around 51.1% of the farmers use grafted seedlings and 48.9% of them grow mango trees from seeds. Most of the farmers focus on the variety Sein Ta Lone (STL) (87.8%). To a minor extent the variety Yin Kwe (9.9%) and further varieties (2.3%) are cultivated. The results from the qualitative study reflect this trend and stress the importance of the genetic material for commercial mango production and genuine characteristics of the variety STL.

More than 80% of the farmers prune their trees to improve the incidence of light (24%), enhance aeration (29%) and improve fruit quality in general (20%). Other reasons are to reduce pests (14%) and to improve the ease of spraying and harvesting (9%). Mango bagging with newspaper or waterproof paper bags is also practiced in 49% of the mango orchards. Moreover, 36% of the farmers use pesticides and fungicides. Nonetheless, mango farmers in the Shan State experience substantial

harvest and post-harvest losses. The 24.8% of the farmers have losses between 5-10% and 16.8% of the farmers between 11-20%. Furthermore, 7.1% experience losses exceeding 40% of their harvest. The reasons are manifold. Losses due to pest and diseases (38%), damaged fruits (19%), overripe fruits (19%) and small sized fruits (5%) are prevalent.

Regarding fruit quality, the qualitative findings emphasize the importance of pest and disease management as pest and diseases restrict the amount of marketable fruits considerably. Major pests in orchards in the Shan State include *inter alia* stem borer, fruit flies, seed weevils and mealy bugs. Like fungal disease, anthracnose is prevalent. Most prevalent pest and diseases are illustrated in Figure 5.

In this context, the practice of fruit bagging, application of agrochemicals and pruning play a major role. These management techniques are already practiced in mango orchards in Myanmar. Nevertheless, agrochemicals for fertilization as well as pest and disease management, imported from neighboring countries like Thailand usually lack of descriptions and application guidelines in the local language. Occasionally, application guidelines are provided by traders or are available in mango clusters. Furthermore, extension services do not cover all mango growing areas. Hence, agrochemicals are frequently not optimally applied and most of the time (70%), no records about application date and dosage are kept. Almost 96% of the farmers are not certified by a certification scheme. The qualitative findings pronounce the positive linkage between irrigation, fertilization and fruit size. In Shan State (Myanmar) the period of rapid fruit growth fall in the dry season. Flowering takes place end of February followed by a phase of rapid fruit growth (end of March/April) and harvesting of fruits (May/June). The supply of water and nutrients during fruit growth is crucial to increase fruit size. Plus, the uptake of macro nutrients, such as nitrogen for fruit growth during the dry season is considerably aggravated without irrigation. The lack of irrigation can result in smaller or shriveled fruits. Conversely, an over-irrigation of mango trees for example by flood irrigation can cause the trunk of the tree to rot. Notwithstanding the importance of irrigation requirements for commercial mango production,

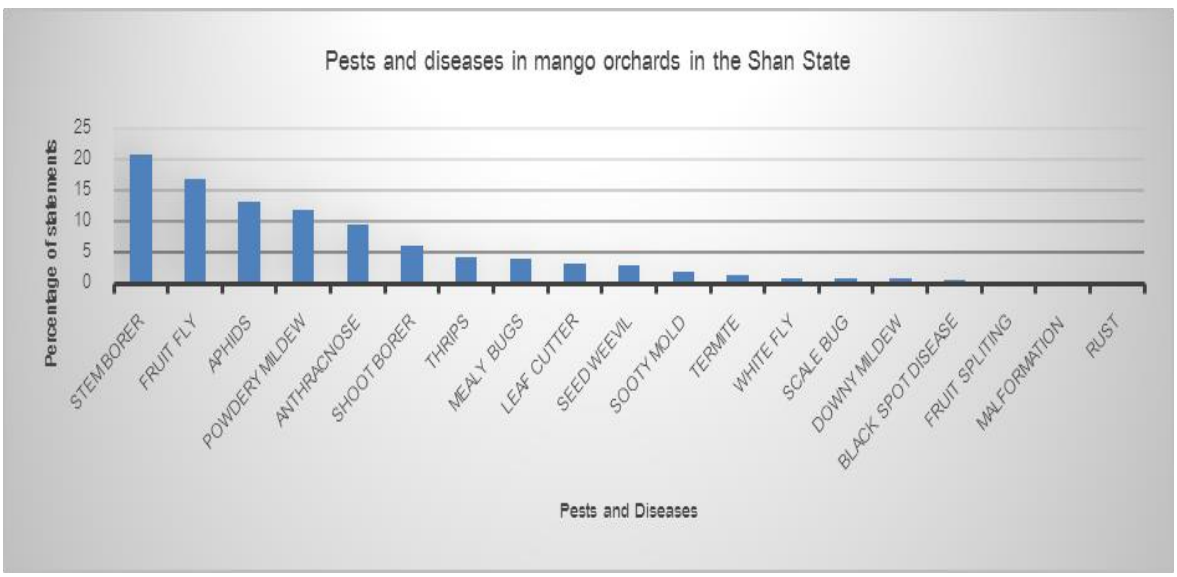

Figure 5. Pests and diseases in mango orchards in the Shan State

appropriate technology such as micro sprinklers or drip irrigation are hardly available (or of minor quality) and have to be imported. Currently 85.7% of the farmers do not employ irrigation systems and maintain their mango orchards under rain fed conditions.

Current post-harvest management practices and marketing

With regard to post-harvest management, the empirical findings show that 98% of the farmers have no adequate facility for post-harvest processing and 90% of the farmers indicated that they do not have trained and skilled staff for post-harvest processing. Currently, almost half the farmers merely cover the harvested mangos with paper and put them into a basket. Approximately 15% separate small and big sizes before wrapping the mangos with paper. This practice corresponds to actual market requirements, where the size of the fruits and, to a minor extent, ripeness and packaging are demanded. The qualitative findings support these results and indicate, that farmers who are producing for export markets mark bagged mangos already in early stages to ensure similar degrees of ripeness when harvesting the fruits. Nonetheless, the lack of hygienic collecting spaces and systematic packinghouses to perform a targeted post-harvest management was underlined.

Market and distribution data of the mango farms show that most of the farmers (69%) sell mangos to foremost one customer coming from Yangon, Shan State or China. In general, the mangos are transported in open trucks to the market and sold or handed over. About 21% of farmer sell their mangos directly at the farm gate and 53% of them have no access to recent price information, then they are not able to negotiate the price for their produce. Moreover, 40% of the farmers have no experience in collective marketing and marketing strategies to approach new customers. However, 33% of the farmers transport their produce together with other farmers. Nonetheless, more than 30% of the farmers aim at diversifying their sales channels by export, engaging in cluster groups or farmer associations and direct sales to Muse and wholesale markets thus skipping middle men.

Discussion

Improving fruit yields in terms of quantity and quality is fundamental to participate in the emerging (international) value chains. Based on a quantitative and qualitative research, direct correlations between different mango pre- and postharvest practices and fruit quality were found.

As mango trees are sturdy the interviewed experts evaluated the importance of fertilizer and soil additives lower than other pre-harvest management processes. Nonetheless, training requirements were identified within this study. A targeted fertilization during phases of fruit growth or after pruning to promote vegetative growth are essential for fruit quality. Currently, mango orchards in Southern Shan State are not fertilized adequately. Planned fertilization and documentation about date and dosage, as necessary for GAP certification, commonly do not take place. The experts emphasized the limited choice and availability of fertilizers as well as the need to systematically integrate natural fertilization to improve nutrient availability in the soil. Instead of knowledge-based procedures farmers rather rely on experience and intuition. While there is a positive correlation between fertigation and fruit size, possibilities for fertigation are lessened, as most of the mango orchards in

Shan State are rain-fed and to a minor extent flood irrigation is applied.

Concerning irrigation systems the interviewed experts recommended micro irrigation systems as flood irrigation can negatively impact on tree health. Currently components for these irrigation systems are barely available or of inferior quality in Myanmar. Despite the currently apparently good availability of water for irrigation in Myanmar (MOAI, 2014), studies about irrigated fruit production in Thailand illustrate that increasing irrigation in mountainous regions may lead to water scarcity. The situation is further aggravated by an increasing number of weather anomalies in recent years, commonly described as climate change (Schulze *et al*., 2013).

The results underline the linkage between insect and pest management and fruit quality as well as the quantity of marketable fruits. With high post-harvest losses due to pest and diseases, the results reveal that mechanical orchard management practices like pruning and fruit bagging are quite evolved and widely practiced in mango orchards in Southern Shan State. Concerning application of pesticides, insecticides and fungicides, substantial training needs in relation to a systematic and coordinated application of these treatments have been identified. Moreover, the choice of agrochemicals in Myanmar is rather limited and product labels about substances and optimal application are often not available in Burmese. However, in line with the hygiene requirements concerning mechanical methods, a coordinated and documented application of agrochemicals are central building blocks of a GAP certification and inappropriate usage of agrochemicals can even lead to a ban of products by importing countries. Therefore, considerable attention must be paid to farmer trainings concerning a systematic and integrated pest and disease management.

Harvest and post-harvest handling are at an early stage of development in Southern Shan State. Virtually no appropriate post-harvest handling facilities and skilled staff for post-harvest processing are available. Analyzing the current situation, cooperation among farmers and between farmers and other actors are not common practice. Thus, one strategy for development cooperation, is to start working together with pioneer grower groups at an early stage (Plewa, 2016). Installing field-packing houses seems to be an appropriate and cost-effective stepping-stone before full packinghouse sequences are installed. Moreover, field-packing houses can be financed by farmer groups and guarantee ownership by the grower group besides fruit quality aspects.

The persisting value chain is highly fragmented and several different types of marketing agents exist including contract buyers, primary collectors, brokers, township wholesalers, retailers and exporters (Myat, 2012). For the export to China - which makes the highest share of the exports - mangos are wrapped with a sheet of white paper, packed in boxes and transported by trucks. As Ksoll *et al*. (2013) emphasize, mango exports are usually conducted on a free carrier basis. Consequently, the exporter has to deliver the freight to the truck or warehouse of the buyer. The fresh fruits are collected by small traders and either first transported to Mandalay for consolidation with other growers produce or directly brought to the trading center at the Chinese border. It is noteworthy to mention that the consolidation of the perishable fruits can take up to one full day and the fruits are often stored outside, where they may be exposed to high temperature or humidity. Only after that process, Chinese brokers

buy the produce. The sales agreements are done informally and on a delivery-to-delivery basis. The weaknesses of this current supply chain comprise low farm gate prices for the produce, little protection of the mango during the transport on bad roads and high risks for the Myanmar exporter that result from no insurance coverage, insecure payment, no mechanism to enforce contracts, to name a few. Thus, the more the mango production evolves, the more important is the cooperation on a national level and the support of the government in terms of providing adequate infra-structure for education, transport and residue analysis (Chomchalow and Na Songkhla, 2008).

Conclusion

While farmers in Southern Shan State apply advanced orchard management techniques in various cases, providing knowledge and training on how to improve the quality and quantity of marketable mango including the use of certified nurseries, irrigation, fertigation, integrative pest and disease management as well as strict compliance with food safety and traceability, represent a key for mango export. Similarly, the establishment of hygienic collecting spaces and packing houses are crucial to participate in international supply chains. As Myanmar mango growers associations are relatively small, collaborative initiatives and horizontal cooperation with actors along the supply chain are needed. Mango clusters and mango grower associations bear a great potential. While strengthening the farmers' bargaining power along with access to information and technology, they make the traditional function of (rural) brokers redundant. Alongside these changes in the value chain, business opportunities including the supply of improved inputs like quality seedlings and agrochemicals in combination with increasing demand for transfer of knowledge and training for an improved cultivation of mango are likely to emerge. As the value chain develops, there is a growing demand for new technologies, post-harvest management facilities and cool chain systems. There are substantial potentials to develop the mango sector in Myanmar, in particular within the policy transition period to provide services and a framework for private sector development.

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