Preliminary Study on Performances of Low Intensity Tapping System with Rainguard in High Rainfall Area in Myanmar

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Title Preliminary Study on Performance of Low Intensity Tapping System with Rainguard in High Rainfall Area in Myanmar

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ABSTRACT

In Myanmar, natural rubber (*Hevea brasiliensis*) is mainly grown in the southern part of the country where the rainfall is high leading to suspending tapping in the rainy season and intensive tapping after the rainy season. Rubber farmers face problems of uneven distributed tapping days, unemployment in the rainy season, low tapper productivity, high tapping cost, and shorter economical lifespan of the tree. Implementing low intensity tapping system (LITS) with rainguard without suspending the tapping in the rainy season was assumed to be hypothesis solution to address the problems. Thus, a preliminary study was carried out by conducting an on-farm experiment with interviewing the farmers to assess yield and socio-economic performances of five tapping systems in the area. Thus, five treatments – T1) S/2 d2 (no tapping in the rainy season, no resting in the wintering period), T2) S/2 2d3 (no tapping in the rainy season, no resting in the wintering period), T3) S/2 (RG) d2 (tapping with rainguard in the rainy season, resting in the wintering period), T4) S/2 d3 ET2.5% Pa1(1) 3/y (m) (tapping without rainguard in the rainy season, resting in the wintering period), and T5) S/2 (RG) d3 ET2.5% Pa1(1) 3/y (m) (tapping with rainguard in the rainy season, resting in the wintering period) – were evaluated. Although the cumulative yield of T5 was less than that of T3, it was comparable with that of T1 with its significant higher tapper productivity along the year. Its bark consumption is 16% and 39% lower than that of T1 and T3 respectively. T5 could reduce 33% and 50% of tapper requirement by T1 and T3 respectively. Tapping costs by T5 were lower than those of other treatments based

on unit area and unit production. It enables the highest total tapper income along the year. Its operating profits to the owners were not the highest but comparable to T1.

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Introduction

1.1 Rational of the study

Natural rubber (*Hevea brasiliensis*) is one of the important industrial crops in the world and a vital commodity used in manufacturing a wide range of rubber-based products. Over 90% of natural rubber production is mainly from South East Asian countries, India and China (ANRPC, 2014). As most of these countries are developing countries, natural rubber industry has been playing a major role in socio-economic fabric of the countries by providing many job opportunities and income sources for millions of farmers.

Myanmar is also a rubber producing country which contributed 1.5 percent of the world rubber production in 2014. Since the last two decades after adopting the market-oriented economic system, the country's natural rubber industry has developed gradually and consequently planted area has expanded rapidly in last decade especially in 2007 (Myint, 2013). Thus, productive area will increase apparently within these years and also the production will be substantial.

In Myanmar, rubber is mainly planted in Mon region, Thanintharyi state, and Kayin region respectively as traditional rubber growing area of the country. The area has 397,000 ha of planted area, 68% of the country's total planted area, and 187,500 ha of productive area, about 88% of the total productive area (DICD, 2015). Rubber has been the main business of the area and the majority of the area is owned by smallholders who mainly depend on rubber growing for their livelihoods.

Although the area is the major rubber growing area in the country, it has some obstacles which retarding the development of the industry. One of the major weaknesses is low productivity of the national average which is only 770 kg/ha/year in 2014 (DICD, 2014).

One reason to the low productivity is limitation of the number of tapping days due to heavily continuous raining in rainy season in the area which starts from June and ends in September. Average rainfall in the area is between 4,500 and 5,000 mm per year (World Weather & Climate Information, 2014). Normally, tapping is suspended completely in the rainy season for three and half to four months. Therefore, around 100-120 working days for tapping are lost in the rainy season without any production from the rubber farms (Zaw, 2012).

Consequently the farmers are used to harvesting late intensively from October to May without resting even in wintering period which occurs normally in February and March, even though the yield is very low in this period. It was found that the farmers are tapping with high frequency, such as two-day tapping and one-day rest in three days, three-day tapping and one-day rest in four days, and even daily tapping, from October to May. As the results, practice of high frequency tapping causes some problems now farmers have been facing. The problems are:

- uneven distributed tapping days
- lack of work assignment of tappers in the rainy season which consequently causes shortage of skilled tappers
- low tapper productivity
- high tapping cost
- high bark consumption resulting shorter economical lifespan of the tree

These problems are now more aggravated under prolonged lowering prices of rubber with erratic weather conditions resulting interrupted working days.

1.2 Hypotheses of the study

Since the suspending the tapping in the rainy season is a main root of the causes, implementing low intensity tapping system with rainguard was assumed to be hypothesis solution to address the problems.

Figure 1 illustrates the causes on the current problems and their impacts to the rubber planting industry in the area. Suspending the tapping in the rainy season due to the heavy rainfall is the main cause of the problems associated with income and practices of farmers, and tree performances regarding the yield performance. Consequently, the problems create the shortage of skilled tappers, high cost of production and shorter lifespan of the tree. Eventually the industry becomes unsustainable and uncompetitive as a result. Thus, hypotheses was constructed that tapping with rainguards in the rainy season under LITS is a solution to address the problems (Figure 2).

Therefore, a study was carried out by conducting an on-farm experiment on different tapping systems including current conventional tapping systems and LITS with rainguards, and interviewing the farmers and tappers in the area.

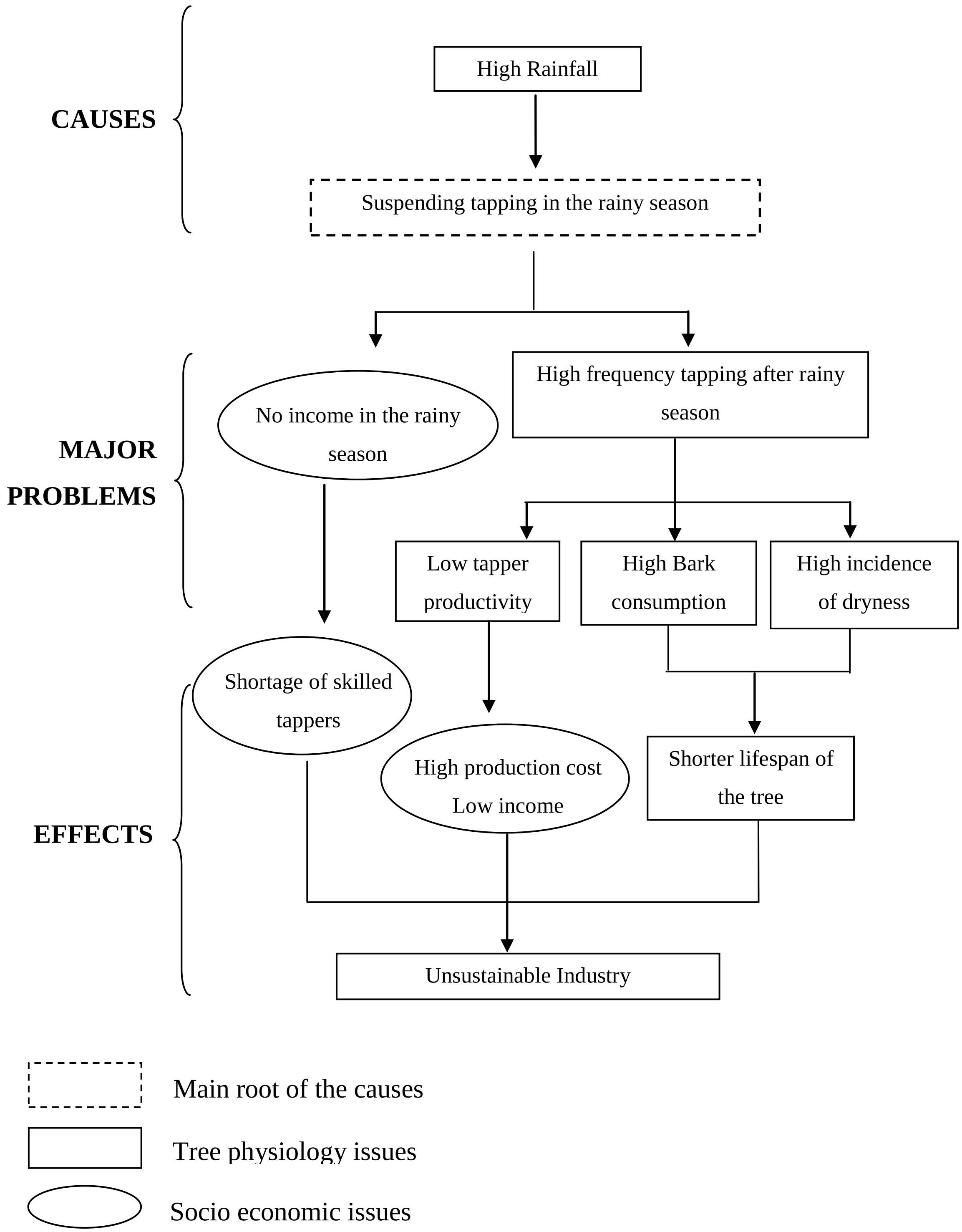

Figure 1 Causes of the current problems and their effects in the area

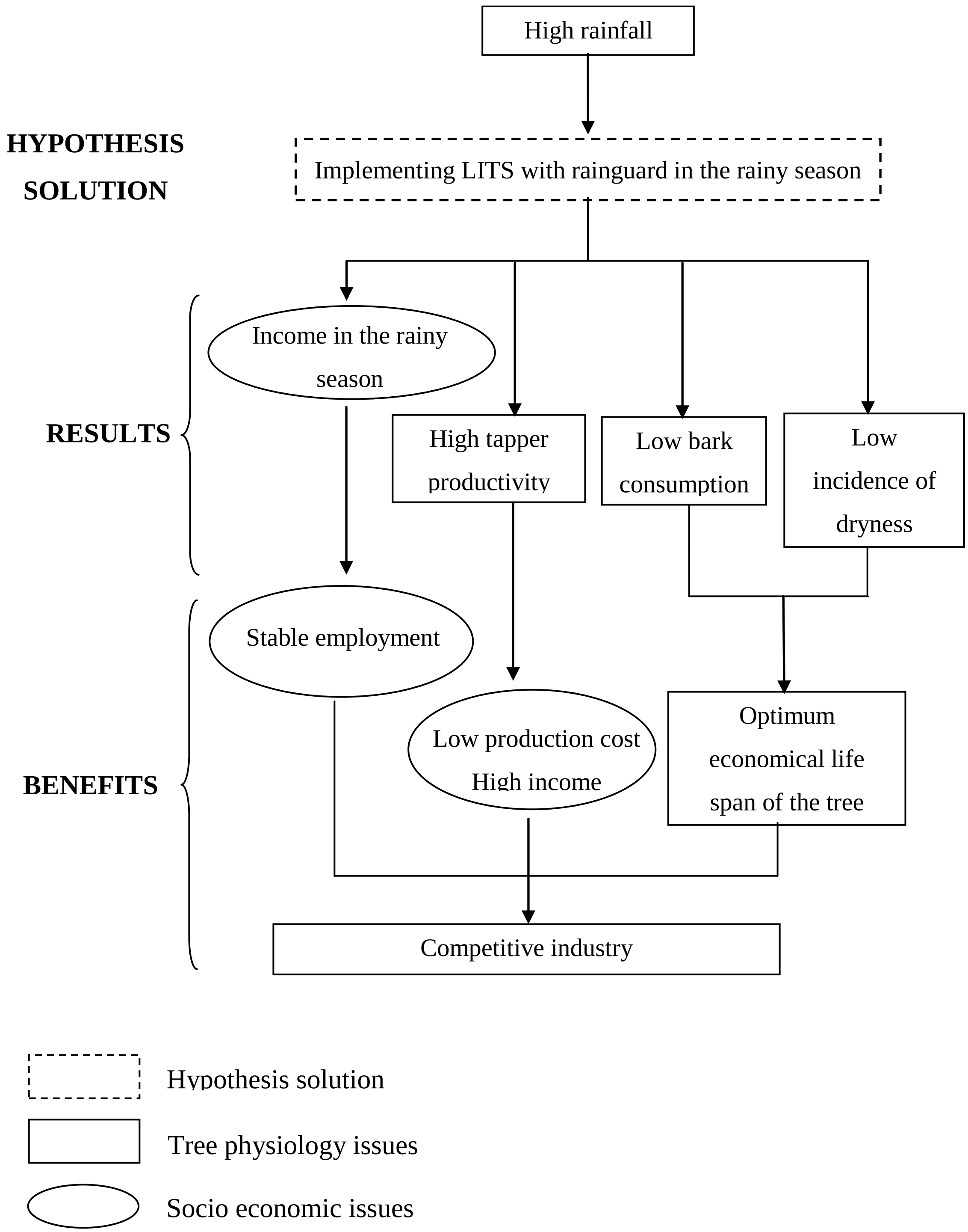

Figure 2 Hypothesis solution to address the problems

1.3 Literals review

1.3.1 Development of latex harvesting (tapping) technology

History of para rubber was started remarkably in 1876, when Sir Henry Wickham, a British explorer, smuggled about 70,000 *Hevea brasiliensis* seeds from the Santarem area of Brazil to the Royal Botanical Gardens, Kew in London. In the same year, from these seeds, about 2,000 seedlings were sent to the Botanical Gardens, Peradeniya, Ceylon (Sri Lanka) and 90 per cent were survived. Then, from the garden, the seedlings were distributed to Malaya, Singapore, Indonesia, India and Myanmar (Loadman, 2005).

The first experiment of tapping was done at Heneratgoda Botanical Garden in Sri Lanka in 1881 by Dr. Henry Trimen, a British botanist and the director of the Royal Botanical Gardens. He modified Brazilian native tapping method, slashing a series of cuts on the tree with an exe or hatchet, to V-shape incisions around the tree, and many vertical cuts on the tree (Wright, 1912). Nevertheless, these tapping methods caused difficulties to collect latex, sever injury, irregular secondary growth and poor yield. The trees could not produce latex for long term due to damages of the bark and were very early abandonment consequently.

In 1889, Sir Henry Ridley, a British botanist and the director of Singapore Botanical Gardens, devised a tapping method that shaves a bark along a sloping groove without damaging the wood at regular intervals. The method consisted of a series of short parallel oblique incisions connected with a vertical groove which allowed the latex flowing to collection cup so that latex collection could be done properly. It also allowed the bark to regenerate above the cut. Later the renewed bark could be tapped again for a subsequent round of tapping. Since the tapping cuts were looked like herring bone, it was called ‘Herring-bone system’. This tapping method was widely adopted at several estates in Sri Lanka and the Malay Peninsula. He improved the tapping method which allowed the rubber trees to be tapped every alternate day and proved that the tree could be tapped after seven years of planting (IRRDB, 2006). His innovations are basic concepts of the present tapping systems. The scientific methods of excision tapping were first published in the annual reports of the Royal Botanic Gardens for 1890 and 1891. A detailed description of the excision method was also published in 1897 (Eaton, 1935) which later known as Ridley's method.

At the early history of tapping, since there were no special knives for tapping, only axe, hatchet, carpenter's chisel, wedge-shape chisel and mallet were used as tapping tools until 1900s. In 1906, Jebong Estate from Malaysia invented and introduced Jebong knife. As it was effective and reduced wounds on the bark, it superseded the other tools and knives. Since then, it has been using widely in most rubber growing countries until now.

In the 1930s, planters looked for ways to increase rubber yield while rubber price were low. In 1939, it was first found that cow dung mixed with clay or oil could be applied on scraped bark to increase latex yield (IRRDB, 2006). 2,4-D, 2,4,5-T, calcium carbide and copper sulfate were also used as stimulants. It was also found that ethylene was the key to delay plug formation and prolonging latex flow. In 1968, 2-choloro ethyl phosphonic acid (ethephon) was first searched as the yield stimulant (Abraham *et al.,* 1968) which decomposes in the bark to release ethylene. Because of this finding, since then, ethephone has been widely using and rubber productivity and production increased within a short period (Sivakumaran *et al.,* 2002; Webster and Paardekoper, 1989b).

Around 1980s, due to the shortage of labour availability in Malaysia, low intensity tapping systems combination with yield stimulation involving either lower frequency of tapping or shorter tapping cuts was started to implement to reduce the labour requirement for tapping without losing the production.

In 1992, Rubber Research Institute of Malaysia (RRIM) introduced gaseous stimulation system which allows directly ethylene gas diffusion to lacticiferous system. It is a technique that ethylene gas is applied directly by fixing a kind of gadget and latex is exploited at high panel of virgin bark with short tapping cut. Although some rubber estates are using this system, it could not be recommended to practice commercially because there are some obstacles in this system in terms of tree physiological and socio-economic factors.

1.3.2 Mechanism of latex flow

Fresh *Hevea* latex in the latex vessels mainly consists of rubber globules, lutoid particles and Frey-Wyssling particles by dispersing with other constituents – amino acids, inorganic acids, proteins, carbohydrates, resins, glucosides, tannins, mineral salts, and alkaloids. Mineral salts, proteins and sugars are also soluble in parenchyma and phloem cells beside latex vessels.

In the early morning, before tapping, latex vessels are under high hydrostatic pressure. Osmotic pressure from surrounding cells also makes the hydrostatic pressure higher. Due to the hydrostatic and osmotic pressure, turgor pressure in the latex vessels is higher. Usually hydrostatic pressure in the latex vessels in the morning is between 10 and 15 atmospheres while outside pressure is low. Because of high pressure difference, once the vessel is tapped, latex exudes out. Then, a fall in pressure in the latex vessels to ambient follows and consequently water from the surrounding tissues enters the latex vessels. It leads the latex less viscous, resulting in an enhanced flowing of latex.

After certain duration, latex flow slows down and cessation of the flow follows. It is because of an inherent clotting mechanism in the latex vessels (Boatman, 1966; Southorn, 1968). While latex flows out, the lutoid particles are ruptured and release destabilizing substances called hevein, a kind of protein, which flocculates and coagulates the latex near the cut ends in the vessels resulting plugging.

The full regeneration of the latex in the vessels after one tapping was estimated to be around 72 hr (Serres *et al.*, 1994). The regeneration of latex between the two tappings is related to the cellular metabolism of the laticifer system and ecophysiological functioning of the tree. Assimilation (photosynthesis), transport of sugars, and allocation of the different competing sinks play a key role in the regeneration of the latex.

1.3.3 Tapping

Tapping is an activity of latex harvesting that removing cut ends of latex vessels that are plugged with coagulated latex from a previous tapping by shaving the bark. Then fresh latex is exuded out from the latex vessels, flows down along the sloping cut and accumulate into a latex receiving container. Different tapping systems have been employed in an effort to maximize yield or optimize profit. The selection of the tapping systems is influenced by a number of factors, including cultivar grown, age of trees, weather, availability of skilled tappers, rubber price and local wage agreements (Webster and Paardekooper, 1989b). Tappable trees (stand per hectare), height of tapping, length, direction and slope of tapping cut, frequency of tapping, time of tapping, depth of tapping, age of tapping bark, bark consumption, tapping panel changing and yield stimulation are basic technical elements in order to obtain the optimum yield.

The ideal tapping system is defined as one which gives the highest yields at the lowest tapping cost, low bark consumption, satisfactory growth and bark renewal and the lowest incidence of dryness (Vijayakumar *et al.*, 2000). However, there is no one tapping system that could give the best results in all cultivars and under all conditions.

1.3.4 Conventional tapping systems

Normally tapping commences at six or seven years after planting in order to get the economic yield. It is recommended to open a plot for tapping that tapping can commence when at least 70 per cent of the trees reach 45 cm of girth at 150 cm height above the union. The opening of the tapping is carried out at 150 cm height from the union with 30 to 35 degree of angle from high left to low right for downward tapping.

One tapping system recommended in most rubber producing countries is downward tapping, half spiral of tapping cut length (S/2) with alternate daily tapping (one day tapping in two days – d2). However, one third spiral tapping cut (S/3) with high frequency tapping is commonly adopted in some rubber producing countries.

Normally the tapping on the basal virgin bark commences at 150 cm height above the ground. After completion of the first side of the basal panel (BO-1), the other side of the basal panel (BO-2) would be tapped. After that, some practice tapping on renewed bark of the first basal panel (BI-1), then followed by tapping on renewed bark of the second basal panel (BI-2). But some tap half spiral of virgin bark at high panel (HO-1) by downward tapping instead of the tapping on the renewed bark. After completion of the high panel tapping, slaughter tapping is adopted for two to three years before felling the trees. It is practiced combination with high concentration of yield stimulation to extract as much latex as possible from the every parts of the tree, with very little consideration of bark consumption, wounding, tapping frequency and tapping quality also.

1.3.5 Bark consumption

Bark consumption – the thickness of the bark shaving removed at each tapping – depends on the skill of the tapper and the degree to which the bark has dried out. The shaving should be thick enough to remove all plugged vessel ends. Normally, under downward tapping systems of d2, d3, and d4, the recommended consumption are 1.0-1.2 mm, 1.3-1.5 mm, and 1.5-1.7 mm per tapping, respectively for virgin bark (Lacote *et al*, 2004). Under low frequency tapping systems, since it results in greater drying out of the bark tissues, it needs to remove a slightly thicker bark shaving per tapping. And it is also important that even thickness of bark is removed properly along the whole tapping cut length. Excessive consumption or thicker shaving waste bark capital and so shortens the economic life span of the tree (Webster and Paardekooper, 1989a).

1.3.6 Yield stimulation

The most common yield stimulant is 2-choloroethyl phosphonic acid which releases ethylene gas, when it is applied, and increases the duration of latex flow by delaying plugging of latex vessels. The main effect of stimulation is that of prolong the duration of flow and thus increasing the amount of latex discharged during tapping. Since latex production is connected with genetic features, the effect of the environment, and tapping systems, response to stimulation is strongly dependent on these different factors. Stimulation treatments must therefore be applied with caution and be suited to the potential of clonal typology in a given environment and for a given intensity of tapping. Stimulation is applied to tree subjected to very varied tapping intensities. It is clear that the interaction between intensity of tapping and intensity of stimulation must be taken into account in rational long-term harvesting (Eschbach and Lacrotte, 1989). Stimulation is an excellent means of removing certain factors which limit flow and/or regeneration of latex. However, excessive use or misuse can lead to serious malfunctioning of the laticifers. Too intensive stimulation leading to excessive outflow of latex also prejudices the physiological state of the tree and may lead to degeneration of the laticiferous system in the bark inducing tapping panel dryness (Jacob *et al.*, 1989). In addition, high frequent tapping reduces effects of stimulation because of over discharge of latex which does not allow the tree to regenerate cell material in the drainage area. Less frequent tapping systems such as half spiral cut tapping every 3rd or 4th day, response to stimulation is more sustained and cumulated production after 7 to 9 years is greater than that of stimulated trees with system of half spiral alternate daily tapping (Sivakumaran *et al.*, 1982).

1.3.7 Low intensity tapping system

In order to increase land and labour productivity significantly, Low intensity tapping systems (LITS) were innovated. LITS also reduce requirement for tappers and cost of production compared to the conventional tapping systems with alternate tapping frequency (Said *et al.*, 1998). Implementation of LITS means a reduction in the intensity of tapping by reduction of tapping frequency and/or tapping cut length (Eschbach and Lacote, 1989; Obouayeba *et al*., 2010; Karunaichamy *et al*., 2012). The reduction in tapping frequency increases number of days between two successive tappings, notably latex generation period, ensuring more latex is regenerated resulting to higher yield per tapping per tree, notably tapper productivity. However, the reduction in tapping frequency reduces cumulative yield. Thanh *et al*. (1996) reported that cumulative yield of d3 was only 93% of that obtained from d2 tapping system. Thus, under LITS, optimum land productivity could not be yield without combination of yield stimulation. However, the frequency of stimulation and the concentration of stimulant should be modulated depend on clone, tree age, weather and tapping system (Sivakumaran, 1982).

Under LITS, the trees of a certain task get more resting time for latex regeneration, so that tapper could be assigned to tap other tasks in the following days while the first task is resting. It enables to reduce tapper requirement, without reduction in level of yield, compared with the conventional tapping system (Soumahin *et al*., 2010). Because of consistently higher tapper productivity under LITS, tapper incomes or wages can be increased. As the result, tapping employment would be competitively attractive and could address problems of skilled tapper shortage (Chan *et al*., 1983; Hassan *et al*., 1999). Higher tapper productivity also contributes lower cost of production. In Sri Lanka, due to a certain higher productivity and land-man ratio of S/2 d3 tapping system with stimulation, the cost of tapping and the tapper requirement could be reduced by 20% and by 30%, respectively (Nugawela *el al*., 2000). In addition, longer economic lifespan of the tree could be expected from LITS because of its lower bark consumption. Under LITSs, although bark shaving per tapping is thicker than that of the conventional frequency tapping, S/2 d2, the effect is marginal compared to overall bark saving (Rodrigo, 2012). In addition, lower bark consumption causes delaying commencement of tapping on renewed barks resulting longer resting period for the renewed bark generation. Hence, potential higher yield could be expected from the renewed bark under LITS.

1.3.8 Tapping in the rainy season

Hevea brasiliensis has been generally performed best in climates of the tropical lowland, evergreen rainforest regions, with annual rainfall of 2000-4000 mm evenly spread through the year. Ideally, the number of rainy days should be range from 100-150. If the number is excess above the range, tapping works would be interfered and leaf and panel diseases would occur (Watson, 1989). Heavy tropical rain can interfere the tapping process, either by direct discouragement of the tappers to tap, or more generally by canopy and branch runoff trickling down the trunk and interfering with the flow of latex into the collection cup. Wycherley (1967) classified interference with tapping due to the rain as follows:

1. Late tapping: when rain falls before tapping, the trees are wet and water trickles down the trunk so that tapping must be postponed.
2. Early collection: when rain falls during tapping, but there is time to carry out an early collection of latex before any interference. If early collection is not possible, and heavy rain washes the latex out of the cups, the situation is termed a 'wash-out'.
3. Very heavy rain before or during the normal tapping prevent trees being tapped at all so that tapping day is lost.
4. Rain after tapping may result in loss of the late drip.

In rainy season, regular tapping can be carried out by rainguard tapping under any given tapping frequency. Although around 140 tapping days are under the rain in India which has averagely over 4,500 mm annual rainfall (Yogaratnam, 2013), the average annual productivity of India is the highest around 1784 kg per ha per year in 2010 among the rubber growing countries (ANRPC, 2011) because of implementing rainguard tapping system successfully. Navarathne (2014) reported that the only way to increase the production by about 20-30% within a couple of months was use of rainguards. Rainguard protects tapping cut, panel and washout from the rainwater. It can significantly reduce panel wetting from rain, compared to other panel without being fixed rainguard, during the previous night or early morning and thus largely prevent loss of tapping days and late tapping (Gan *et al*., 1985). However, chances of panel diseases are high so that systematic application of fungicides for panel diseases should be applied at weekly intervals (Jacob *et al*., 1995). Tapping under d3, d4 or d7 frequency will be successful only with effective and timely rainguarding. The use of rainguard reduces also the problem of seasonal unemployment of rubber tappers because of regular incomes by rainguard tapping in the rainy season (Tillekeratne and Nugawela, 1995).

Generally there are two main types of rainguard: polythene skirt type and gutter type. The skirt type is used commercially in Sri Lanka and India where the rain falls heavily. It can protect the tapping panel and also latex collection cup from interference of rainwater not only from the stem flow also from beside by wind. However, there are two main disadvantages: humid conditions under the skirt, leading to panel diseases; and the need to lift the skirt for every tapping (Watson, 1989). The gutter type can protect the tapping panel only from the stem flow of rainwater. It is now being widely used in Malaysia, Vietnam, and China where the rainfall is not over 3000 mm per year (Yogaratnam, 2013).

If the whole tapping day is lost due to prolonged rainfall, recovery tapping may be carried out on the afternoon of the following day after the tapper has tapped his normal tapping. Since the yield is lower and the tappers have to be paid overtime rates, the recovery tapping is not always economically justified (Watson, 1989). By undertaking recovery tapping, however, it can minimize losses of yield due to rain interference. About 40-50 out of about 140 tapping days lost per annum due to rain could be recovered by recovery tapping (Yogaratnam, 2013).

1.3.9 Wintering period

Trees older than 3 or 4 years are subjected to ‘wintering’, which is the term used to describe the annual defoliation of senescent leaves which renders the trees completely or partially leafless for a short period. Defoliation is normally followed within 2 weeks by the terminal buds bursting and by the expansion of new leaves within a further week. There are marked differences that some clones defoliate partially while some others defoliate completely. The differences are because of clonal characteristic. Latex yields usually fall slightly at the onset of the wintering and are more markedly reduced during refoliation (Webster and Paardekooper, 1989b). Normal yield only could be obtained back several weeks after the period because of that during refolition followed by shortly afterwards by flowering, the tree uses in priority its organic and mineral reserves for the reconstitution of its leaves and for fruit growth instead of latex-producing function (Jacob *et al*., 1989).

1.4 Objectives

The overall objective was to design suitable tapping systems which could yield optimum production and income with smooth adaptation to the farmers in the area.

Specifically, the preliminary research objectives were –

- to study yield performances of the LITS with rainguards in the high rainfall area
- to study socio-economic performances of the LITS with rainguard under different payment systems.

1.5 Scopes and limitations of the study

The research focused only the area of high rainfall more than 4,000 mm per year. Since most farmers practice half spiral tapping cut (S/2) with downward tapping in the area, it was not possible to conduct different lengths of tapping cut at the on-farm experiment. Due to the time limitation of the experiment, incidence of Tapping Panel Dryness could not be studied.

Regarding the socio-economic aspects, the study focused particularly operating costs based on unit area and unit production, tapper incomes and operating profits under different payment systems currently practiced in the area. The study did not focus on investments and capital for planting and up-keeping period.

The research mainly based on primary data quantitatively and qualitatively which were collected from the on-farm experiment and from interviews with the farmers in the area.

1.6 Outcomes of the study

The study exhibited that optimum yield could be harvested with low cost of production resulting in optimum profits practically along the year by implementing the LITS with rainguard. As the outcomes, the study could contribute the rubber planting industry to be more resilience and competitive.

Chapter 2
Research Methodology

2.1 Location of the experiment

The on-farm experiment was conducted at Ye Zet Taung Rubber Estate, which is located at16.00˚N and 97.63˚E, and 11m of altitude, near Kyone Kadat village, Thanbyuzayet Township, Mon State, Myanmar. Soil type is lateritic with pH 4-5 at the area. According to previous records from a local weather station, maximum and minimum temperature are 32˚C and 22˚C, respectively, average relative humidity is 75% in the area. The rainy season starts in the end of May and ends in September with 4800 mm of average annual rainfall. The cold season lasts for 4.5 months from October to the middle of February. Then the hot season continues for 3.5 months from the middle of February to May. Normally, in the area, tapping is carried out from in the middle of September to the middle of May for 8 months. However, it is totally suspended typically in the rainy season. The wintering period (defoliation and refoliation period) is normally between the end of February and the end of March.

2.2 Planting material

The trial was conducted on BPM 24 clone which is recommended by Ministry of Agriculture and Irrigation to plant in high rainfall (above 4500 mm) regions (Appendix 2) because of its tolerant to *Phytophthora* leaf fall which is the most prevalent disease in the area. It is the most planted clone in the area because it gives the highest yield between 1500 and 2000 kg/ha/yr under well plantation management with S/2 d2 tapping system. The trees were planted in 2005 and opened for tapping in 2011. The trees are planted in 3 m x 7 m spacing on flat land.

2.3 Experimental design and treatments

Five treatments of different tapping systems were evaluated with four replications in randomized complete block design (RCBD). Each plot consists of 60 trees in 6 rows with 10 trees. Thus, the total number of trees conducted is 1200 in 20 plots. The five treatments of tapping systems were as follows:

- Treatment 1 (Control): S/2 d2 (Oct – May)/12 tapping system, currently most estates are using – half spiral cut with alternate daily tapping without rainguard in 8 months from October to May without resting in wintering period.
- Treatment 2: S/2 2d3 (Oct – May)/12 tapping system, currently most smallholders are using – half spiral cut with two-day tapping in 3 days in 8 months from October to May without resting in wintering period.
- Treatment 3: S/2 (RG) d2 (Apr – Feb)/12 tapping system – rainguarded half spiral cut with alternate daily tapping in 11 months from April to February with resting one month in wintering period.
- Treatment 4: S/2 d3 (Apr – Feb)/12 ET2.5% Pa1(1) 3/y (m) tapping system – half spiral cut with third daily tapping without rainguard, three applications of ethephon 2.5% stimulation per year in 11 months from April to February with resting one month in wintering period from the middle of February to the middle of March.
- Treatment 5: S/2 (RG) d3 (Apr – Feb)/12 ET2.5% Pa1(1) 3/y (m) tapping system – rainguarded half spiral cut with third daily tapping, three applications of ethephon 2.5% stimulation per year with rainguards 11 months from April to February with resting one month in wintering period from the middle of February to the middle of March.

Table 1 Summary of the treatments conducted in the experiment

Treat-ment	Length of tapping cut	Tapping frequency	Tapping in the rainy season	Using rainguard	Stimulation	Resting in wintering period
1	S/2	d2	No	No	No	No
2	S/2	2d3	No	No	No	No
3	S/2	d2	Yes	Yes	No	Yes
4	S/2	d3	Yes	No	ET2.5% Pa1(1) 3/y (m)	Yes
5	S/2	d3	Yes	Yes	ET2.5% Pa1(1) 3/y (m)	Yes

Stimulation times: June, November and December

Tapping was carried out on second basal panel of virgin bark (BO-2) with same age of trees. The tapping for the experiment commenced at the first year of BO-2 at 120 cm height above the ground. Each replication with 5 treatments was tapped by one tapper so that four tappers were assigned. Normally, the tappings were carried out at 5 o'clock in the morning. If the tapping in schedule tapping days was disturbed by heavy rain, the recovery tapping was carried out on no-rain day or the following day.

For the stimulation treatments, 1 gram of 2.5% ethephon (2-chloro ethylphosphonic acid) was applied three applications with monthly interval (once a month in June, November and December) per year. It was applied on 1 cm band on panel (renewed bark) above the tapping cut by using a painting brush.

2.4 Installation of the rainguard

The rainguards were installed in the second week of May before starting the rainy season. A polythene plastic sheet, 80 cm in width and 60 cm in length, was used for making a rainguard on the tree which has 50 to 60 cm of girth at 100 am of height from the ground. Lightly scraping on the bark at 150 cm height from the ground was carried out to clean mosses and dust from the bark by using a sand paper or a light scraper. The width of scrape band on the bark was around 2.5 to 5 cm.

After scraping, a kind of traditional sealant, which is used in traditional boat making, was attached along the scrape band. Then, the polythene plastic sheet was attached tightly on the sealant. Some folded frills were prepared at the top end of the sheet in order to avoid the touching of the sheet and the tapping panel when the wind is heavy. The tapping panel and the cup had to be covered by the plastic sheet. After that, rubber scrap band, cutting from used inner tube, was banded tightly over the top end of sheet. Finally, the sealant was caulked again between the sheet and the bark to ensure that there was no leakage in order to protect the tapping panel from rain wetting.

Two workers were needed to fix a rainguard and could finish around 150 to 200 fixings per day. Mencozeb fungicide was sprayed on the tapped panel of the trees tapped with the rainguards at weekly interval in the rainy season to prevent panel diseases.

Figure 3 Tapped tree with polythene skirt type rainguard

2.5 Study parameters

2.5.1 Climatic data

Daily rainfalls, temperature, and relative humidity were recorded by a mini weather station in the estate. From the rainfall records, rainfall, number of raining days and raining patterns were identified to understand how rains could interfere the tapping works.

2.5.2 Daily yield

Daily yield from each treatment was calculated by multiplying of actual dry rubber content (DRC) and volume of latex received from each plot (RRIM, 1973).

Actual daily yield = Actual DRC x Volume of latex

Volume of fresh latex from every plot was measured daily. DRC was first estimated by a Materolac. Then sample sheets represent to respective plots were prepared and dried in smokehouse. After four-day drying in the smokehouse, the sample sheets were weighted to calculate actual DRC (RRIM, 1973).

Actual DRC = Weight of dry sample sheet/Volume of sample latex

Average yield of daily tapping per tree was expressed by gram per tree per tapping. It is calculated by dividing the actual daily yield by average number of tapped tree in a treatment. Cumulative yield per tree was also calculated by sum up of the all average daily yield per tree.

2.5.3 Bark consumption

Bark consumptions were measured monthly during the study period and the total consumption were also carried out in the end of May of 2016. It measured height of tapped panel from the beginning to the current tapping cut. Bark consumption per tapping was also calculated.

2.5.4 Socio-economic performance

In terms of socio-economic aspects, tapper requirement, tapping costs including stimulant, fungicide, rainguard and fertilizer costs, tapper incomes, and tapper income and operating profit were calculated. in terms of different tapping systems and payment systems based on specific local rate of wages and payment systems. Operating costs for tapping which, associated with works of tapping and latex collecting, based on unit area and unit production were calculated. The costs were calculated based on yields resulting from the experiments, and also local rates of different payment systems and the farmer practices resulting from interviews and field surveys.

Tapping costs per unit area were calculated as follows;

TCA_{PW} = TTA x WDT x piece work rate per tree

TCA_{S} = Salary x number of tappers x number of tapping months

TCA_{PS} = TP x TTA x WDT x rubber price x 0.5

Where,

TCA_{PW} = tapping cost per unit area under the piece work payment system

TCA_{S} = tapping cost per unit area under the salary payment system

TCA_{PS} = tapping cost per unit area under the product sharing payment system

TTA = number of tapped tree a day per unit area

WDT = number of working days for tapping

TP = tapper productivity

Tapping costs per unit area were calculated as follows;

$$TCP_{PW} = TCA_{PW} / (TP \times TTA \times WDT)$$

$$TCP_{S} = TCA_{S} / (TP \times TTA \times WDT)$$

$$TCP_{PS} = \text{price} \times 0.5$$

Where,

TCP_{PW} = tapping cost per unit production under the piece work payment system

TCP_{S} = tapping cost per unit production under the salary payment system

TCP_{PS} = tapping cost per unit production under the product sharing payment system

Total tapper incomes were calculated as follows;

$$TTI_{PW} = TCA_{PW} / \text{number of tappers}$$

$$TTI_{S} = \text{Salary} \times \text{number of tapping months}$$

$$TTI_{PS} = TCA_{PS} / \text{number of tappers}$$

Where,

TTI_{PW} = total tapper income under the piece work payment system

TTI_{S} = total tapper income under the salary payment system

TTI_{PS} = total tapper income under the product sharing payment system

Total operating profits were calculated as follows;

$$TOP_{PW} = (\text{total yield x price}) – (TCA_{PW} + RGC + FC + SC)$$

$$TOP_{S} = (\text{total yield x price}) – (TCA_{PW} + RGC + FC + SC)$$

$$TOP_{PS} = (\text{total yield x price}) – (TCA_{PW} + RGC + FC + SC)$$

Where,

TOP_{PW} = total operating profit under the piece work payment system

TOP_{S} = total operating profit under the salary payment system

TOP_{PS} = total operating under the product sharing payment system

RGC = rainguard cost

FC = fertilizer cost

SC = stimulant cost

2.6 Field survey and interview

Field surveying some smallholdings and estates, and interviewing some tappers, smallhoders and estate owners/managers were carried out to realize the current problems, roots of the problems, and production costs resulting from different tapping systems and different payment systems. To find out the hidden facts, semi-structured interviews in opened type were conducted at rubber fields, workplaces. Different tapping costs were calculated based on local rates resulting from the interviews and the field surveys.

Questionnaires used in the interviews were formulated for three groups – tappers, smallholders and estate managers – to understand different perspectives mainly related to tapping works. The interviewees were from Thanbyuzayat and Mudon where their workplaces, rubber fields, existed. They were also selected according to their current payment systems and holding sizes. Other persons such as local fertilizer distributers, rubber dealers, processors, officers from the government and also from rubber associations, were also interviewed in order to understand the situation of the supply chain in the area comprehensively.

2.7 Data analysis

An analysis of variance was carried out using Duncan's multiple range test, at $p \leq 0.05$, to compare the data of the five treatments including mean yields, cumulative yields, average bark consumptions, tapping costs per unit area, tapping costs per unit production and monthly tapper incomes by using Sirichai Statistics 6.00.

2.8 Secondary data

The secondary data used in the study consist of published documents, previous research papers, data and statistics from local ministries and associations, central statistical office, international institutes and research organizations, and supported in order to understand the overview of the industry, explore the problems, construct hypothesis, design the on-farm experiment, formulate questionnaires.

Chapter 3
Results

3.1 Rainfall and raining pattern

The rainy season started from the mid of May and ended in September in the study area in 2015. Total rainfall was 4028 mm during the study period from June 2015 to May 2016 (Figure 4). The total number of raining days was 125 days from June 2015 to May 2016 (Table 2). Ninety six percent of the total rainfall was recorded during the rainy season. It peaked in July and August with 1521 mm and 973 mm, respectively (Figure 4).

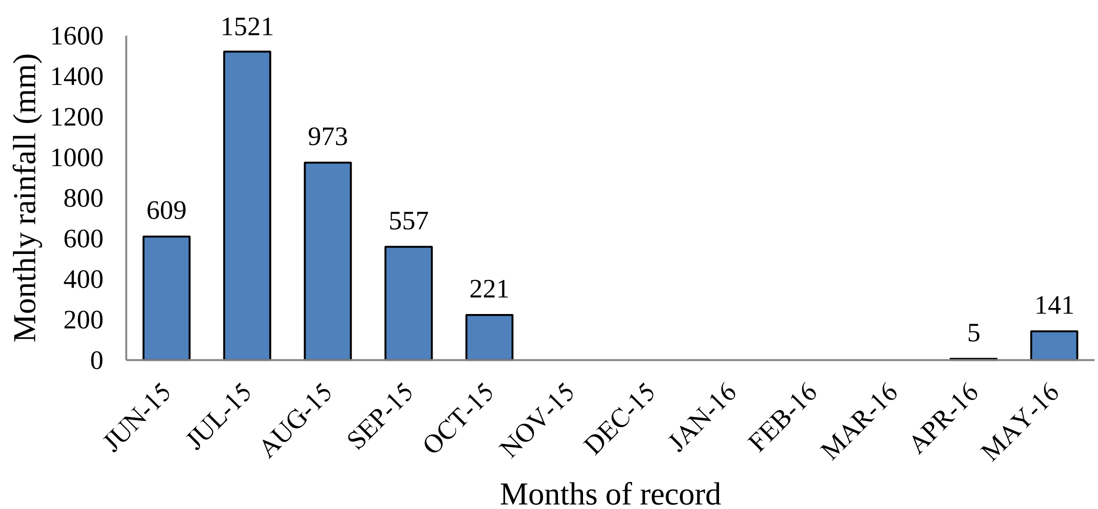

Figure 4 Monthly rainfall from June 2015 to May 2016 at the experiment plot

It was notable that seed-fall season was taken places in the last week of June 2015 when the rain had intermitted for one week. After that, the rain proceeded continuously until the end of September particularly in July and August with 58 raining days in these two months. There was no rain after the rainy season between November and the mid of May except a little shower in the mid of April with only 5.2 mm in two days.

Table 2 Number of raining days during June 2015 to May 2016 at the experiment

Months	Number of raining days
June	17
July	29
August	29
September	24
October	13
November	0
December	0
January	0
February	0
March	0
April	2
May	11
Total number of raining days	125

Figure 5 shows aggregated rainfall during the study period according to three-hourly time patterns. It was found that rainfall distributed along the day and peaked in the morning. Thirty six percent of the total rainfall was aggregated between 3:00 am and 9:00 am in the morning.

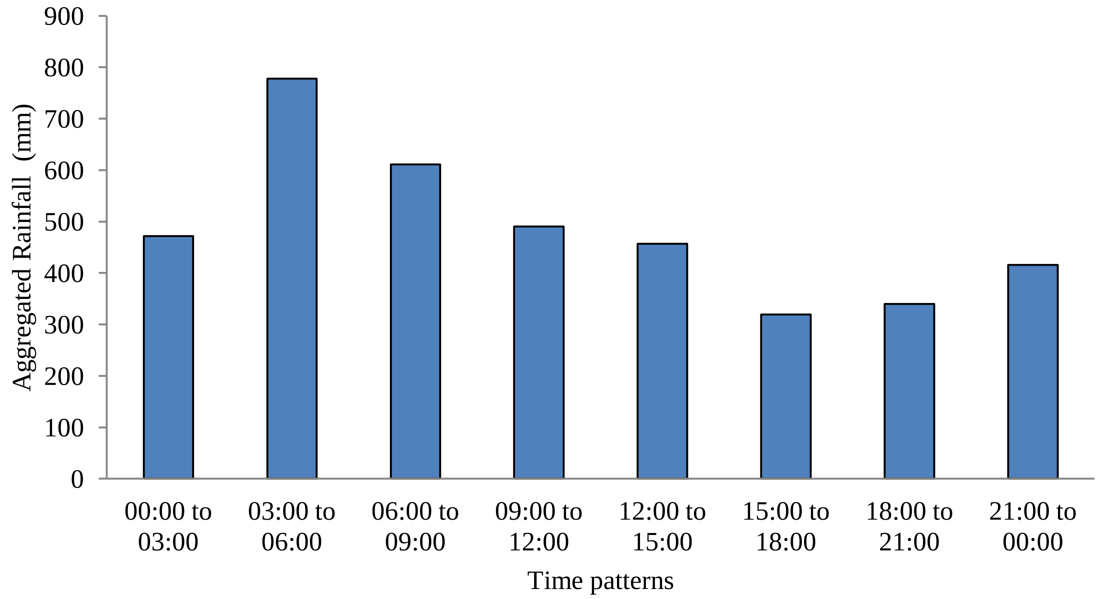

Figure 5 Aggregated rainfall by third hourly time patterns

Table 3 Tappable days in the five treatments during the rainy season

Months	No. of raining days	T1		T2		T3		T4		T5	
		TTD	ATD	TTD	ATD	TTD	ATD	TTD	ATD	TTD	ATD
JUN	17	0	0	0	0	10	7	7	5	7	5
JUL	29	0	0	0	0	16	5	11	4	11	4
AUG	29	0	0	0	0	16	11	11	5	11	9
SEP	24	0	0	0	0	15	15	10	8	10	11
Total days	99	0	0	0	0	57	38	39	22	39	29
Tappable days (%)			0		0		67		56		74

TTD = Targeted Tapping Days; ATD = Actual Tapping Days

Table 3 shows comparison of tapping efficiencies among the treatments in terms of tappable days during the rainy season based on targeted tapping days.

Comparing only T3, T4 and T5, which were tapped in the rainy season, number of tapping days of T4 was the lowest, only 22 days with 56% of targeted tapping days. T5 could tap 74% of targeted tapping days effectively while T3 could meet only 67% of targeted tapping days despite it had more tapping days.

3.2 Yield performance

3.2.1 Latex production

Table 4 shows latex production of the different treatments in terms of mean yield (tapper productivity) and cumulative yield per tree from June 2015 to May 2016.

Table 4 Average yield (g/t/t) and cumulative yield (kg/t) in the five treatments from June 2015 to May 2016

Treatment	Mean yield (g/t/t)	Cumulative yield per tree (kg/t)	Number of tapping days
T1	20.81 d	2.39 b	114
T2	19.67 e	2.85 a	146
T3	22.11 c	2.96 a	134
T4	23.24 b	2.09 c	85
T5	25.64 a	2.40 b	93
CV	2.48	2.85	

Means with different letter in the same column are significantly different at $p \leq 0.05$, computed by Duncan's multiple range Test.

Regarding the cumulative yield per tree during the study period, T3 and T2 were higher significantly, with the higher number of tapping days, followed by T5 and T1 while T4 was the lowest significantly among the treatments. However, in terms of tapper productivity (g/t/t), T5 was the significant highest followed by T4. T2 gave the lowest tapper productivity significantly although it had the highest number of tapping days.

Figure 6 illustrates that the trends of different tapper productivities varied according to the different seasons. In the rainy season from June to September, T5 could yield the higher tapper productivity than the other two treatments, T4 and T3. In the cold season from October to January, T5 and T4 yielded the highest taper productivity in November with over 40 g/t/t while T3 reached its peak 35 g/t/t in December. T2 surged its yield in the first month of tapping, then reached its peak 28 g/t/t in November while T1 could yield 33 g/t/t in December. After that, all the trends turned down in January.

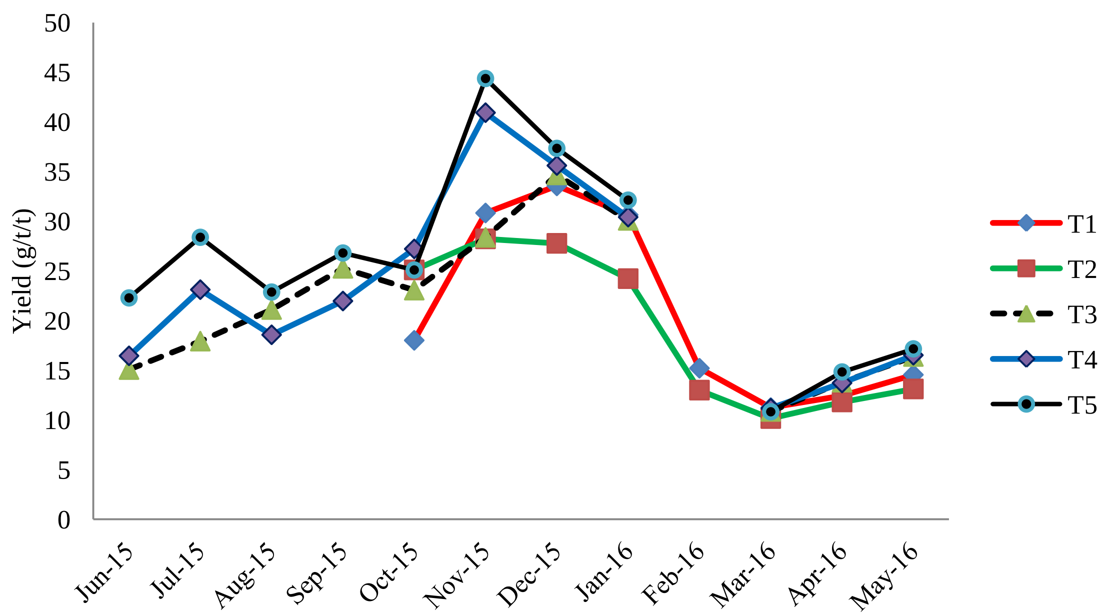

Figure 6 Average yield (g/t/t) by months in the five treatments from June 2015 to May 2016

The hot season started from February to the mid May and the winter period occurred from February to the mid March. Hence, tappings of T3, T4 and T5 were suspended for 5 weeks from the beginning of February to the first week of March. T1 and T2 kept tapping without resting during the wintering. It was found that the yield were comparatively low and reached the lowest in March as T2 and T1 yielded only 10.14 g/t/t and 11.24 g/t/t. T3, T4 and T5 resumed the tappings in the second week of March but count not yield over 15 g/t/t in March and April. However, trends of all the treatments went up gradually in April.

3.2.2 Bark consumption

Table 5 shows comparison of bark consumptions among the treatments during the study period. It was apparent that the average bark consumption in 2d3 frequency tapping, T2, was the highest with 23% higher than that of d2 frequency tapping, T1. Regarding the monthly bark consumption, d3 frequency tappings, T4 and T5, consumed comparatively lower than the other treatments as only 57% and 62% respectively when compared to that of T1. However, T4 and T5 consumed 0.19 cm per tapping which was comparatively higher than the other treatments.

Table 5 Bark consumptions in the five treatments from June 2015 to May 2016

Treatment	Average bark consumption (cm)	Monthly bark consumption (cm)	Bark consumption per tapping (cm)
T1	20.67 c (100)	2.58 (100)	0.18
T2	25.52 a (123)	3.19 (123)	0.17
T3	22.69 b (110)	2.11 (82)	0.17
T4	15.9 e (77)	1.48 (57)	0.19
T5	17.3 d (84)	1.61 (62)	0.19

Means with different letter in the same column are significantly different at $p \leq 0.05$, computed by Duncan's multiple range Test.
Figures in parenthesis indicate percentage of control.

3.3 Socio-economic performance

3.3.1 Payment Systems

In that area, it was surveyed that three types of payment systems: salary, piece-work, product sharing payment systems are employed for tapping and the latter has been started only since last few years ago. The payment systems normally vary particularly with the size of holding. It is noted, however, that it also varies with rubber price and availability of tapper.

Salary Payment System:

As rubber planting in Myanmar was started by British companies, most rubber area was owned by the British companies until 1960s. The companies practiced the salary payment system with well plantation management. After 1960s, the company owned estates were nationalized and transferred to the government. Then the government also used the salary payment systems. The one reason was that the availability of tapper was not a big issue at that time. At that time since these estates operated successfully in well management system, new private estates also practiced the salary payment system. Thus, the salary payment system has been employed for more than 100 years.

Currently most big and some medium estates have employed the salary payment system. This system includes not only salary, but also incentive system to ensure to meet target working days, target yield, and tapping quality. Normally, the basic salary payment for tapper starts from between 110,000 kyat (96 USD) and 180,000 kyat (157 USD) per month with following standard obligations. The tappers must tap all the trees in their task size. Then the tappers must collect latex from their task plots and send to collection point. They do not need to work in processing. Thus, their work includes only tapping and collecting. After their work, in the afternoon, they could join a half-day work with daily wage payment. In terms of incentive systems, if the tapper works over the target working days without absence, normally 28 days-per-month is targeted, they get incentive 5000 kyat for an extra working day. For extra weight more than target yield, the tapper obtains 100 kyat per pound (0.2 USD per kg). The target yields are different with the age of the trees and also the seasons. Tapping quality is checked by supervisors in terms of bark consumption, wounding, slope of tapping cut and also cleanliness of utensils for collecting. If a tapper is found as not good in tapping quality and does not meet the target working days, he or she is transferred to temporary tapper group which replaces and supports to permanent tappers. Social supports for tappers and workers such as labour wards, huts, educational and health allowances are also provided by the estates.

Piece work payment system:

This system is the most prevalent payment system employed at some estates and most medium and small holdings in the area. This is a payment based on the number of tapped tree. Currently the rate is around 7 kyats per tree. Though this is piece work payment which a tapper is paid a fixed piece rate for each tapped tree, since the number of tree for tapping is fixed constantly, it is a fixed cost, in fact, for a certain unit and not directly proportional to the yield as the variable cost. Normally, it does not include other incentive payments as the salary payment does. The tapper is responsible for tapping, collecting, and also processing. But some estate, the tapper is responsible only for tapping and collecting. The tapper must tap all the trees in their task size. After that, latex is collected from their task plots and sent to collection point or to processing factory. Normally they carry the latex by their own bicycles/motorcycles or on foot to the processing factory. Some also have to work to produce unsmoked sheet. Thus, their work finishes around 2 o'clock in the afternoon. Their works are supervised by owner or a manager. Most of tappers are from same family group who stay in the field.

Product sharing payment system:

This system has been implemented since last 10 years ago only in few smallholdings. It is found that sharing ratio currently employed is only 50:50 between owner and tapper. The owner and the tapper share equally not only produced rubber but also costs of acid for processing and fertilizer as well. Most of rubber farm owners do not recommend this system as it makes higher tapping cost and they had bad experience that some tappers tapped with over exploitation by using high concentration of stimulant to obtain the maximum yield in the short term without considering for the long term production.

3.3.2 Task size

According to result from the interviews, it is noted that most employs around 700 trees of the task size.

It was found that under the salary payment system, the task size is wide range between 350 to 700 trees. The reason is both unskilled and skilled tappers are employed with different salary scales. Most of them are migrant workers from the other regions and were recruited and trained for tapping by some experience tappers who work at the estates. By their skills and quality of tapping, supervisors or manager define the task size as unskilled tapper gets less number of trees around 450 while skilled tapper get large number of trees up to 700 trees. The estates control the number of trees around 500 and not more than 700 due to their experience on plantation management.

Under the piece-work payment system, the task size is mostly employed between 700 and 1000 trees. It is defined by the owner according to the number of available employed tappers. Tappers in this system are both local and migrant. Normally, their workable family members also work at a same rubber field.

In the product sharing payment system, the task size is around 700 to 1200 trees and normally defined by negotiation of owner and tapper. Most of the tappers used to be migrant tappers in Thailand.

3.3.3 Tapper requirement

T1 and T3 split the trees into two plots and tapped only one plot a day. T2 separated its trees into three plots and tapped two plots a day. However, T4 and T5 split the trees into three plots and tapped only one pot a day. Table 6 shows the requirement of tapper for 4000 trees of rubber field based on 700 trees of task size.

Since the tapper requirement mainly depends on the number of tapped tree per day, d3 frequency tappings, T4 and T5, needed only 67% of tapping requirement by d2 tappping, T1 and T3. d3 frequency of tapping systems could reduce 33% and 50% of tapper requirement by d2 and 2d3 frequency of tapping systems, respectively. However, the requirement of 2d3 frequency tapping, T2, was 33% higher than d2 tapper requirement (Table 6).

Table 6 Tapper requirements in the five treatments

Treatment	No. of tapped tree per day	No. of tapper required for 4000 tapped trees
T1	2000	3 (100)
T2	2667	4 (133)
T3	2000	3 (100)
T4	1333	2 (67)
T5	1333	2 (67)

Task size = 700 trees; Number of trees for tapping = 4000 trees
Figures in parenthesis indicate percentage of T1 (control).

3.3.4 Tapping cost per unit area

Regarding the total tapping cost per hectare during the study period (Appendix 4), the high frequency tapping system, T2, cost the highest followed by T3 and T1 while low frequency tapping system, T4 and T5 costs lower under the all payment systems (Figure 7).

However, the costs of the all five treatments under the product sharing payment system were apparently higher than that of the other payment systems.

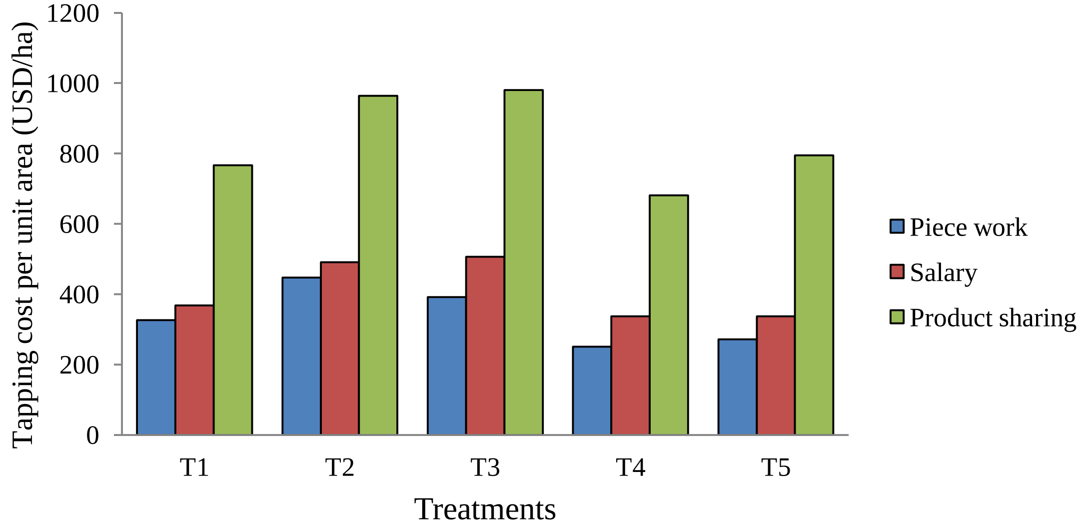

Figure 7 Tapping costs per unit area of the five treatments under different payment systems

3.3.5 Tapping cost per unit production

Regarding the average tapping cost per unit production (Appendix 4), the high frequency tapping system, T2, cost higher than that of other treatments while the low frequency tapping system, T5, cost the lowest under the piece work payment system. Under the salary payment system, T3 and T4 made the higher cost while T1 and T5 made the lower cost (Figure 8).

However, the costs of the all treatments under the product sharing payment system were same at 0.67 USD per kg and stood clearly higher than the costs of the other payment systems.

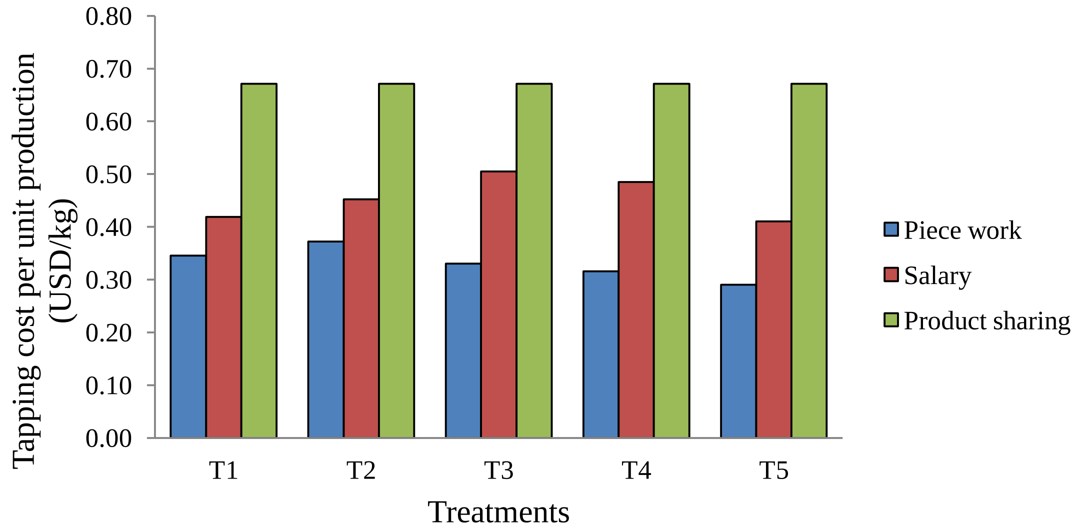

Figure 8 Tapping costs per unit production of the five treatments under different payment systems

3.3.6 Total tapper income

Regarding the total tapper incomes during the study period (Appendix 4), the treatments, T3, T4 and T5, which tapped in the rainy season, made the higher total income to the tapper when compared to the other two treatments, T1 and T2, which suspended the tapping in the rainy season. Among the treatments, particularly T5 gave 25%, 40% and 51% higher incomes than that of T1 under the piece work, the salary and the product sharing payment systems, respectively (Figure 9).

Comparing the incomes among the different payment systems, the product sharing payment system resulted in the highest incomes in all treatments. It was at least two times higher than the incomes of every treatment under the other payment systems.

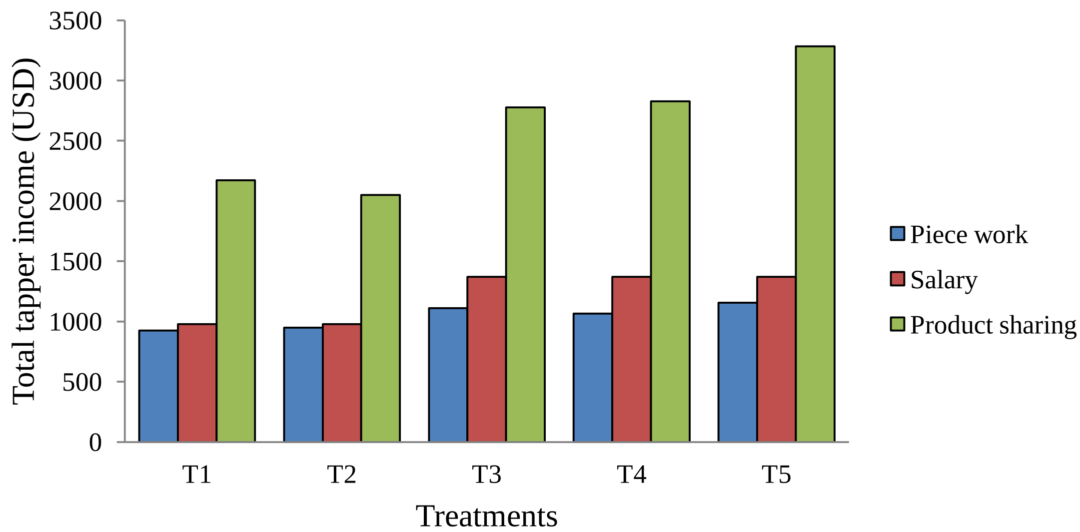

Figure 9 Total tapper incomes of the five treatments under the different payment systems

3.3.7 Total operating profit

Regarding the total operating profits based on 4000 tapped tree for the study period (Appendix 4), T2 and T3 made the profits 18% to 39% higher than the profits of T1 and T5, while the profit of T4 was the lowest, under the all payment systems (Figure 10). Comparing among the payment systems in terms of the operating profit, the product sharing payment system caused the lowest profit in the all treatments, particularly in T5 the profits were 46% and 56% lower than that of the salary and piece work payment systems, respectively.

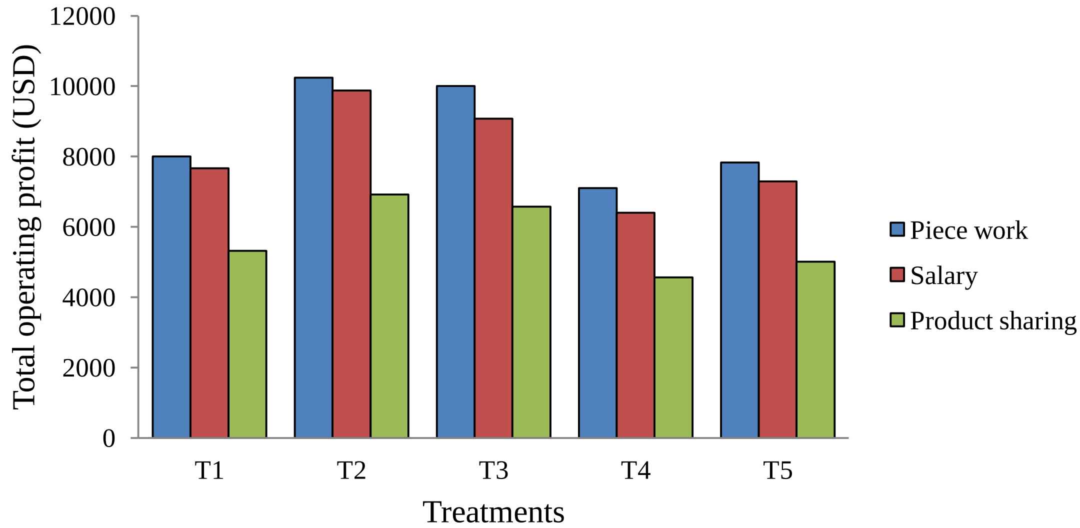

Figure 10 Total operating profits of the five treatments under the different payment systems

Chapter 4
Discussion

4.1 Tapping in the rainy season

According to the observations on rainfall and raining pattern during the rainy season, it is confirmed that regular tapping could not be carried out without rainguard during the rainy season in the area because of high rainfall. And it peaks in the morning between 3:00 and 9:00 am when the tapping works are carried out. The study proved that around 40 and 30 actual tapping days could be extended by rainguard under d2 and d3 tapping systems, respectively, in the rainy season. The study confirms that under rainguard tapping, d3 tapping system is more effective than normal conventional tapping system, d2, in terms of tappable days during the rainy season. Yogaratnam (2013) reported that rainguard is necessary to implement LITS effectively in India where the annual rainfall is around 4500 mm and around 140 tapping days are lost each year due to the heavy rain.

4.2 Yield performance

During the study period, T2 and T3 had the highest cumulative yield with lower tapper productivity. It proves that the cumulative yield is directly associated to the number of tapping days because T3 and T2 had the highest number of tapping days among the treatments. But the high number of tapping days of T3 was contributed by the rainguard tapping in the rainy season and it made evenly distributed tapping days. However, the high number of tapping days of T2 was due to intensive tapping after the rainy season that caused the lowest tapper productivity among the treatments. On the other hand, T5 showed the highest tapper productivity with above the average in cumulative yield. It was contributed not only by the higher tapper productivity along the study period due to LITS with stimulation, but also by the higher tapping efficiency in the rainy season as T5 could tap higher percentage of targeted tapping days effectively when compared to another rainguard tapping treatment T3 but which is d2 frequency of tapping system. However, T4 showed despite its tapper productivity was above average due to LITS with stimulation, the cumulative yield was the lowest because of its lowest number of tapping days, because rain interferes the tapping works as the result of without rainguard. It shows the effect of tapping frequency (numbers of tapping) to tapper productivity and cumulative yield as previous studies have proved that tapping frequency is negatively correlated to the yield per tapping per tree, notably tapper productivity, and positively corrected to the cumulative yield (Obouayeba *et al*., 2011; Lacote *et al*., 2014). The result is consistent with that since low frequency tapping has longer interval between tappings to allow for regeneration in the latex vessels, thus replenishing laticiferous content removed during previous tapping, its tapper productivity is comparatively higher (Sivakumaran *et al*., 1982; Jacob *et al*., 1989). Tapper productivity is important under current situation of low rubber prices and high wages of labour rather than the cumulative yield because it is one of the approaches for reduction in cost of production (Vijayakumar *et al*., 2001). The result of the study also replicates the report of Navarathne *et al*. (2014) that the rainguard tapping in Sri Lanka increases the normal yield to 20-30% by the higher number of tapping days. The above results strongly confirm that only LITS with rainguard could achieve the substantial cumulative yield with higher tapper productivity along the year in the high rainfall area.

4.3 Bark consumption

According to the result of the bark consumption, it is confirmed that the bark consumption is associated with the number of tapping days. It is also found that the treatment with lower bark consumption gave the higher tapper productivity. That finding confirms that the reduction in tapping frequency increases number of days between two successive tappings, notably latex regeneration period, ensuring more latex is regenerated resulting in higher yield per tapping per tree, notably tapper productivity. It is also found in the result that although low frequency tapping system, T4 and T5, caused the thicker bark shaving per tapping than the other treatment, the total bark consumption of T4 and T5 during the study period were apparently lower. It replicates the finding by Rodrigo (2012) that although bark shaving per tapping of LITS is thicker than that of the conventional tapping, S/2 d2, the effect is marginal compared to overall bark saving. Besides, economic lifespan of T4 and T5 are expected to be higher as Vijayakuma *et al*. (2003) reported his finding in India that LITS could extend at least four to eight years in the productive lifespan comparing with the conventional tapping system, S/2 d2.

4.4 Socio-economic performance

4.4.1 Tapper requirement

As the result of the comparison in tapper requirements among the treatments, it provides a relationship between the tapping frequency and the tapper requirement that the higher tapping frequency needs the higher number of tapper while the lower tapping frequency needs the lesser number of tapper for a certain productive area. Since the number of tapper requirement mainly depends on the number of tapped tree a day, 2d3 tapping system needs higher number of tappers due to the higher number of tapped tree compared to d2 tapping system. Under LITS, the number of tapped tree is lesser than the conventional tapping system in a certain productive area so that the number of tapper is lesser. It does not mean that the number of tapped tree a day for a tapper, notably task size, is reduced. Thus, it shows that frequency of a tapping system is a major determinant to control the number of tapped tree a day in a certain productive area and the number of tapper requirement as well. Under LITS, the trees of a certain task get more resting time for latex regeneration, so that tapper could be assigned to tap other tasks in the following days while the first task is resting. It means that LITS enables not only to reduce the number of tapper requirement but also to increase the tapper productivity and land-man ratio compared with the conventional tapping system (Soumanhin *et al*., 2010; Nugawela *et al*., 2000). Thus, this finding addresses the concerns of the rubber farmers that the tappers normally worry the lesser number of tapped trees in their certain tapping task while the owners worry the lower yield of production due to the lesser number of tapped tree a day.

4.4.2 Tapping cost per unit area

Determinants of tapping cost per unit area per year of the treatments vary with different payment systems. Under the piece work payment system, the cost is positively associated with the number of tapped trees a day in the certain productive area rather than the number of tapping work days along the year. Under the salary payment system, the cost is mainly directly proportional to the number of tapper rather than the number of tapping months. However, under the product sharing payment system, the cost is associated directly with the cumulative yield and price. The result showed that T2 and T3 made the higher cost among the treatments under the all payment system because of their higher number of tapped trees a day in the area, higher number of tapper requirement and higher cumulative yields. On the other hand, the result showed that T4 and T5 made the lower cost compared to the other treatments under the all payment systems because of their less number of tapped trees a day in the area, less number of tapper requirement and comparatively lower cumulative yields. Thus, it is confirmed that the tapping cost per unit area can be reduced by implementing LITS under the all payment systems.

4.4.3 Tapping cost per unit production

This cost is a major consideration of both tapper and owner as it is directly related to the daily profit. It is, in fact, a direct cost on daily production and the higher cost results lower income. Determinants of the cost of the treatments vary with the different payment system. Under the piece work payment system, the cost is inversely proportional to tapper productivity rather than the number of tapped trees a day and directly associated to the piece work rate which is normally same for the all tapping systems. Under the salary payment system, the cost is associated to the number of tapper requirement and tapping month positively, and to the tapper productivity negatively rather than the number of tapped trees a day and the number of working days for tapping. Under the product sharing payment system, however, its only one determinant is the price. The result by comparing the cost among the treatments shows that under the piece work payment system, T2 caused the highest tapping cost per unit production mainly because of its lowest tapper productivity among the treatments, while T5 caused the lowest cost because of its highest tapper productivity. Under the salary payment system, T3 and T4 showed the higher cost because of their higher number of tapper requirement, higher number of tapping month and lower tapper productivity. However, T5 caused the lowest cost under this payment system also because of it lesser number of tapper requirement and the highest tapper productivity among the treatments. Under the product sharing payment system, the costs in the all treatments were same as it only depends on the price. The results highlight the benefits of LITS with rainguard that enables to reduce the cost per unit production under the piece work and the salary payment systems. However, due to there is no difference in this cost among the treatments under the product sharing payment system, the owners and the tappers are not likely to consider the benefits of LITS.

4.4.4 Total tapper income

Total tapper income is a crucial factor to the tapper and the owner as well to address the shortage of tapper because if one work does not create stable enough income, it is unattractive job. The total tapper incomes vary with the different treatments under the different payment systems. Under the piece work payment system, the tapper income is positively related to the number of tapping work days along the year and negatively related to the number of tapper requirement, rather than the rate of piece work and the number of tapped trees a day. Under the salary payment system, the major determinants are only the number of tapping months. Under the product sharing payment system, the tapper incomes is mainly associated with tapper productivity, the price, the number of tapping work days positively, and the number of tapper requirement negatively. According to the study results, T3, T4 and T5 created the higher total tapper income under the all payment systems because of their higher number of tapping work days along the year and tapping months due to the tapping in the rainy season while the other two treatments suspended the tapping. However, T5 made the highest tapper income under the product sharing payment system because of not only its higher number of tapping work days along the year but also its highest tapper productivity. Thus it is confirmed that the tapper income can be increased by tapping in the rainy season especially implementing LITS with rainguard which gives higher yield with the higher number of tapping work days along the year.

4.4.5 Total operating profit

Operating profit is, in fact, gross margin in a year to the owner. The result confirms that it mainly depends positively on the cumulative yield rather than other inputs such as costs of tapping, rainguard, fertilizer, stimulants, etc. (Appendix 4), under the all payment systems. The results showed that T2 and T3 gave the higher profits because of its higher cumulative yield during the year while T4 made the lowest margin as its cumulative yield was the lowest among the treatments under the all payment systems. However, although there were costs of rainguard and stimulants in T5, the profits of T5 were almost same with that of T1 under the all payment systems because of its comparatively lower tapping cost. Thus, this result confirms that the profit of LITS with rainguard is comparably not different to that of conventional tapping system (S/2 d2).

According to the results of the study, the LITS with rainguard has superior competitive advantages among the treatments. However, there are needs to study details on long-term performance of the LITS with rainguard especially clonal response to long-term effect of stimulation under the LITS. Moreover, it is suggested to set up more on-farm trials to allow further assessments on adaptability of the farmers and impact of this system to livelihood of the farmers.

Chapter 5
Conclusion

The study was set out to assess preliminarily on yield and socio-economic performances of low intensity tapping systems with rainguard in order to address the problems of the rubber farmers due to the high rainfall in the area. The study has clearly identified the performances of LITS with rainguard comparing with the conventional tapping systems. In terms of the yield performance, although the cumulative yield obtained from LITS with rainguard was less than that of 2d3 frequency of tapping system, it was comparable with that of d2 frequency of tapping system, with its superior tapper productivity along the year. In addition, its lower bark consumption enables the greater tapper productivity and the longer lifespan of the tree. In terms of economic performance, the LITS with rainguard could reduce the requirement of tapper resulting to solve the shortage of the tapper. The tapping costs based on both unit area and unit production of the LITS with rainguard under the all payment systems were lower than that of the conventional tapping systems. On the other hand, its total incomes to tappers were the highest under the all payment systems. Besides, it enables the tapper to earn the regular incomes along the year while the conventional tapping systems could not provide any income in the rainy season. However, its operating profit to the owners were not the highest but comparable to the conventional tapping system, S/2 d2.

In conclusion, the study revealed that an optimum yield could be harvested with low cost of production resulting in optimum profits practically along the year with longer economic lifespan of the tree by implementing that LITS with rainguard which exhibits the competitive performances which are likely to be a solution to address the problems of the rubber farmers in the area.

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Appendices

Appendix 1

Current tapping practices in the southern part of Myanmar

Since the immature period is more than 7 years in Myanmar, most smallholders and some estates are not likely to wait for the tree reaches the standard girth, (45-50 cm at the height of 120 cm from the ground) to open for tapping. As the result, the trees are being opened mostly at the girth of 35-40 cm. And some tappers carry out opening the tree at the lower height around 90-100 cm from the ground for the small girth trees. That means the trees are being tapped at immature stage.

Consequence of the low planting success and supplying many times, the trees are not uniform and stands per hectare in the productive area are relatively low only between 350 and 400 stands per hectare at the opening age. Immature trees are opened although it does not meet the standards for the opening. It is recommended that a plot could be opened for tapping when at least 50 percent of the plot should reach the standard girth.

Task size in Myanmar is ranged between 350 to 1000 trees per tapper per day. Although it depends on many factors, payment systems or contracts between the tapper and owner is considered to be a main dependent. In estates, mostly all tappers are paid by salary plus incentives and task sizes are controlled around 500 trees per tapper per day. However, smallholders are using now product sharing system between the tapper and owner. In this system, the task sizes could not be controlled and tappers ask for large task size between 700 and 1000 trees per tapper per day. The system makes high production cost leading even no profits when the price is going down. Depending on the task size, tapping time is varied from the mid night to around 6:00 am.

One reason of low productivity in Myanmar is limited tapping days. Pattern of tapping days is not evenly distributed. Normally tapping is suspended in the rainy season which starts from June to the middle of September. In the southern regions, tapping is carried out normally only 7 months with resting one month in wintering period.

But almost all the smallholdings and some estates do not rest in the wintering period although the tree gives very low yield in this period. Normally the wintering period is in February but it is varied slightly with different regions. After that the dry weather follows with over 35°C for three months. Thus, favorable months for tapping with economical yield are only four to five months from October to January or the middle of February. That means tapping days are limited to obtain high yield.

Although normally half spiral with alternate tapping (S/2 d2) is recommended, almost all the farmers in the southern part are tapping with high frequency from two days tapping in three days to daily tapping. As the result, the land man ration is low and tapper productivity is very low.

Liquid stimulation is being just started in some estates and smallholders. But the farmers are using improper application and high frequency. In addition, Gaseous stimulation was introduced by some companies, but not successful because farmers were not able to carry out correctly the fixing applicators and gas injection with the reduction of tapping frequency from alternate daily tapping (d2) to low frequency tapping.

It is found that economic life span of tree is only around 20 years because tapping panels are not managed systematically. Only basal panels are tapped several times with downward tapping. After basal panel has been tapped completely, half spiral of high panel was tapped with downward tapping. However, the yield from the high panel is not high as expected and becomes lower and lower because the downward tapping at the high panel makes smaller drainage area of latex in the bark and consequently the yield becomes considerable drop. It shows that there are lack of knowledge of Controlled Upward Tapping – CUT, Low Intensity Tapping System – LITS and tapping panel management.

Appendix 2

Planting recommendation

The planting recommendation was categorized into three agro-ecological regions based on the prevailing climate and rainfall intensity.

1. Cultivars recommended for regions with high rainfall (above 45000 mm) and wet humid climate (Mon State, Tanintharyi Region, Kayin State, and Yakhine State) were BPM 24 (50%), RRIC 100 (20%), RRIM 717 (10%), PB 260 (10%), and PB 235 (10%).
2. Cultivars recommended for regions with moderate rainfall (2500-3000 mm) and dryer climate (Bago Region, Yangon Region, and Ayeyarwaddy Region) were PB 260 (50%), RRIM 717 (20%), PB 235 (10%), RRIM 623 (10%), and GT 1 (10%).
3. Cultivars recommended for regions with low rainfall (1250-1500 mm) and cooler climate (Kachin State and Shan State) were RRIM 600 (50%), GT 1 (20%), PR 255 (10%), PR 107 (10%), and RRIM 623 (10%).

Appendix 3

Fertilizer Application

Normally fertilizer application is carried out two times: at the beginning and the end of the rainy season. Recommended N-P-K-Mg ratio for the productive trees in the area is 15-7-18-2 and recommended rate for application is 1 kg per tree per year.

According to the interviews, majority of the smallholders and some medium estates use compound fertilizer while some estates use straight fertilizer. Compound fertilizer is roughly around 10,000 kyat (8.9 USD) higher than mixed fertilizer with the recommended ratio in price per 50 kg bag. However, some farmers do not follow the recommended ratio and recommended rate of application. Especially smallholdings less than10 acres (4 hectors) could not follow the recommendations as they could not get the information about the fertilizer recommendation. Majority of the farmers both smallholders and estate owners has been reducing the frequency of the fertilization application to one time instead of two times per year since last two years ago because of low income due to the low price.

Appendix 4

Table 1 Average tapping cost per unit production (USD/kg)

	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	Average cost
<u>Piece work payment</u>													
T1	0.00	0.00	0.00	0.00	0.34	0.20	0.18	0.20	0.40	0.54	0.49	0.42	0.35
T2	0.00	0.00	0.00	0.00	0.24	0.22	0.22	0.25	0.47	0.60	0.52	0.46	0.37
T3	0.40	0.34	0.29	0.24	0.26	0.21	0.18	0.20	0.00	0.56	0.44	0.37	0.33
T4	0.37	0.26	0.33	0.28	0.22	0.15	0.17	0.20	0.00	0.54	0.44	0.37	0.32
T5	0.27	0.21	0.27	0.23	0.24	0.14	0.16	0.19	0.00	0.56	0.41	0.35	0.29
<u>Salary Payment</u>													
T1	0.00	0.00	0.00	0.00	0.40	0.20	0.18	0.22	0.42	0.57	0.50	0.85	0.42
T2	0.00	0.00	0.00	0.00	0.26	0.22	0.22	0.26	0.49	0.59	0.53	1.05	0.45
T3	0.88	1.04	0.40	0.25	0.29	0.22	0.17	0.23	0.00	0.73	0.45	0.76	0.51
T4	0.76	0.67	0.67	0.35	0.25	0.15	0.17	0.22	0.00	0.73	0.45	0.75	0.49
T5	0.56	0.55	0.30	0.23	0.25	0.14	0.16	0.21	0.00	0.75	0.42	0.72	0.41
<u>Product sharing payment (50:50)</u>													
T1	0.00	0.00	0.00	0.00	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
T2	0.00	0.00	0.00	0.00	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
T3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.00	0.67	0.67	0.67	0.67
T4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.00	0.67	0.67	0.67	0.67
T5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.00	0.67	0.67	0.67	0.67

Table 2 Total tapping cost per unit area (USD/kg)

	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	Total cost
Piece work payment													
T1	0	0	0	0	782	902	932	816	872	874	902	451	6,531
T2	0	0	0	0	1,143	1,203	1,243	1,181	1,181	1,243	1,203	541	8,937
T3	421	301	662	902	842	902	932	816	0	709	902	451	7,839
T4	301	241	301	481	541	601	621	565	0	458	601	301	5,012
T5	301	241	541	601	601	601	621	565	0	458	601	301	5,433
Salary Payment													
T1	0	0	0	0	920	920	920	920	920	920	920	920	7,364
T2	0	0	0	0	1,227	1,227	1,227	1,227	1,227	1,227	1,227	1,227	9,819
T3	920	920	920	920	920	920	920	920	0	920	920	920	10,125
T4	614	614	614	614	614	614	614	614	0	614	614	614	6,750
T5	614	614	614	614	614	614	614	614	0	614	614	614	6,750
Product sharing payment (50:50)													
T1	0	0	0	0	1,552	3,065	3,447	2,755	1,461	1,083	1,237	723	15,323
T2	0	0	0	0	3,161	3,742	3,805	3,152	1,692	1,389	1,566	783	19,289
T3	699	594	1,540	2,511	2,141	2,821	3,561	2,704	0	848	1,372	815	19,607
T4	545	613	615	1,165	1,623	2,713	2,439	1,894	0	564	910	547	13,628
T5	738	753	1,365	1,777	1,663	2,941	2,557	2,000	0	546	983	569	15,891

Table 3 Total tapper income (USD)

	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	Total income
Piece work payment													
T1	0	0	0	0	111	128	132	116	124	124	128	64	925
T2	0	0	0	0	121	128	132	125	125	132	128	58	950
T3	60	43	94	128	119	128	132	116	0	100	128	64	1,111
T4	64	51	64	102	115	128	132	120	0	97	128	64	1,065
T5	64	51	115	128	128	128	132	120	0	97	128	64	1,155
Salary payment													
T1	0	0	0	0	130	130	130	130	130	130	130	65	978
T2	0	0	0	0	130	130	130	130	130	130	130	65	978
T3	130	130	130	130	130	130	130	130	0	130	130	65	1,370
T4	130	130	130	130	130	130	130	130	0	130	130	65	1,370
T5	130	130	130	130	130	130	130	130	0	130	130	65	1,370
Product sharing payment (50:50)													
T1	0	0	0	0	220	434	488	390	207	153	175	102	2,171
T2	0	0	0	0	336	398	404	335	180	148	166	83	2,050
T3	99	84	218	356	303	400	505	383	0	120	194	115	2,778
T4	46	130	131	248	345	577	518	403	0	120	193	116	2,827
T5	63	160	290	378	354	625	544	425	0	116	209	121	3,284

Table 4 Average cost of fertilizer application

Description	Rate	Price (kyat)	Amount (kyat)
Cost of Compound Fertilizer	(1.5 bags/ac) x 2 times	32000	96000
Labour Cost	(0.4 man-day)x2 times	4500	3600
Transportation cost			500
Total Fertilizer cost per acre			100100
Total Fertilizer cost per tree			500.5
Total fertilizer cost for 4000 trees		2,002,000	(1740.87 USD)

Average number of trees per acre = 200 trees

1 USD = 1150 Kyat

Table 5 Cost of rainguard

Description	Unit	Price (kyat)	Total (kyat)
Plastic	4000	150	600000
Sealant	4000	50	200000
rubber scrap band	4000	5	20000
Fungicide (1 Kg)	15	5000	75000
Labour cost (man-day)	40	4500	180000
Total Cost			1075000 (934.78 USD)

Table 6 Cost of stimulant

Description	No. of the bottle	Price (USD)	Total cost (USD)
25% 500 g stimulant (8 bottles x 3 times)	24	6	144

Table 7 Total operating profits of the five treatments

	Piece work payment				
	T1	T2	T3	T4	T5
Mean Yield (g/t/t)	20.81	19.17	21.51	23.24	25.64
Total yield from 4000 tapped tree (kg)	9,245.78	11,638.96	11,830.90	8,222.97	9,588.74
Average Price per kg (USD)	1.34	1.34	1.34	1.34	1.34
Total Income (USD)	**12,389**	**15,596**	**15,853**	**11,019**	**12,849**
Total Tapping cost (USD)	2,644	3,618	3,174	2,029	2,200
Rainguard cost (USD)	0	0	934.78	0	934.78
Fertilizer cost (USD)	1741	1741	1741	1741	1741
Stimulant cost (USD)	0	0	0	144	144
Total production cost (USD)	**4,385**	**5,359**	**5,849**	**3914**	**5,019**
Profit (USD)	**8,004**	**10,237**	**10,004**	**7,105**	**7,830**

	Salary payment				
	T1	T2	T3	T4	T5
Total Tapping cost (USD)	2,981	3,975	4,099	2,733	2,733
Rainguard cost (USD)	0	0	935	0	935
Fertilizer cost (USD)	1741	1741	1741	1741	1741
Stimulant cost (USD)	0	0	0	144	144
Total production cost (USD)	**4,722**	**5,716**	**6,775**	**4,618**	**5,553**
Profit (USD)	**7,667**	**9,880**	**9,078**	**6,401**	**7,296**

	Product sharing payment				
	T1	T2	T3	T4	T5
Total Tapping cost (USD)	6,204	7,809	7,938	5,517	6,434
Rainguard cost (USD)	0	0	467	0	467
Fertilizer cost (USD)	870	870	870	870	870
Stimulant cost (USD)	0	0	0	72	72
Total production cost (USD)	**7,074**	**8,680**	**9,276**	**6,460**	**7,844**
Profit (USD)	**5,315**	**6,916**	**6,577**	**4,559**	**5,005**

Appendix 5

Questionnaires for rubber farm owners

Date………………

Questionnaire for rubber farm owners (small/medium/estate holdings)

- to study current tapping practices, explore acceptance to advanced harvesting systems, and identify costs of production and availability of tappers

A. Personal Data

1. Gender
2. Name
3. Age
4. Marital Status
5. Education
6. Contact address
7. Number of family members
8. Business(es) only rubber planting (or) other business?
9. Reasons planting rubber

B. Profile of the rubber field(s)

Basic Planting Data

1. Location(s) of rubber field(s)
2. Area of the field(s) (arable and unarable area)
3. Planted area
4. Planted year
5. Productive area
6. Type of soil
7. Degree of land gradient

Activities in Mature Phase

8. Opening year for tapping

9. Stands per hectare at the opening
10. Stands per hectare at the moment
11. Tapping Systems
12. Fertilizer applications by year
    - type
    - rate
    - frequency
    - season
    - method
    - cost
13. Disease Management
    - diseases
    - season
    - losses
    - control method

C. Tapping Profile

1. Height of the opening
2. Girth of the opening
3. Tappability % at the opening
4. Tapping systems
5. Yields by months
6. Yields by years
7. Number of tapping days per month and per year
8. Number of tapping months
9. Tapping in the rainy season
10. Number of tapping days in the rainy season
11. Recovery tapping
12. Using rainguards (if yes, types, how to prepare, and cost)
13. Occurrence of diseases in the rainy season

14. Application of fungicide on tapping panels
    - name of fungicide
    - application rate
    - cost
15. Resting in Wintering period
16. Months of Wintering period
17. Application of Stimulant
    - months of application
    - concentration
    - frequency
    - application method
    - cost
18. Bark consumption
19. TPD occurrence (losses, how to control)

D. Profile of Tappers (Workers)

1. Criteria to control the tapping quality
2. Is there in-charges (supervisors) on tappers? If yes, how many supervisors?
3. Tapping task size
4. Number of tappers
5. How to assign tappers in the rainy season
6. How to assign tappers in the wintering season

E. Payment systems on Tapping

1. Payment system
2. Responsibilities of Owners
3. Responsibilities of tapper (tapping/collection/processing)
4. Which person takes the decision on works?
5. Do you accept this payment system? (why?)
6. How to get market information

F. Cost of tapping

1. Cost of tapping per unit area and per unit production by seasons
   - productivity
   - number of tapped tree a day
   - number of working days for tapping in a year
   - task size
   - tapping systems

G. Availability of Tappers

1. Availability of workers
2. Availability of tapper
3. Types of tappers (hire/family member)
4. How to recruit tappers
5. Local or migrant tappers
6. Gender of the tappers: How many males and females?
7. Average age of the tappers
8. How to maintain or motivate the workers (incentive, bonus, welfares, etc.)

H. Income

1. Daily income or monthly income from rubber
   - changes of incomes with price changes
   - changes of incomes with seasonal yield changes
2. Other incomes besides rubber
3. Resting periods (Which months? and why?)
4. Other works during the resting period

I. Knowledge on tapping systems

1. Expected life span of the tree
2. Tapping schedule for the whole life span of the tree
3. Perspective on rainguard tapping
4. Perspective on stimulation
5. Perspective on CUT

6. Perspective on Low frequency tapping system

J. Problems now facing

K. Questions from the questionee

L. Comments and some suggestions from the questionee

Appendix 6

Questionnaires for tappers

Date……………..

Questionnaire for tappers

- to classify different types of tappers, study current tapping practices, incomes, and explore acceptance to advanced latex harvesting systems

A. Personal Data (Tappers)

1. Gender- Male/Female
2. Name
3. Age
4. Marital Status
5. Education
6. Contact address
7. Number of family members
   - works
   - incomes
   - their educations

B. Tapping work

1. Number of plantations currently working
2. Years of Experience in tapping
3. Who trained the tapping?
4. Period of the training

5. Tapping systems
    - standards of tappability
    - normal tapping times
    - What are materials and tools for opening?
    - What time is the tree normally opened for tapping?
    - What are materials and tools for tapping?
    - tapping system
    - task size/current task size
    - number of tree you can tap, or you want to tap, and the reasons
    - resting periods
    - When is the tree normally resumed for tapping after resting?
6. How to control the tapping quality?
7. Tapping in rainy season
    - difficulties of tapping in the rainy season
    - Do you want to tap in the rainy season? (Why? If yes, how?)

C. Payment Systems

1. Payment system
2. Responsibilities of Owners
3. Responsibilities of tapper (tapping/collection/processing)
4. Which person takes the decision on works?
5. Do you accept this payment system? (why?)
6. How to get market information

D. Income

1. Daily income or monthly income
    - changes of incomes with price changes
    - changes of incomes with seasonal yield changes
2. Holidays
3. Other works besides tapping
4. Other incomes

5. Unemployment periods
6. Other works during the resting period

D. Certainty of Employment

1. Availability of Tapping work during the low price
2. Availability of Tapping work during the rainy season and other resting periods
3. Competition among the tappers

F. Knowledge on tapping systems

1. Expected life span of the tree
2. Tapping schedule for the whole life span of the tree
3. Perspective on rainguard tapping
4. Perspective on stimulation
5. Perspective on CUT
6. Perspective on Low frequency tapping system

E. Problems now facing

F. Questions from the tapper

G. Comments and some suggestions from the tapper

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