CHAPTER VI

DISCUSSION

6.1 Field survey

The results of the study (Figure 4.2) reveal that the mango plants can be grown easily. Moreover, this plant is drought tolerant and can be managed in low input. Furthermore, it can provide remunerative income to the farmers. This fact supports the findings of Radanachaless and Krasaechai, (1991a and 1991b). They have reported that mango plants are well adapted in rainfed environment with relatively higher survival rates than the other fruit trees, and able to set fruit in the third year. In addition, the price of fruit per weight unit although is not high, but whole garden sale can provide more benefit to the farmer and because of its small canopy, it does not affect on other annual crops between allays during early three years. Besides this, as a native species, these trees are highly resistant against some pests and diseases.

However, the farmers constraints in mango orchards are appeared to be water deficiency, weed interference, some species of insect and disease infection, fire and storm hazards (Table 4.1). The problems of mango growing in rainfed upland area have described by Radanachaless and Timm (1991). According to their report, the farmers considered the pests and lack of water as the most significant constraints. In addition, 70, 14 and 14 percent of mango mortality were caused by lack of water, pests and diseases, and others respectively.

6.1.1 Weed management in mango orchards

According to field survey (Table 4.2) in rainfed uplands, broadleaved and grass weeds are appeared as the major constraints in the first and second year of mango establishment. As small trees are too tender and weak, they can be covered by common weeds easily and can not cope with the weeds regarding competition of growing factors such as light and nutrition. Similar result has reported by Krasaesindhu (1998). He has found that weed infestation is severe especially during young stage of oil palm. However, weed interference declines when the plants become mature (at five years), because weed competition reduces by the mango shading.

The most favorable weeding practice, which is usually done by the farmers in mango orchard is as intercropping followed by mechanical practice (done by cutting machine). Radanachaless and Timm (1991) recorded that all households grew the annual crops between the alleys of fruit trees in the early planting. The reason of preferring the intercropping by the farmers is they can grow mungbean, soybean etc. as additional cash crops. Radanachaless and Krasaechai (1991a) also observed that soybean and annual crops could decrease weed interference and source of fire during dry season. Nevertheless, the present study shows that the mechanical practice by cutting machine is the most appropriate weeding practices according to the farmers opinion, when the plants become more than 3 years old. This is because of big trees, when cutting machine is convenient and able to provide high performance. On the other hand, before 3 years as the trees become smaller, cultural practice is more suitable than cutting machine.

According to farmers' opinion, tillage is the most convenient practice. However, as fruit tree alleys are less than 8 meters, therefore, it is difficult tillage between them and may damage the small trees. Moreover, the fruit tree basements can not be practiced. Thus, it is repeatedly practiced by digging on it (Radanachaless and Krasaechai, 1991a). In addition, weeds are gotten rid off by turning them into the soil through tillage. Cultural practice is due to its convenience and suitability in small areas. Weed control in soybean production system is similar practice in Chiang Mai valley (Ekasingh *et al.*, 1988). Conventional weed control by hand hoe is not common in the irrigated area as it is very laborious and time consuming. Hand weeding is generally done by family labor. The use of herbicide is preferred by the farmers because of time and money saving and its effectiveness against serious weeds.

In addition, according to farmers' opinion in the past decade and current weeding practice, fire problems has been solved through weed management by tillage, cutting by machine, herbicide applications and other cultural practices. It is reported that there are some farmers cleaned their orchards by burning crop residues before dry season (Radanachaless and Timm, 1991). However, very few farmers have reported that the neighboring orchards can make fire problem, which may extend to near unclean orchards which contains weed residues.

6.1.2 Cattle feed

The upland is well drained, and consists of private and communal lands, roadsides and house surrounding small lands. Some mango growers in rainfed upland keep cattle in their farms during the past ten years. However, nowadays the number of keeping cattle has extremely declined (Table 4.5) which is due to lack of natural vegetation. The decreasing of keeping cattle is mentioned as expanding of cultivated land during 1981-1990 (Radanachaless, 1990). The report has also indicated the reason as lack of natural vegetation and water during dry season.

However, the present result shows that half of the farmers desired to raise cattle in future if grazing area is available and if government organizations provide any financial support. However, no any report is available regarding this aspect.

Regarding feed stuff of cattle, usually farmers provide natural grasses. However, when natural grass is not available, they use mostly rice straw and sometimes legume crops like soybean, peanut and mungbean etc. This finding agrees with the report of Radanachaless (1990). He recorded that legume crop residues were used as fodder because they were locally available in low cost. Radanachaless and Timm (1991) observed that soybean plants (after harvesting the seeds) and rice straw were used as animal feed by the farmers. Moreover, Wilaipon and Pongskul (1984) explained that during the dry season in lowland, cattle were grazed together on the harvested paddy fields, where they take the rice stubble.

6.1.3 Legume cover crops

Perception of mango growers on legume cover crops in rainfed upland area has presented in Table 4.6. Among thirty-eight mango growers, about half of them do not know about the relevant legume cover crops. Except using as cattle feed, they do not have any knowledge of other benefits of cover crops. However, the remaining farmers have the knowledge about the beneficial effects of cover crops as they get some ideas from the Agriculture extension departments including Faculty of Agriculture of Chiang Mai University. Gypmantasiri and Kittiwat (1993) reported that *S. hamata* has been chosen by the farmers because of its better competition habit with weeds and having the ability of providing high biomass. According to the report, farmers have also agreed that this species can be controlled fire during dry season. In addition, farmers discussion concludes that *S. hamata* will be preferred because of its erect growth character, which permits special arrangement when it is intercropped with fruit tree due to not trailing their stems.

Moreover, some farmers have reported that they do not want to grow legume cover crop instead of cash crop as the cash crop can provide money for them.

However, some farmers agree to grow if they get subsidy and more technical knowledge.

6.1.4 Farmers' perception of intercropping *Stylosanthes hamata*

The farmers' perception of *S. hamata* intercropping in rainfed upland area has been given in Table 4.7. The results show that half of the mango farmers expect to grow *S. hamata* in their mango orchards. Most farmers understand that fertilizer application can not give beneficial effect for *S. hamata* establishment and that is why they do not want to apply fertilizer. However, the rainfed upland soil is infertile with relatively low phosphorous (Table 5.1). The results of present investigation revealed that the height, dry matter and ground coverage of *S. hamata* increase significantly due to phosphorus fertilizer application. Similar results reported by Tening *et al.* (1994). They found 300 kg/ha dry matter increased including resistance to drought after application of super phosphate. They also observed that because of fertilizer application the yield became 2 to 5 t/ha while the control plot gave only1.6 t/ha. Also, mango growers believe that *S. hamata* is a drought tolerant species with good weed competibility as well as easy to establish in rainfed upland. Similar reports were recorded by Amaruekachoke *et al.* (1994) and Amaruekachoke and Kittiwat (1994). In addition, the farmers do not have adequate knowledge regarding proper management of *S. hamata*. Nevertheless, the appropriate management of establishing *S. hamata* in mango-based integrated farming systems under the rainfed upland conditions are important part of increasing biomass of the above ground cover as well as getting quality forage (Radanachaless *et al.,* 1999).

Regarding the harvesting time of *S. hamata*, most farmers prefer to harvest twice in a year i.e. first in the mid of wet season and second in the end of wet season. As a result, after harvesting first time, leaves and shoots can be regenerated and then again harvesting can be done in the end of rainy season. The farmers have reported that the idea of this harvesting practice is provided by the extension workers and Faculty of Agriculture, Chiang Mai University.

6.2 Field experiment

6.2.1 Soil characteristics of the study site

The soil of study site is sandy loam (Korat soil series). Radanachaless *et al.*, (1993) also recognized that soil as sandy loam. The soil analysis reveals that the soil has low water holding capacity, acidic in reaction, low organic matter content, low cation exchange capacity (CEC), low moisture storage capacity and low nutrient content. Specially, the amount of available phosphorus in 0-30 cm depth has found to be very low (6 ppm), which is not suitable for *S. hamata*. According to Nilnond and Chatupote (1996) the appropriate phosphorus level for growing *S. hamata* should be about 20 ppm.

6.2.2 Climatic conditions

The statistical data of the year 2000 indicates the annual rainfall is 895.4 mm. In 1993, the average annual rainfall was 900 mm and especially in April-June (Radanachaless *et al.*, 1993). However, Kirsch (1995) recorded that the average of annual rainfall during 1986-1993 was about 690 mm. From the above reports it is revealed that the amount of rainfall is widely varied with a double peak in mid-April-June and August-October due to the influence of the southwest monsoon. The annual average temperature in 2000 was ranged from 17.3 to 35.2 °C while it was found to be 27-47 °C in April-June in 1993 (Radanachaless *et al.*, 1993).

6.2.3 The predicament of field experiment

Stylosanthes hamata seeds were sown between mango alleys in August 1998 when amount of rainfall, which had declined for over one and half month (mid-June to July), started to increase again. In regard to management strategies, Redanachaless *et al.* (1999) recommended that months with sufficient and reliable amount of rainfall are the most the suitable time for growing annual crops and fruit trees i.e. soybean, maize, legume cover crops, and mango in rainfed upland areas. That is planting should begin from the first till the third week of August.

During the first year of establishment, the branches of *S. hamata* plants grew slowly to cover the ground due to insufficient water, which primarily stemmed from the short period of rainfall (late rainy season). Consequently, *S. hamata* were not high enough for harvesting for the cattle. de Leeuw and Mohamed-Saleem (1994) reported that forage's palatability was lower in early growing season as compared with that in the late rainy and early dry season.

Thus, the management of *S. hamata* in the second year of establishment in rainfed upland area was required. Nevertheless, the field experiment failed because of two factors. Firstly, non-of the main input factors showed any effect on *S. hamata* establishment. Secondly, *S. hamata* in some plots were harvested by outside farmers. Hence, field experiment was laid out again at the end of April of 2000 (early rainy season) which was the third year establishment of *S. hamata* in the mango orchard.

6.2.4 Effect of phosphorus fertilizer, cutting frequency and weeding on growth characteristics of *Stylosanthes hamata* and weeds

6.2.4.1 Population of *S. hamata* and weeds

The result of present investigation showed that phosphorus fertilizer did not affect on the number of mature plants. However, the number of seedling is affected slightly due to phosphorus fertilizer. Similar result was recorded by Gardener (1982) cited in McIvor and Gardener (1998). They observed that *S. hamata* plants were slightly affected by season or management (stocking rate, fertilizer application, companion species) in terms of survival of plants. Moreover, McIvor and Gardener (1998) reported that superphosphate had no significant effects on seedling numbers.

In addition, the number of mature plant is not affected by weeding and cutting practice. However, cutting practice has effected on newly germinated plants during 17-25 WAE. Agishi (1982) and Mott *et al.* (1989) cited in de Leeuw *et al.* (1994) observed that high plant density of *S. hamata* could change due to grazing which usually attributed on reduction the competition of aggressive volunteer grasses. Following preferential grazing, long-term effects of grazing may cause change in the seed pool. Similarly, de Leeuw *et al.* (1994) confirmed that it could retain long-term productivity provided a large seed pool was kept intact across growing season.

The total population of newly germinated and mature plants declined about 25 percent from the early to late wet season (25 WAE). In addition, about 20 percent mature plants of late wet season were survived during dry season and remaining 80 percent plants were died. The information from Jama (1998) revealed that the establishment of *S. hamata* in two locations. In one location which area was 2.5 ha, 27 and 38 percent *S. hamata* was found as established standing crop in the first and second year respectively. In another location which area was 3.75 ha, 16.2 and 16.9 percent establishment was found in first and second year respectively. According to Northern Territory of Australia (1999) in the no tillage (NT) it behaves either as a self-regenerating annual or a biennial plant with generally 40 percent of plants surviving from one wet season to a second. Moreover, about 30-40% of plants will perennate under grazing, and continue to grow into the dry season after flowering (NSW Agriculture, 1995). In addition, Tarawali *et al.* (1994) revealed that *S. hamata* plants were able to survive the dry season and about 25 perenating plants/m^2.

Although plant density declined by 20% during July, surviving Verano stylo plants expanded rapidly tripling their cover within a 65-day period and covering about half the available space. As in the two-year-old stand, competition from volunteer grass and weeds was limited and up to the end of July 80 percent of the green cover consisted of Verano stylo.

Regarding to population density of broadleaved and grass weeds, the result revealed that phosphorus fertilizer had significant effect on their population. Less number of weed were found after phosphorus application compared to without applied treatment. The reason of decreasing the population of weed in phosphorus applied treatment was the vigorous growth of ground coverage of *S. hamata* which suppress growth of weed. Nevertheless, in cutting practice and weeding practice did not affect on the numbers of broadleaved and grass weeds.

6.2.4.2 Height of *S. hamata* and predominant weed (*Richardia brasiliensis*)

Phosphorus fertilizer and cutting practice had effect on height of newly germinated plants and mature plants of *S. hamata*. The height of phosphorus fertilizer applied treatments was higher than control. However, phosphorus fertilizer had no effect on the height of predominant weed.

In regard to cutting practice, it became effective by decreasing height of *S. hamata* and predominant weed in double cutting practice compared to single cutting practice. Similarly, weeding practice directly decreased on height of predominant weed at the middle and late rainy season. However, no significant effect was noticed on the height of *S. hamata*.

Some seedlings of *S. hamata,* and broadleaved and grass weeds were suppressed by mature plants of *S. hamata*. However, some strong weeds were able to interfere them. Thus, the suitable time for weeding practice should be decided on some factors such as weed species, serious interference, percent coverage and mature plants (flowers booming and seed set).

The farmers of rainfed upland area should harvest *S. hamata* before rainfall starting (July to August) when the height becomes about 30 cm. Growth rate of *S. hamata* declined during rain stopped (mid June-August) due to low moisture content. According to the leaf analysis of present investigation, the young leaves contain higher quality of chemical component compared to mature leaves. The result confirms the findings of Northern Territory of Australia (1999). They found good quality hay could be made from *S. hamata* if it cut early while became green and leafy. After that stage the plant contained lower nutrition value because some leaves dropped already.

In addition, the growth habit of *S. hamata* was both semi-erect and prostrate. In prostrate type, the height increases than stem which is difficult to harvest. Regarding such case, we should harvest before developing a flat crown.

The height of *S. hamata* was about 55 cm in rainfed upland area. Humphreys (1980); NSW (1995) and Northern Territory of Australia (1999) revealed that erect stems of *S. hamata* may grow 70-80 cm high under good conditions.

The increasing of height of predominant weed becomes slower than *S. hamata* when rain starts (mid-August). Moreover, the mature plants of predominant weed turn into old plants and some of them died. Simultaneously, new seedlings of weed germinate, which can not be able to compete with *S. hamata*.

6.2.4.3 Ground coverage of *S. hamata*, broadleaved and grass weeds

The initial ground coverage of *S. hamata* (mature plants) at the early wet season suppresses the ground coverage of weeds. Moreover, some newly germinated plants of *S. hamata* able to establish due to getting enough space for them and combine with the mature plants. In addition, ground coverage of both *S. hamata* and weeds becomes almost stable as their leaves turn into brown color and eventually fall down. This happens when the rainfall decreased (Figure 5.1) during the month of mid June to mid August.

Ground coverage of *S. hamata* was responded strongly when phosphorus fertilizer applied (Figure 5.15). After phosphorus fertilizer application, more branches of *S. hamata* were appeared which resulted to be very extended and intense ground coverage. Similarly, Walaipon *et al.* (1979) revealed that the highest of branch numbers was 4,980 brances/m^2 at 96 day after planting (DAP). Moreover, Tudsri *et* *al.* (1988) reported that there were 1,946 and 1,634 leaves/plant at 117 and 131 DAP respectively. In addition, phosphorus fertilizer affected on ground coverage of broadleaved and grass weeds as well, but negatively. The ground coverage of weeds decreased due mainly to the vigorous ground coverage of *S. hamata*, which probably caused suppression of weeds' ground coverage by the scarcity of space. However, no any report has been found regarding this aspect. Moreover, hardly any report was found in respect to allelochemical interference. In relevant work, de Leeuw *et al.* (1994) showed that cover of volunteer vegetation remained low indicating that although sufficient bare ground was available (32-65% in late July), moisture competition from the dense *S. hamata* patches may have prevented establishment of weeds. However, in the present study, lack of space found to be obvious for weeds including moisture.

Cutting practice also affected on both *S. hamata* (Figure 5.17) and weed coverage (Figure 5.31) by decreasing the canopy of them at the first cutting in double cutting practice. The ground coverage became lower in double cutting practice compared to single cutting as in double cutting they were cut in two times. Although, cutting of *S. hamata* at 17 WAE decreased the ground coverage only in 6 weeks, but their ground coverage and height rapidly recovered like single cutting because of heavy rainfall in August to October. Nevertheless, ground coverage of weeds increased in double cutting practice compared to single cutting practice, as more space was available.

The result of existing investigation revealed that weeding practice did not influence on the ground coverage of *S. hamata* (Figure 5.16). Some population of *S. hamata* (mature plants) suppressed weed growing at the early wet season, which did not let the weed interference seriously. The suppressing of weed was due to perennating and drought tolerance behavior of *S. hamata* (Northern Territory of

Australia. 1999). Moreover, the seeds of this legume can stay in the soil with its viability and again can germinate with high percentage. Thus the new seedlings replace the previous plants and always continue to cover the soil (Humphreys, 1980 and Skermann *et al.,* 1988). The another characteristic of this plant is it can produce flower followed by seed throughout the year and the seeds keep fall on the soil almost all the year (de Leeuw *et al.*, 1994).

6.2.4.4 Dry matter of *S. hamata* and broadleaved weeds and grass weeds

From the result it is revealed that phosphorus fertilizer increased the dry matter content of *S. hamata* (Figure 5.20). On the other hand, phosphorus fertilizer did not show any significant effect on dry matter content of weeds. According to Skermann *et al*. (1988), *S. hamata* had the strong ability to response to phosphorus in the soil. Similarly, Peters (1992) in Tarawali *et al*. (1994) found that application of P_2O_5 up to 300 kg/ha improved not only dry-matter yield but also able to resist against drought. Moreover, de Leeuw and Mohamed-Saleem (1994) reported that 0, 30 and 120 kg P_2O_5 per hectare were able to give the yield by 2.8, 6.0 and 8.7 t DM/ha respectively. However, among them, the optimum economic dose was found to be 30 kg P_2O_5 per hectare.

The result cutting practice did not show any significant effect on dry matter content of *S. hamata* when the cutting was done two times. Nevertheless, in work of Termsombuttaworn (1992) it was found that infrequent cutting gave more dry matter of *S. hamata* compared to the frequent cutting treatments. In addition, Kosakhan (1991) and Yodsurin (1992) found that infrequent cutting or cutting every 45 days gave higher dry matter pasture yields than frequent cutting treatments or cutting every 15 days. The present result has not been supported by the above findings because of interval of cutting was longer. Moreover, after first cutting, heavy rain appeared and as a result, the plant could be able to recover their growth easily.

On the other hand, double cutting practice had positive effect on dry matter of broadleaved and grass weeds (Figure 5.34). The reason was due to first cutting, the height and ground coverage of *S. hamata* decreased and the weeds got enough space to be strong. As a result, the growth of weeds increased which led to increase the dry matter of weeds including more flowering and seed production. These seeds are responsible for huge weed production in the following years.

The result of present investigation showed that weeding practice had no effect on dry matter of *S. hamata* and weeds. Although due to weeding the weeds were only cut down and remained the basal part where it was able to regenerate within 9 weeks.

The results of present investigation revealed that the first cutting of *S. hamata* was done at end of August. Unfortunately, the time was not suitable for drying the forage by the sunlight due to heavy rainfall (Figure 5.1), which affected to forage quality. However, the second cutting was practiced at the end of October during which weather condition was favorable, e.g., little rainfall and strong sunlight, which allowed for easier harvesting, drying, and the storage of the forage. Moreover, generally double cutting practice of *S. hamata* increase dry weight and chemical components. However, double cutting of *S. hamata* is not profitable unless the farmers keep cattle. In fact, comparing cost, increasing of dry matter is not significant. Nevertheless, the comparison between cutting cost and feeding value should be determined and compared.

6.2.4.5 Forage qualities of *S. hamata*

From the result it was found that in late wet season, cutting practice gave highly significant effect on neutral detergent fiber (NDF), acid-detergent fiber (ADF) and crude protein (CP) (Table 5.9). Fiber in single cutting practice was higher than double cutting practice, which was due to high NDF and ADF and low moisture content compared with double cutting treatment. For cattle feed, less NDF and ADF is better than high NDF and ADF (Tudsri, 1997). So, young plants are not only in better quality but also most preferable for cattle as they like it too much. After double cutting practice, better quality of forage as well as yield can be produced compared to single cutting practice.

At 25 WAE, CP content was found to be higher in double cutting in comparison to single cutting due to more frequency of cutting, which regenerated young leaves and shoots. In addition, in mid and late season CP decreased by 13.84 and 13.64% respectively. Similarly, Tarawali *et al.* (1994) reported that CP content was 10.4% at the beginning of dry season, which decreased at 6.1% in the second half of the dry season. According to Skerman and Riverose (1990) in Tudsri, 1997, the natural grass (*Dactyloctenium aegyptium*) contains CP 8.3% (dry grass). However, the result of the present study revealed CP content is much higher (14.9% in double cutting practice in a year) compared to natural grasses.

From the present study it can be recommended that first cutting practice in double cutting practice should be done before rainfall stop (July to August), which affect on growth of *S. hamata*. Because, due to early cutting young plant part generates which becomes high quality of forage. Regarding forage quality, Sritawan (1991) reported that the legumes at vegetative stage generally contained higher in CP, ether extract (EE), ash, calcium and phosphorus than the other growth stage and chemical composition tended to decrease with increasing of growth. Similarly, dry matter, crude protein, gross energy (GE), crude fiber (CF), ADF, NDF and acid detergent lignin (ADL) increased with growth.

Nevertheless, on the basis of the present finding, both fertilizer and weeding practice did not show any significant effect on the forage qualities.

6.2.4.6 Weed interference

In study area, interference of weed in *S. hamata* field was observed throughout the seasons. Lowest weed species were found in the early wet season, which due to low moisture content in soil as well as the ground soil covered by some mature plants. On the other hand, highest weed interference observed in mid wet season, which was due to availability of high moisture in the soil as rainy season. Again the weed interference decreased in the late wet season when the moisture started declining.

Various types of weed species were noticed in *S. hamata* field. The most notorious found to be *Richardia brasiliensis* and *Rhynchelytrum repens* during early and mid wet season. In the late wet season, *Borreria laevis* was appeared to be most serious one. Due to short life cycle and sensitive to drought, some weeds of *R. brasiliensis* and *R. repens* species were died. However, there were some young seedlings germinated but they were not as serious as *B. laevis*. Many noxious weeds were often found as major interfering factors to the establishment of Verano stylo population. Forage quality of *S. hamata* population interfered by weeds was reduced considerably. Regarding preference of cattle, *R. repens, Digitaria setigera*, and *Dactyloctenium aegyptium* were favored (Radanachaless, 1990). Nonetheless, *B. laevis* is not preferred by cattle because of its latex-like substance.

On the basis of the present finding, effect of weeding depends on weed species, amount of rainfall and mature plats (flowering and seed set) etc. Therefore, farmers should provide weeding before flowering and seed setting. Following this way, weed seed bank in soil can be reduced.

Mango trees grown under different climatic and biophysical conditions usually experience remarkably different morphological growth rates. One of the instances is the difference in the size of plant canopy. It was observed that, due to various constraints such as lack of water, poor soil fertility, and so on, the 3-year-old mango trees in rainfed upland area normally produce smaller canopies than mango trees with same age planted in lowland area. Thus, the space between mango alleys in the rainfed upland area can be grown to a number of cash crops i.e. soybean, mungbean, and maize, as well as legume cover crops, especially the Verano stylo.

Fitting management is crucial for better establishment, high yield, and ground coverage of *S. hamata*. That is to keep *S. hamata* free from/and outgrow other noxious weeds throughout their lifetime, especially, in the fourth year of their establishment during which the crops might be less competitive. These primarily require an additional application of phosphorous fertilizer to *S. hamata*. In so doing, coupled with double cutting a year, a good harvest of forage of *S. hamata*, both qualitatively and quantitatively, is insured.

S. hamata embryo seeds are covered by seed-coat that provides protection for the seeds against out-of-season rainfall and fire hazards. However, seed-coat is often a deemed as a limiting factor to a low germination rate of *S.hamata* seeds. In such a case, it is suggested that breaking the seed-coats before sowing is very important should a high percentage of germination is desired. This requires the need for *S. hamata* seeds being exposed to a certain degree of heat. According to de Leeuw and Mohamed-Saleem (1994), the required temperature to break hard-seededness of *S. hamata* should be greater than 50 °C.