CHAPTER 4

RESULTS AND DISCUSSION

This chapter presents the biological and climatic conditions, socioeconomic status, fertilizer use, soil fertility management practices, different knowledge levels, the factors determining farmers' knowledge about ISNM of the sampled sugarcane farmers and the yield and profitability of different soil nutrient management practices in sugarcane production system in Paukkaung township, Myanmar.

4.1 Biophysical conditions

Paukkaung township is located in Pyay district, Bago division and lower Myanmar. It is geographically located between latitudes 18° 40' N to 19°50' and longitudes 95° 40' E to 96° 50' E and the altitude is about 30 to 62 meters above the sea level. Paukkaung is situated 325 kilometers to the north of Yangon city. It has a total area of 1,907.59 square kilometers. Its neighboring townships are Aunglan, Pyay, Thegon, Oktwin, Taungoo and Yedashe.

A significant characteristic feature of Paukkaung township is that it is one township that grows sugarcane the most in Myanmar. Sugarcane farmers in Paukkaung township mainly rely on rain-fed condition for sugarcane cultivation. Meteorological factors of particular growing area such as total rainfall, rainfall pattern and density, solar radiation or sunshine duration, minimum and maximum air temperature, air humidity, wind speed and direction affect the improvement of the sugarcane plantation and yield. Therefore, annual sugarcane yield and the economic status of sugarcane farmers in the study area depend absolutely on the unexpected and on controllable climatic conditions.

4.1.1 Climatic conditions

The normal average annual rainfall was about 1,132 mm with 107 average rainfall days per year. We can see the monthly average rainfall (30 years) and 2010 in the study area. During the year of 2010, the annual rainfall was about 1,011mm with only 67 rainy days. Therefore, both annual rainfall and rainy days in 2010 had being decreased compared to the last decade. Although the highest monthly rainfall was 277 mm, there was no rain in some months and it was not unfair rainfall pattern for cane cultivation (Figure 4.1).

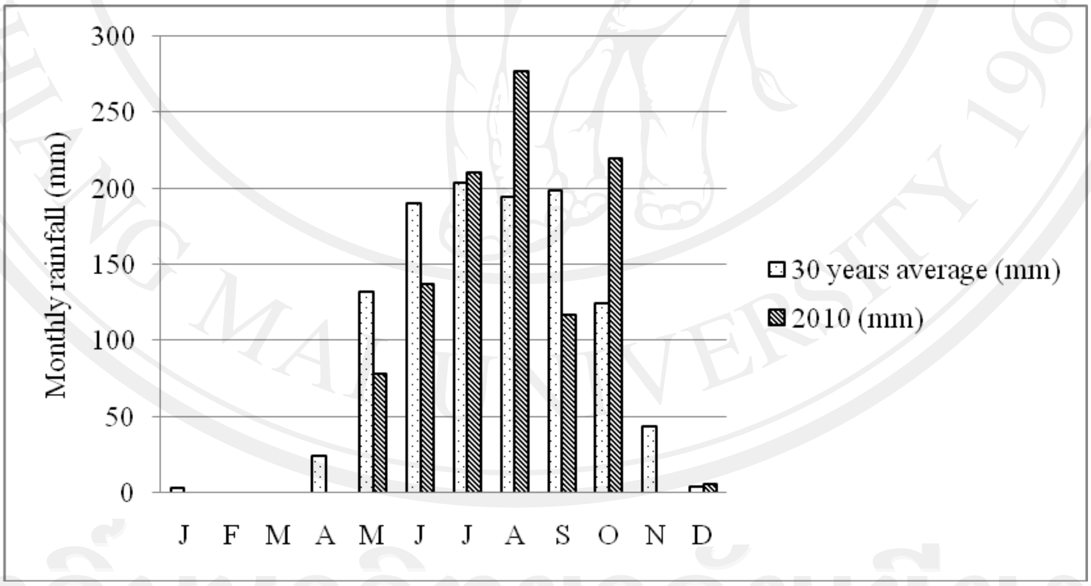


Figure 4.1 Distribution of monthly rainfall in the study area

Source: Township Agriculture Office, Paukkaung (2011)

The comparison of the minimum and maximum sunshine duration in 2010, the minimum sunshine duration of about 3 hours per day in June and maximum sunshine duration of 9 hours per day in November could be seen in Figure 4.2.

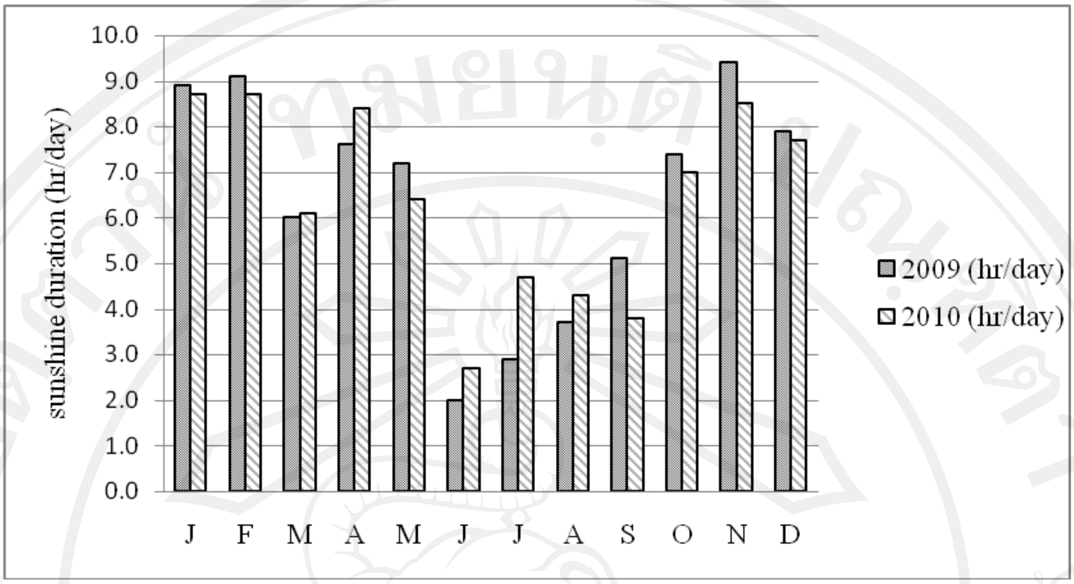


Figure 4.2 The average monthly sunshine duration of the study area (2010)

Source: Township Agriculture Office, Paukkaung (2011)

This area is dry and semi-arid region where day temperature can reach up to 43˚C and the minimum temperature falls down 13˚C. April and May were the hottest months with the average temperature 43˚C and January was the coolest month with an average temperature of 13˚C. The monthly minimum and maximum air temperature of the study area is shown in the Figure 4.3.

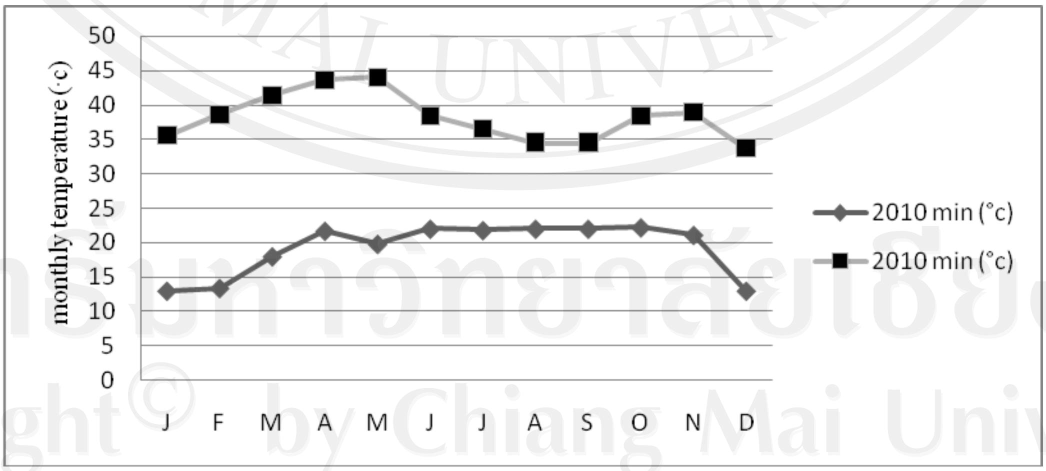


Figure 4.3 The average monthly temperature of the study area (2010)

Source: Township Agriculture Office, Paukkaung (2011)

There were two series of relative humidity measurements of Paukkaung township. Humidity I (%) was measured at 9:30 a.m. (Myanmar Standard Time) and humidity II (%) was measured at 4:30 p.m. Figure 4.4 showed the two series of humidity of the study area. The average lowest morning and the evening humidity were 64% and 33% during the months of February and April. The average highest morning and evening humidity were 88% and 84% during the month of August. The most suitable relative humidity for cane production is about 80%.

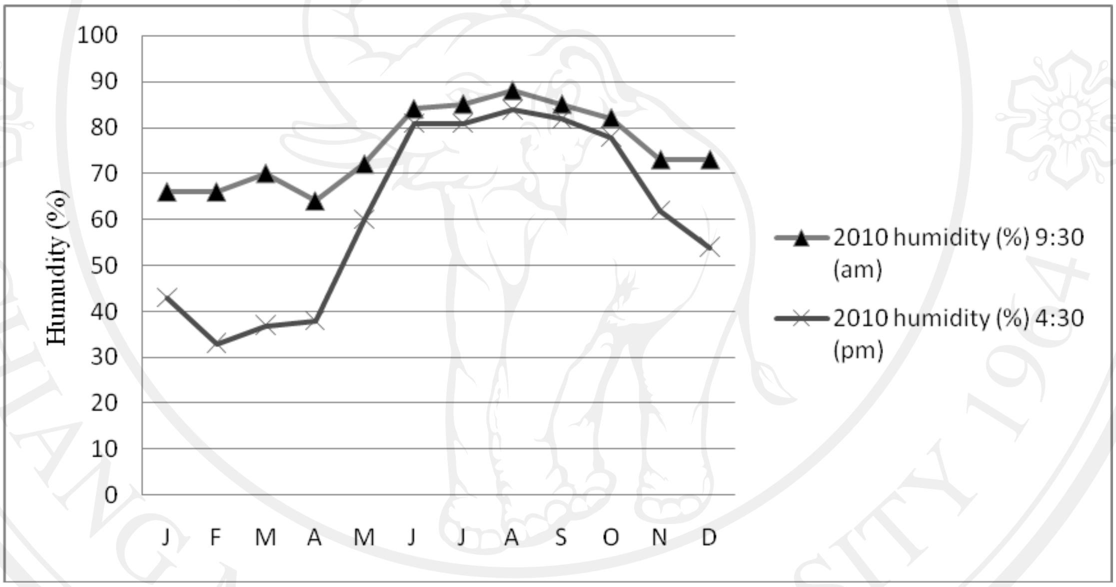


Figure 4.4 Average monthly relative humidity of the study area (2010)

Source: Township Agriculture Office, Paukkaung (2011)

We can compare monthly average highest wind speed of 4.6 meter per second during June, July and August (2010) and monthly average lowest wind speed of 0.89 meter per second in January (2010).Table 4.1 shows the wind speed and direction of the study area.

Table 4.1 The wind direction and speed of the study area (2009-2010)

No.	Month	2009		2010	
		Direction	Speed (m/s)	Direction	Speed (m/s)
1	January	SW	0.89	N	0.89
2	February	SW	0.89	NE	2.268
3	March	SW	1.34	NW	3.12
4	April	SW	2.24	SW	3.57
5	May	SW	2.24	SW	3.12
6	June	SW	2.24	SW	4.46
7	July	SW	1.78	SW	4.46
8	August	SW	1.78	SW	4.46
9	September	SW	1.34	SW	3.12
10	October	SW	1.78	SW	2.24
11	November	NE	0.89	NE	1.78
12	December	NE	1.78	NE	1.34

Note: N = North, S = South, E = East, W = West

Source: Township Agriculture Office, Paukkaung (2011)

4.1.2 Soil conditions

Yellow brown dry forest soil, light yellow forest soil and structure less soils were found and so it was difficult to maintain soil nutrients and low water holding capacity (Figure 4.5). Most of top soils are sandy and loamy soil in texture and low concentration of organic carbon and manure content. It is normally well porosity with high infiltration rate to lower soil layers.

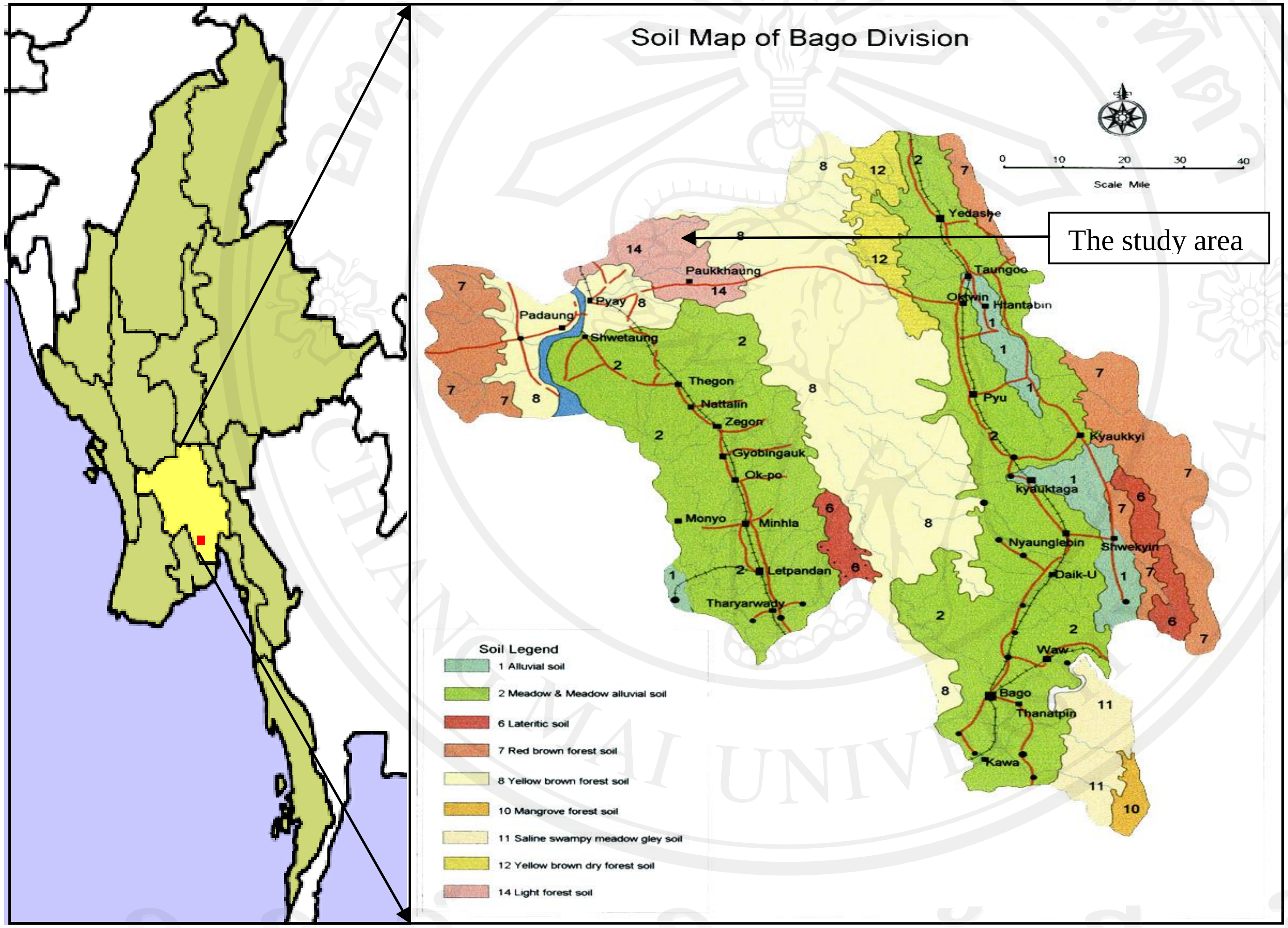


Figure 4.5 Soil map of Paukkaung township

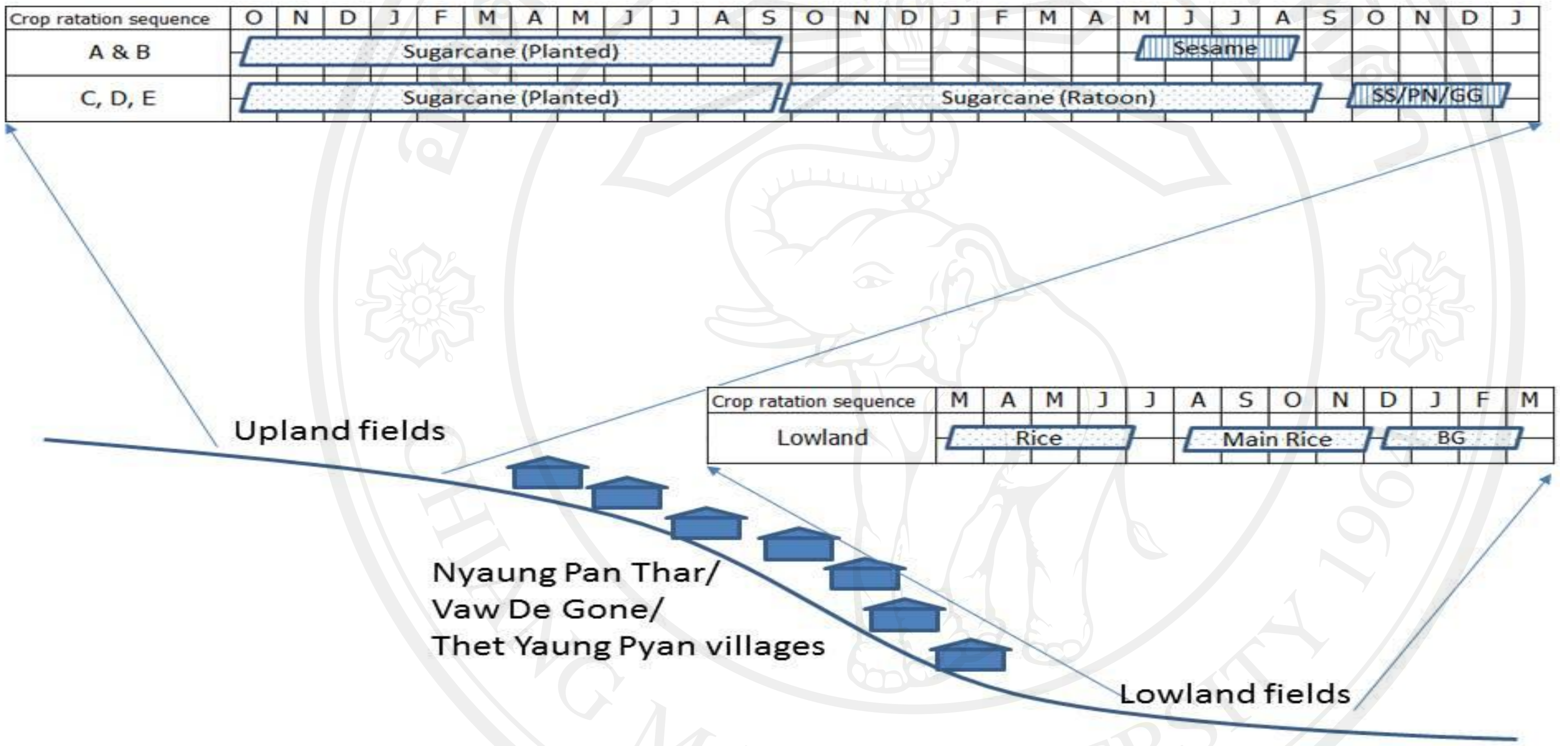
Source: Land use division, Divisional Agriculture Office, Pyay (2011)

According to physical soil properties, low in cation-exchangeable capacity, low concentration of plant nutrients, in particular, N, P and K. Most of soils contain kaolinitic clay minerals and accumulate of carbonates in some sub soil layers. Soil pH ranges about 5.3 to 6.5 and normally moderately acidic to slightly acidic. This soil type is suitable to cultivate upland crops such as sesame, groundnut and pulses.

4.2 General characteristics of study area

4.2.1 Cropping systems

Crop sequences vary according to climate and soil types. Cropping patterns have different effects on soil properties and thereby govern the soil conditions. Changes in nutrient contests of different soils also occurs due to the use of different fertilizers and the doses of such fertilizers applied to different cropping systems (Farouque *et al.*, 2008). Farmers in the study area grow multiple cropping of rice, sesame, cotton, green gram and black gram, one after one in year round in their lowland plots. For example summer rice from March to June, rainy season rice from middle of July to middle of November, and black gram from December to February. In their upland plots, some farmers grow sesame from middle of May to middle of August, cane from middle of November to December of next year. Some farmers grow alternately groundnut from middle of May to middle of August, cane from middle of November to December of next year (Figure 4.6).



Note: SS=Sesame; PN=Peanut or groundnut; GG=Green gram; and BG=Black gram.

Figure 4.6 Crop calendar and rotation in the study area

Source: Survey data (2011)

4.2.2 Sugarcane Variety

In the study area, farmers used different kinds of sugarcane variety namely, VMC 74/527, Co 798, K 84/200, K 88/92 K 95/84, K 95/283 according to their soil types and slopes, plot condition and soil fertility levels. Most of farmers used their own seeds and some farmers obtained from their neighbors, other villagers and relative seed farms. Total net sown area of sugarcane in Paukkaung township (2010-2011) was 5,008.5 ha with new sugarcane plantation of 3,710.5 ha and ratoon crop of 1,298.0 ha (Table 4.2).

The average yield of VMC 74/527,Co 798, K84/200, K 88/92, K 95/84 and K95/ 283 cane varieties in Paukkaung (2010-2011) were 37.0, 39.7, 46.5, 48.2, 48.85 and 45.7 tons per ha respectively. The last two sugarcane varieties were most popular and attractive to sugarcane growers with their high yield.

Table 4.2 Total sugarcane production of Paukkaung township (2010-2011)

Item	Net sown area (ha)	Average fresh cane yield (t/ha)	Production (MT)
New plantation	3,710.52	50.83	188,605.73
Ratoon	1,297.97	22.38	29,046.23
Total	5,008.49	36.61	217,651.96

Source: Township Sugarcane Office, Paukkaung (2011)

The use of different sugarcane varieties grown by interviewed farmers were presented in Table 4.3. Almost all of farmers kept and used own cane setts and some of them obtained cane setts from others. About 65% of selected farmers used high yield varieties such as K 84/200, K88/92, K 95/84 and K 95/283 and 35% of farmer used other varieties. Nearly 26% of survey farmers used Co 798 and about 26% of farmers used K 84/200. 10% of them used K 88/92 and nearly 11% of sample sugarcane farmers cultivated K95/283. About 10% of farmers used K95/84 and about 18% of them used VMC 74/527.

About 90% of sugarcane farmers who owned fertile soils prefer high yield varieties but small scale farmers liked VMC 74/527 because this cane variety could be adapted to a range of soil type and needs low amount of fertilizers compared to other high yield cane varieties and to be grown on the plots which are close to villages and the ways. It was observed that most of farmers in Nyaung Pan Thar village area used high yield varieties as the fields in this village area were fertile while farmer in Vaw De Gone village area prefer VMC 74/527 according to their low soil fertility.

Table 4.3 Use of different cane varieties of in three selected villages (N=120)

Sugarcane Variety	**Nyaung Pan Thar**	**Vaw De Gone**	**Thet Yaung Pyan**	**Total**	**Percent**
Co 798	9	9	13	31	25.83
K84/200	11	12	8	31	25.83
K88/92	2	3	7	12	10.00
K95/283	6	2	5	13	10.83
K95/84	-	12	-	12	10.00
VMC 74/527	-	14	7	21	17.51

Source: Survey data (2011)

4.2.3. Soil fertility status of sugarcane land of the households

According to Table 4.4, nearly 14% of the land was coarse-textured soil, about 66% was medium and 20% was fine-textured soils. The majority of farmers were aware of the soil fertility status of their sugarcane fields, as only 2% of the interviewed farmers perceived the current level of soil fertility as low, while 37% believed that the soil fertility is still medium and manageable whilst only 61% perceive the fertility in their farms as still high (Table 4.4).

Corbeels *et al.* (2000) observed that soil color was an important criterion for farmers. It was often the reflection of the soil's hidden parent material which determines the specific soil characteristics. The texture of the surface layer had some influenced on many other soil properties, and gave farmers a clear indication of to whether a soil could be cultivated.

Nearly 21% of cane lands the study area had light colored of top soil and 56% of cane lands possessed grey colored top soil while 22% of cane lands were remained with dark colored. Farmers viewed that the colors of top soil were related with the amount of organic matter content, soil fertility and water holding capacity of fields.

Farmers classified dark black soil to be the best soil in terms of productivity of sugarcane. Owing to its high water holding capacity, this soil gave better cane yield than other soils. However, the major limitation of this soil was sticky when wet and hard when dry; making it difficult to till (Abera *et al.*, 2011).

4.3 Background information of sugarcane farmers

4.3.1 Socio-economic characteristics

In this part, the socio-economic characteristics of sampled sugarcane growers were shown. Table 4.4 presents to soil status conditions and the sugarcane cultivation in Paukkaung township.

Table 4.4 Soil fertility status of surveyed households (N = 120)

Soil status	Nyaung Pan Thar	Vaw De Gone	Thet Yaung Pyan	Percent
Soil texture				
Coarse-textured	3	9	4	13.33
Medium-textured	32	27	21	66.67
Fine-textured	5	4	15	20.00
Soil fertility				
Poor	-	2	-	1.67
Medium	7	16	21	36.67
Good	33	22	19	61.66
Soil slope				
Flat	14	12	14	33.33
Moderately steep	15	11	11	30.83
Steep	11	17	15	35.84
Top soil color				
Light	4	13	8	20.83
Grey	29	18	21	56.67
Dark	7	9	11	22.50

Source: Survey data (2011)

The minimum age of respondents in the study was 24 years and maximum age was about 65 years with an average of 46 years. The age of about 12% of responded farmers was under 35 years, of 42% was between 35 to 45 years, of 29% was between 46 to 55 years and of about 17% was older than 55 years. Thus, most farmers were active, could work hard and easy to get information and ISNM technologies.

According to Figure 4.7, about 8% of selected farm household heads were women and 92% were men. It was found that high proportion of household heads was male and they were very important in decision making and managing their farm and other social status.

About 33% of selected farmers had educated at the primary level, 40% of selected farmers had educated at the secondary level, and 25% of selected farmers educated had possessed high school level while 4% of selected farmers had completed higher degree or bachelor. The education level of cane farmers was low. Some respondents have no high education level but they have good local knowledge in sugarcane cultivation.

According to the results of filed survey, most of sugarcane farmers had good experience in cane cultivation. The farming experience in sugarcane cultivation of selected farmers was form 4 years to 45 years in sugarcane cultivation with an average of 23 years. Therefore, it can be concluded that they had sufficient knowledge to manage the sugarcane plantation and to understand on ISNM.

The farmers were small scale and owned from less than one hectare to 9 hectares with an average of 2.29 hectares of sugarcane cultivated land (new). About 38% of farmers owned less than 2 hectares of sugarcane area, about half of selected farmers own from 2 to 4 hectares and 11% of them owned larger than 4 hectares.

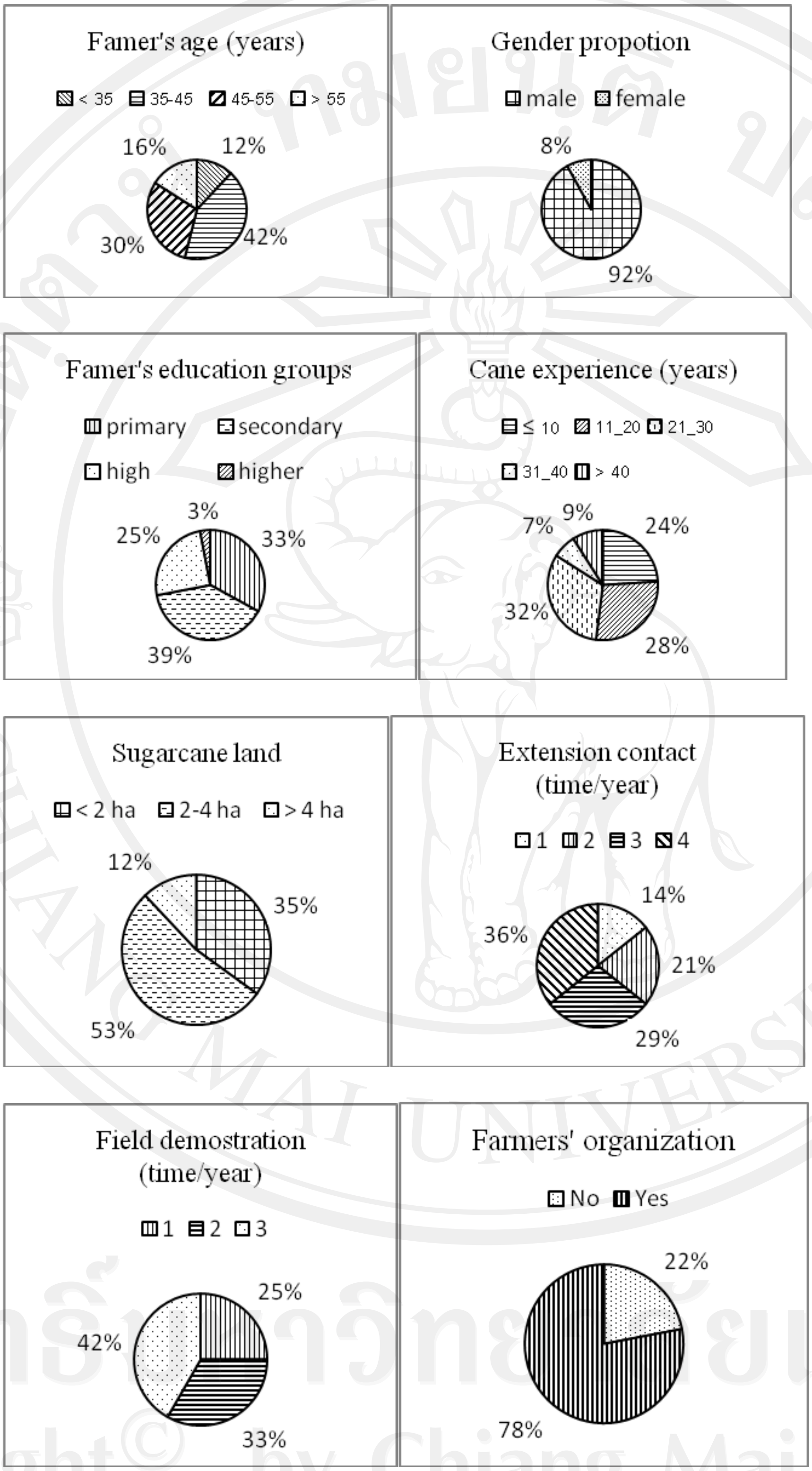


Figure 4.7 Socio-economic characteristics of surveyed households

Source: Survey data (2011)

It was found that about 24% of farmers had met two times to extension officers, about 24% had met three times per season and 37% had met four times while 15% had met five times during the sugarcane cultivating period of 2010-2011.

About 17% of the cane farmers never attended in field demonstrations that were related to ISNM, more than 8% participated one time per season (2010-2011), 29% participated two times and near half (46%) participated more than two times per season. It was observed that 8 out of 10 farmers (77%) had participated farmers' local and social organizations while about 23% never attended to organizations in their villages.

4.3.2 Use of fertilizers

About 7% of sample farmers did not use any type of fertilizers and farmyard manure (FYM), and 12% of selected farmers used only urea while about 11% of interviewed farmers used urea plus biocomposer, 36% used urea, biocomposer and FYM and 31% used compound fertilizer and FYM (Table 4.5). Inorganic fertilizers are easy to apply, not bulky and have immediate effect on crop production and thus farmers prefer to use inorganic fertilizer as compared to organic fertilizer.

In the study area, farmers' choice of using either organic or chemical depended on the supply of sugar mills of biocomposer and chemical fertilizers. In the Vaw De Gone and Thet Yaung Pyan village area, the farmers normally used both urea and biocomposer because this area was under the control of Inngagwa sugar mill which supplied urea and biocomposer according to the cane plantation area. In Nyaung Pan Thar village area, the farmers used only chemical fertilizers because this area was under the control of Nawaday sugar mill which supplied only compound fertilizers according to the cane yield of farmers.

The cost of a cart-load of FYM was about 2,000 to 2,500 kyats in crop year of 2010-2011. But the sugarcane farmers normally gave priority to FYM for application in their rice fields. The most common form of chemical fertilizers used was urea and 30% of farmers applied chemical compound fertilizers (N+P+K+S+Zn). About 60% of selected farmers used biocomposer during land preparation and earthing up periods. The cane farmers applied two and half bags (125 kg) of compound fertilizer per ha while other farmers used five bags (500 kg) of urea per ha. The cane farmers applied five bags (125 kg) of biocomposer per ha before cane sowing and next five bags (125 kg) of biocomposer per ha during earthing up.

Table 4.5 Fertilizer use of surveyed households (N = 120)

Use of fertilizer	**Nyaung Pan Thar**	**Vaw De Gone**	**Thet Yaung Pyan**	**Percent**
No use	2	6	1	7.50
Urea	-	3	12	12.50
Urea + Biocomposer	-	9	5	11.67
Urea + Biocomposer +FYM	-	22	22	36.67
Compound + FYM	38	-	-	31.66

Source: Survey data (2011).

4.3.3 Soil fertility management practices

In the study, it was found that every farmer practiced crop rotation with groundnut, sesame, and bean, green gram after and before cane plantation. Farmers were well aware that it can improve soil productivity and chose which crops to grow in rotation with sugarcane according to how they adapt to the soil and the rainfall pattern. Personal preference and economic considerations such as the price of the crop influenced the farmers' choice. Cash crops grown in the area got priority for manuring as they assured the family's income.

The major crop rotations with sugarcane practiced by the cane farmers in their upland plot area were (Figure 4.6):

A• Sugarcane (new) –groundnut

B• Sugarcane (new) –sesame

C• Sugarcane (new) – sugarcane (ratoon) – groundnut

D• Sugarcane (new) – sugarcane (ratoon) – sesame

E• Sugarcane (new) – sugarcane (ratoon) – green gram

Use of livestock manure was related to ownership of cattle. Most farmers in the study area owned 3 to 4 heads of adult cattle, as hence the limited use of livestock manure. In the Nyaung Pan Thar village area, the cane farmers were difficult to purchase biocomposer from sugar mills and they owned wider area of farmland as compared to other two village area, they prefer to use organic fertilizers.

Farmyard manure was typically applied as a mixture of animal dung, urine, crop residues and soil. The main sources of animal dung in the study are cattle, pig and chicken. Usually, the farmers collected FYM daily during morning and kept it in pits near their houses and sometime covered with roof to it. Before application, the manure had usually been decomposed in these pits. FYM was applied to their cane fields during land preparation as basal fertilizer.

The farmers in the study area did not adopt the fallowing technology because they own small scale plot area and it was difficult to fallow their land. Population grew over the years and land holding sizes declined and fallowing became impossible. Thus, soils were being over mined due to continuous sugarcane cultivation leading to declining soil fertility. Decline in soil fertility caused low agriculture production.

Manure is an important input for maintaining and enhancing soil fertility. Green manure crops like sunnhemp, black gram, mung bean, and cowpea were not sown and incorporated in the field of sugarcane. Short duration legumes were not used as intercrops along cropping pattern because the intercrops compete with cane on nutrients, sunshine and moisture. Composting with cane leaves and trash was not made. Green manure and cover crops have an important place in cane plantations and their nutrient values can be considered as an external input to sugarcane.

4.4 Farmer knowledge levels on ISNM

An integrated soil nutrient management technology in this study, was understood as the use of inorganic fertilizers and organic fertilizers combined on the same field with combination of green manuring, composting, fallowing, intercropping and crop rotation in order to improve the soil fertility and sugarcane yield. The farmers' knowledge was meant that the local or indigenous knowledge of sugarcane farmers on ISNM in sugarcane cultivation.

Knowledge level of the sugarcane farmers was measured with 8 questions that are related to integrated soil nutrient management practices in sugarcane farming system in the study area. The total scores for 8 questions ranged from 20 to 37. According to the results of farmers' answers, they can be classified into three levels of farmer knowledge (low, medium and high levels) by using Lickert scale method.

According to results of survey, the selected farmers scored from the minimum of 20 points to the maximum of 37 points. It was observed that 18% of the sugarcane farmers had high knowledge level on ISNM, while 60% of them belonged to medium level on ISNM and 22% of farmers had low level on ISNM. The farmers who had high level knowledge were assumed that they had knowledge about the use and advantages of green manure, farmyard manure and compost, the advantages of intercropping with legumes, crop rotation, fallowing, composting and biocomposer, the amount, application time and methods of chemical fertilizers and micro-nutrients of cane plantation.

It was observed that while about 22% of them had low knowledge level on ISNM, more than half of respondents belonged to medium level category (Table 4.6). This result indicates that there is a need to focus attention to ensure that two groups of low and medium knowledge level categories possess accurate knowledge of ISNM.

Table 4.6 Distribution of sugarcane farmers according to their overall knowledge level on ISNM (N = 120)

No.	**Knowledge level about ISNM**	**Sugarcane farmers**	
		Number	**Percent**
1	Low knowledge level (mean – SD) or (< 23.5)	26	21.66
2	Medium level (mean ± SD) or (23.5 - 31.1)	72	60.00
3	High level (mean + SD) or (> 31.1)	22	18.34
	Mean	27.3	
	SD	3.8	

Source: Survey data (2011)

Table 4.7 shows that the scores of the selected farmers on knowledge about compost and green manure stood 4 to 9 in total scores of 12 and of farmers on knowledge about farmyard manure and animal manure were 2 to 5 in total scores of 6.

Table 4.7 Famers' knowledge on ISNM (N = 120)

Knowledge about ISNM	**Farmers' scores**		
	minimum	**maximum**	**average**
The application of compost and green manure	4	9	6.31
(1) Increasing water holding capacity			
(2) Reducing of soil drying			
(3) Retaining the nutrients added			
(4) Improving soil fertility			
(5) Prevention of wind and water erosion			
(6) Weed supression			
(7) Increasing crop yield			
(8) Improving soil aeration			
(9) Reduction of soil temperature			
(10) Improving organic matter content			
(11) Increasing soil microbe activity			
(12) Maintenance of soil physical properties			
FYM and animal manure	2	5	3.63
(13) Maintaining the soil organic content			
(14) Increasing microbial activity			
(15) Enhancing the soil physical properties			
(16) Increasing soil aeration			
(17) (5 cart-loads)			
(18) (before land preparation)			

Table 4.7 (Con't)

Knowledge about ISNM	Farmers' scores		
	minimum	maximum	average
Intercropping with legumes	1	5	3.18
(19) Enhancing soil fertility and structure			
(20) Weed suppressing			
(21) Reducing soil temperature			
(22) Reducing soil and water erosion			
(23) Maintaining crop yield			
(24) Maintaining soil moisture			
Crop rotation with legumes	1	2	1.96
(25) Maintaining soil fertility			
(26) Recovery of deep nutrients			
Mulching with cane stubble/leaf trash	1	4	2.25
(27) Reducing evapotranspiration rate			
(28) Reducing the weeds			
(29) Reducing the soil erosion			
(30) Increasing water holding capacity			
(Improved) fallowing	1	4	2.39
(31) Maintaining soil fertility			
(32) Recovery of deep nutrients			
(33) Improving the crop yield			
(34) Increasing returns to land and labor			

Table 4.7 (Con't)

Knowledge about ISNM	Farmers' scores		
	minimum	**maximum**	**average**
Chemical fertilizers	5	9	6.68
(35) Urea (100 kg)			
(36) T super (50 kg)			
(37) Potash (50 kg)			
(38) Use of NPK as basal			
(39) Use N fertilizers as first top dressing after 6 weeks of planting			
(40) Use N fertilizers as second top dressing after 10 weeks of planting			
(41) Use N fertilizers as third top dressing after 14 weeks of planting			
(42) Applying fertilizers in furrows and covered			
(43) Spread fertilizers on soil surface			
(44) applying equally on plot			
(45) Zinc			
(46) Boron			

Source: Survey data (2011)

While the scores of the survey farmers on knowledge about intercropping with legumes lay 1 to 5 in total scores of 6, the scores about crop rotation with legumes lay 1 to 2 in total scores of 2. The respondents got 1 to 4 scores on knowledge about mulching with cane stubble/leaf trash and 1 to 4 scores on knowledge about (improved) fallowing. Most of sugarcane farmers in the study area were familiar to chemical and organic fertilizers and they got 5 to 9 in total scores.

The cane farmers with low knowledge level about ISNM obtained 20 to 23 in total scores while those with medium knowledge level received between 24 and 31 total scores. The scores of farmers with high knowledge level varied between 32 and 37.

4.5 Factors determining farmers' knowledge about ISNM

This section shows the results concerning factors that determine the farmers' knowledge about ISNM in the study area.

4.5.1 Descriptive statistics of Independent variables

The descriptive statistics such as mean and standard deviation, minimum and maximum values of each independent variable included in the model are shown in Table 4.8.

Table 4.8 Independent variables of surveyed sugarcane households used in regression analysis (N=120)

Variable	Minimum	Maximum	Mean	Std. Deviation
AGE	24	65	45.88	9.468
GENDER	0	1	0.92	0.264
EDUCATION	1	4	1.99	0.845
EXPERIENCE	1	5	2.48	1.195
LOCATION	0	2	1.00	0.820
EXTENSION	0	5	3.39	1.095
DEMOPART	0	3	2.02	1.115
MEMBER	0	1	0.77	0.419

Where,

AGE = Age in years of head of household (continuous variable)

GENDER = Gender of the household head (Dummy: 1=male, 0=female)

EDUCATION = Education level of head of farm household

EDU1= Primary level

EDU2 = Secondary level

EDU3= High school level

EDU4 = Higher education level

EXPERIENCE = Years of sugarcane experience (continuous variable)

LOCATION= Location of sugarcane farmers

LO1= Nyaung Pan Thar

LO2= Vaw De Gone

LO3= Thet Yaung Pyan

EXTENSION= Extension contact in time per season (continuous variable)

DEMOPART = Participation in field demonstrations in time per season (continuous variable)

MEMBER = Membership of farmer organization (1=yes, 0 =no)

4.5.2 Testing OLS regression assumptions

The basic assumptions of OLS regression model were operated as follows:

(a) Normal distribution

The normal distributions are the most commonly observed probability and very important statistical distributions. They are symmetric and have bell-shaped density curves with a single peak (Figure 4.8). By using histogram, the normal distribution was tested for the normality assumption. The variables which confirm in this condition were included in the multiple regression analysis.

(b) Multicollinearity

Multicollinearity is another problem observed among livelihood resource variables considered. Multicollinearity can have significant impact on the quality and stability of the fitted regression model. Partial correlation coefficient is a measure of the linear association between two independent variables.

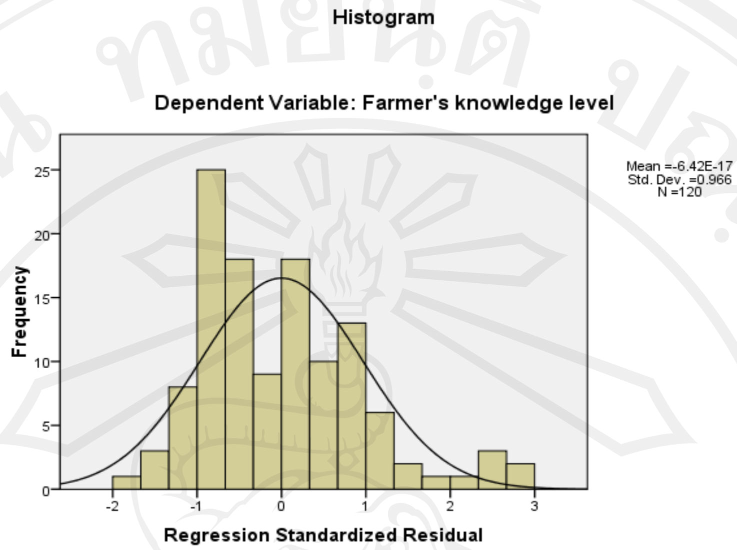


Figure 4.8 Normal distribution of regression standardized residual

Multicollinearity was diagnosed by studying at the part and partial correlation and collinearity statistics. Table 4.9 shows the correlation coefficients between each pair of independent variables. All of them were below the muticollinearity criteria of 0.8 (80%). Therefore, it was concluded that there was no collinearity among selected independent variables.

(c) Heteroscedasticity

Heteroscedasticity is common in cross- sectional data and concerns increasing of error terms as the value of dependent variable (farmers' knowledge) increases. Heteroscedasticity was examined by plotting regression standard predicted value in X axis against regression standard residual in Y axis (Figure 4.9). As a collection of random variables did not stand horizontally, it was concluded that the data was not heteroscedastic. Therefore, it could assumed that there was a strong relationship between dependent variable and selected independent variables and modeling errors were correlated and normally distributed and that their variances varied with the effects being modeled.

Table 4.9 Coefficients of correlations among independent variables

Variable	**V1**	**V2**	**V3**	**V4**	**V5**	**V6**	**V7**	**V8**
V1	1.00							
V2	-0.27	1.00						
V3	-0.42	0.22	1.00					
V4	-0.34	0.14	0.35	1.00				
V5	-0.03	0.15	-0.01	0.09	1.00			
V6	-0.39	0.39	0.42	0.42	0.10	1.00		
V7	-0.35	0.26	0.40	0.43	0.14	0.56	1.00	
V8	-0.26	0.23	0.37	0.22	0.20	0.41	0.30	1.00

Note: V1 = Age of household head, V2 = Gender of household head,
V3 = Education level of household head, V4 = Experience in cane cultivation,
V5 = Location of cane farmers, V6 = Extension contact,
V7 = Participation in field demonstrations, V8 = Membership of farmer organization,

(d) Autocorrelation

Autocorrelation is usually associated with time series data but it can also occur in cross-sectional data. The Durbin-Watson Test is a statistic that indicates the likelihood that the error values for the regression analysis. It is the most common test for detecting autocorrelation. The Durbin-Watson value is 1.874 and closer to 2, it is concluded there is no autocorrelation.

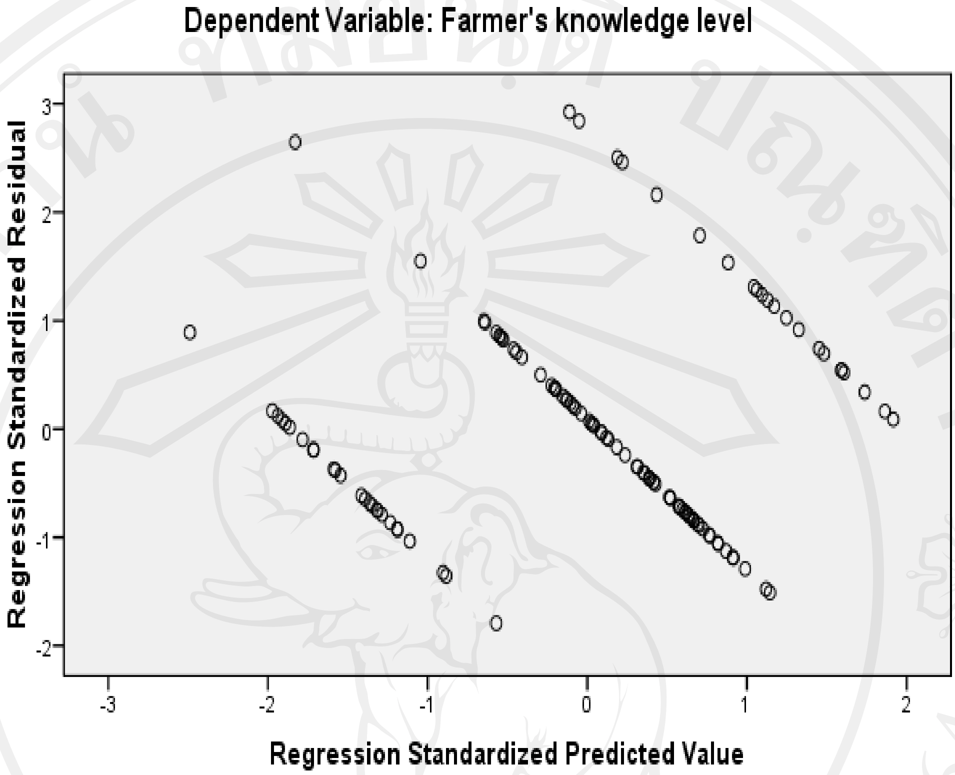


Figure 4.9 Scatter plot showing random array dispersion of dots

4.5.3 Results of multiple regression model

The test of multiple regression model was significant at 1% significant level with adjusted R-square of 0.65 (Table 4.10). The following variables are significant in explaining the dependent variable (farmers' knowledge about ISNM).

Table 4.10 Parameter Estimates of multiple regression (N=120)

Independent variable	**Coefficient**	**Standard error**	**t-ratio**	**P-value**
Constant	-0.243	0.306	-0.792	0.430
AGE	-0.009	0.004	-2.130	0.035**
GENDER	0.260	0.144	1.812	0.073
EDUCATION	0.124	0.050	2.510	0.014**
EXPERIENCE	0.118	0.034	3.533	0.001***
LOCATION	-0.011	0.043	-0.254	0.800
EXTENSION	0.113	0.043	2.626	0.010**
DEMOPART	0.115	0.039	2.931	0.004***
MEMBER	0.304	0.094	3.228	0.002***

Correlation is significant at 1% (***), 5% (**) and 10% (*) level

Ordinary least squares regression Weighting variable = none

Observations =120, Residuals: Sum of squares= 15.46526414,

R-squared = 0.676910, Adjusted R-squared =0.65362,

Model test: F [8, 111] = 29.07, Prob value =0.00000

Diagnostic: Log-L = -47.3389, Restricted (b=0) Log-L = -115.1283

Log Amemiya Pr Crt. = -1.899, Akaike Info. Crt. = 0.939

Durbin-Watson Statistic = 1.87416, Rho =0.06292

The negative and significant signs of age of farm household head indicated that when other variables were constant, one unit increase in age caused 0.01 unit decrease in level of farmers' knowledge about ISNM at 5% level. This means that as the age of farmers increased, access to ISNM information and knowledge decreased and vice-versa. A recent study showed that cocoa farmers' knowledge scores of integrated crop and pest management was negatively influenced by the farmer's age in Ashanti Region, Ghana (Soniia *et al.*, 2011).

The positive and significant signs of household head education indicated while other variables were constant, one level increase in household head education caused 0.12 unit increase in level of farmers' knowledge about ISNM at 5% level. Therefore, it was apparent that farmers' education level favored acquisition of knowledge and widened the knowledge horizon by getting exposed to extension officers and contacting other information sources and this finding was consistent with (Maraddi *et al.*, 2007; Adeola 2010).

The positive and significant signs of experience of household head in cane cultivation indicated that while keeping other variables constant, one unit increase in experience of household head caused 0.12 unit increases in level of farmers' knowledge about ISNM at 1% level. Maraddi *et al.* (2007) found that farming experience of sugarcane respondents exhibited positive and significant relationship with the knowledge of selected sustainable cultivation practices.

Extension contact to sugarcane farmers was positive and significantly contributed to farmers' knowledge about ISNM at 5%. It indicated that one time increase in extension contact caused 0.043unit increase in level of farmers' knowledge level about ISNM keeping with other variables constant at 5% level. This finding of the study was in agreement with the results of (Umar *et al.*, 2009).

The coefficient of farmer's participation in field demonstrations had positive sign and significant correlation and it indicated that one time increase in farmer's participation in field demonstration caused 0.12 unit increase in level of farmers' knowledge about ISNM at 1% level while keeping other variables constant. Godtland *et al.* (2004) approved that farmer who participate in the program have significantly more knowledge about IPM practices than those in the non-participant comparison group in potato production in the Peruvian Andes.

The coefficient of membership of farmers' organization had positive sign and significant correlation and it indicated that one time increase in membership of farmers' organization caused 0.30 unit increase in level of farmers' knowledge about ISNM at 1% level while keeping other variables constant. Increased social participation was important to improve farmers' knowledge on proper use of pesticides and its effect on their health and environment (Nagenthirarajah *et al.*, 2008).

4.5.4 Ordered probit regression analysis

The model correctly predicted 76.5% of the observation outcomes; the accuracy level was comparable across the three farmer knowledge levels. The model was able to distinguish among low, medium and high knowledge levels of sugarcane farmers. There were more actual famers with low knowledge level than predicted, 26 and 24, respectively. Similarly, there were more actual famers with medium knowledge level than predicted, 67 and 72, respectively and these were more actual famers with high knowledge level than predicted, 15 and 22, respectively.

Table 4.11 Cross tabulation of predictions of ordered probit model (N=120)

Knowledge level	**Predicted Outcome**			**Actual Outcome**
	Low	**Medium**	**High**	
Low	24	2	0	26
Medium	2	67	3	72
High	0	7	15	22
Percent (Actual over Predicted)	92.3	93.1	68.2	76.5

According to Table 4.11, the model showed reasonably high goodness of fit and significant at 1% level, which suggests that 76.5% of the variability in knowledge can be explained by the eight selected socio economic independent variables in the ordered probit regression model.

The result of the ordered probit analysis of the 120 observations is presented in Table 4.12. The ordered probit model focused on the factors that influence the farmers' knowledge about ISNM. Six out of the eight explanatory variables were found to be statistically significant at the 1% and 5% levels. Only gender and location were insignificant. The ordered probit model results indicated that farmers' experience in sugarcane cultivation, farmers' participation in field demonstration, farmers' age, education level, extension contact and membership of farmers' organization were significantly contributed to farmers' knowledge levels of ISNM.

Table 4.12 Parameter estimates of ordered probit model (N=120)

Variable	**Coefficient**	**Standard Error**	**T ratio**	**P-value**
Constant	-2.527	1.246	-2.03	0.043**
Age	-0.042	0.018	-2.33	0.023**
Gender	1.056	0.649	1.63	0.104
Education	0.508	0.204	2.49	0.013**
Experience	0.400	0.146	2.74	0.006***
Location	-0.062	0.182	-0.34	0.733
Extension	0.384	0.177	2.17	0.030**
Demopart	0.519	0.181	2.87	0.004***
Member	1.467	0.486	3.02	0.003***

Correlation is significant at 1% (***), 5% (**) and 10% (*) level

Log likelihood function -48.69463

Restricted log likelihood -113.8656

Chi squared 130.3419

Degrees of freedom 8

According to their respective t-statistic values, membership of farmers' organization, farmer's participation in field demonstration of ISNM and experience of household head in sugarcane cultivation than education level of household head had the largest effect, extension contact to farmers and age of household head on farmer knowledge levels.

Membership of farmers' organization was exhibited positive and significantly related with farmers' knowledge level about ISNM at 1% level. Group membership of respondents was thus expected improve farmers' knowledge level. Farmer's membership to groups enabled farmers learn about a technology via other farmers and obtain information from other development agencies (Nkamleu, 2007).

The coefficient of farmer's participation in field demonstration of ISNM was positive and significantly contributed to farmers' knowledge level about ISNM at 1% level. Thus, famer's participation in field days was important tools for disseminating agricultural technologies to diversified farming communities and improved knowledge and skills of participated farmers. This finding of the study was in agreement with the results of (Amudavi *et al.*, 2009).

The coefficient of experience of household head in sugarcane cultivation was positive and significantly contributed to farmers' knowledge about ISNM at 1% level. This result suggests as farmer's farming experience increased so did farmer access to information and increased knowledge level and that household heads with high relative farming experience took shorter time to assess potential of the information and skills based on past experiences with new practices. Farming experience and social participation were significantly related to farmer knowledge level about pest management practices in Pambaimadu, Vavuniya District, Sri Lanka (Nagenthirarajah *et al.*, 2008).

Education level of household head was positive and significantly contributed to farmers' knowledge about ISNM at 5% level. It may be concluded that farmer's education enhanced famer knowledge level because better-educated farmers were able to understand the benefits of ISNM and accepted them faster. Our result agreed with the result of (Farouque *et al.*, 2007; George *et al.*, 2007). Farmers' total knowledge, entomological knowledge and insecticide knowledge were found to be positively and significantly affected by farmers' education in rice production in Vietnam (Chi *et al.*, 1999).

Extension contact to the sugarcane farmers was positive and significantly contributed to farmers' knowledge about ISNM at 5% level. Farmers' contacts with extension service made them ensure that information regarding the effects of ISNM practices and improved knowledge levels of ISNM. Our result was in conformity with the finding of (Maraddi *et al.*, 2007).

Age of household head was negative and significantly associated to farmers' knowledge about ISNM at 5% level. This implies that older household heads were more conservative, risked averse and did not easily interest new technology and information (Odendo *et al.*, 2009). This finding was consistent with (Khanna, 2001) who found the older farmers may not want to jeopardize themselves by trying out a completely new methods and knowledge.

The gender of cane farmers had showed no relationship with knowledge level of ISNM. This result agreed with the result of (Brito *et al.*, 2007) who found it did not appear that gender heavily affected these particular adoption patterns and gender alone had minimal independent effects on ISNM practices.

4.5.5 Summary of factors influencing on different knowledge levels of sugarcane farmers about ISNM

The above section identifies the factors influencing on different knowledge levels of sugarcane farmers about ISNM. In the multiple regression model, farmers' experience in cane cultivation, and farmers' participation in field demonstration and membership of farmers' organization influenced at 1% significant level and farmers' age, education, extension contact and farmers' participation in local organization influenced at 5% significant level on farmers' knowledge about ISNM.

The ordered probit model results indicate that farmers' experience in cane cultivation and farmers' participation in field demonstration influenced at 1% significant level and farmers' age, education level, extension contact and membership of farmers' organization influenced at 5% significant level on farmers' knowledge of ISNM. The gender of farm household head does not influence on farmers' knowledge of ISNM in both multiple regression and the ordered probit models.

4.6 Gross Margin Analysis

In order to access the yield and profitability of different soil nutrient management practices in sugarcane production in Paukkaung township, gross margin analysis of 120 sampled cane farmers was operated with a point of view of farmers' location, different use categories of fertilizers and different knowledge levels on ISNM.

4.6.1 Cost of sugarcane production

Using the data of field survey, cost of sugarcane production was computed under the components of sugarcane production such as cost of land preparation, cost of sowing, cost of inputs (seed, fertilizers and FYM), cost of earthing up, cost of hired and family labors, cost of harvesting and transportation.

The main inputs used in sugarcane production are cane setts (seeds), chemical fertilizers, biocomposer and FYM. Operating costs included land preparation, sowing, earthing up and transportation and labor costs consist of sowing, fertilizer application, harvesting and transporting.

Figure 4.10 shows that 29% of total variable cost in sugarcane production was cost of cane setts (seeds). The interviewed sugarcane farmers in the study area normally used 9 to 11 tons cane setts per ha. Therefore, the small economic scaled farmers were difficult to start growing sugarcane. About 18% were costs of land preparation (family labor) and harvesting (hired labor). Cost of chemical fertilizers, cost of earthing up and cost of transportation constituted by 13%, 8% and 4% respectively.

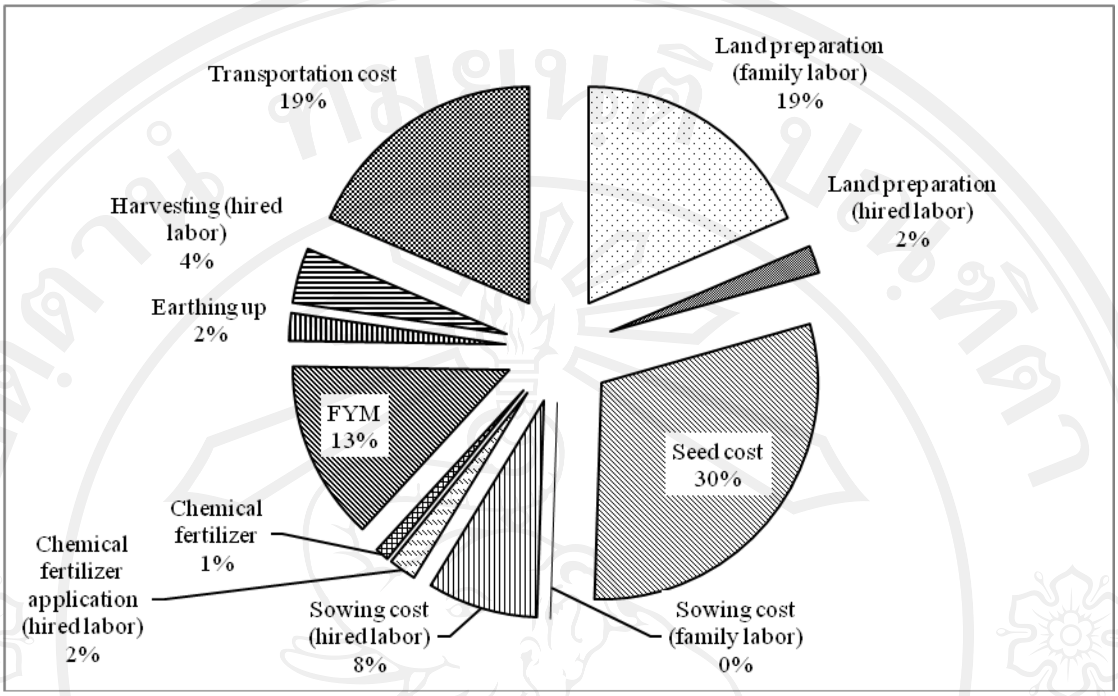


Figure 4.10 Constitution of main cost components of sugarcane production

4.6.2 Cost of sugarcane production in three village areas

In order to get an idea of the production cost, that sugarcane farmers have to bear to produce one ha of sugarcane in different three village areas, computation of average cost of sugarcane production was conducted.

Table 4.13 compares production in cost Nyaung Pan Thar village, Vow De Gone and That Young Pan villages. The average total variable cost of sugarcane farmers in Nyaung Pan village area was 587,197 kyats per ha, of those in Vow De Gone was 532,666 kyats per ha while of those in That Young Pan was 569,419 kyats per ha.

Table 4.13 Average cost of sugarcane production (kyat/ha) in three village areas

Production cost (kyat/ha)	**Nyaung Pan Thar**	**Vow De Gone**	**That Young Pan**
TVC	587,197	532,666	569,419
land preparation (family labor)	99,170	119,566	121,497
Land preparation (hired labor)	22,560	7,495	1,335
seed cost	172,233	177,840	175,917
Sowing cost (family labor)	2,096	1,942	144
Sowing cost (hired labor)	47,304	47,458	48,722
Biocomposer	0	24,956	22,110
Fertilizer application	7,419	4,565	3,007
Chemical fertilizers	117,994	39,988	43,258
FYM	13,750	5,664	6,369
Earthing up	27,339	18,525	27,337
Harvesting	116,043	103,825	104,349
Transportation	19,837	9,955	15,374

Source: Survey data (2011)

Note: 1 US$ = 813 kyats (May, 2011)

4.6.3 Profitability of sugarcane production

Gross margin was used to compare profitability of sugarcane production on different soil nutrient managements in the study area.

The price of sugarcane was fixed price for the whole growing season of 2010. This was determined by sugar mills and thus price was not fluctuated by the other factors. Interviewed sugarcane farmers replied that they wanted to discuss the administrative heads of sugar mills to increase sugarcane price. But, the sugarcane farmers were supplied inputs such as chemicals fertilizers, biocomposer and loans for cane setts (seeds), land preparation, earthing up, harvesting and transportation according to their cane plantation area and expected sugarcane yield.

Inngagwa sugar mill supplied the sugarcane farmers 177,840 kyats per ha for sugarcane setts (seeds), 83,980 kyats per ha for chemical fertilizer, 74,100 kyats per ha for biocompser and 3,000 kyats per cane ton for harvesting and transportation. Nawaday sugar mill supported those 222,300 kyats per ha for cane setts (seeds), 86,450 kyats per hectare for chemical fertilizers and 3,000 kyats per sugarcane ton for harvesting and transportation.

Average sugarcane yield with relevant to different soil nutrient management practices was computed to find out the impact of different soil fertility and nutrient management practices on the sugarcane yield and profitability.

Table 4.14 shows the average sugarcane yield of different soil nutrient management practices in the study area. The average sugarcane yield received compound fertilizer and FYM was 58 ton per ha which is higher than the average sugarcane of other soil nutrient management practices.

Table 4.14 Sugarcane yield of different soil nutrient management practices

Average yield (t/ha)	**No use**	**Urea**	**ISNM practices**		
			Urea + Biocomposer	Urea + Biocomposer + FYM	Compound + FYM
No of farmers	9	15	14	44	38
Percent of farmers	7.50	12.50	11.67	36.67	31.66
Maximum yield (t/ha)	44.46	49.40	56.81	61.75	66.69
Minimum yield (t/ha)	41.99	41.99	41.99	44.46	44.46
Average yield (t/ha)	43.09	44.79	48.34	54.90	58.01

Source: Survey data (2011)

It was observed that the sugarcane farmers who used compound fertilizers and FYM earned 1,044,225 kyats per ha. Those who used urea, biocomposer and FYM earned 988,225 kyats per ha while those who applied urea and biocomposer obtained 870,146 kyats per ha. Farmers who used only urea received 800,280 kyats per ha and those who used neither chemical nor organic earned 775,580 kyats per ha. Therefore, it was concluded that sugarcane farmers were able to obtain the highest total revenue by using compound fertilizer and FYM.

Table 4.15 shows the average sugarcane yield, total variable costs total revenue and gross margin of farmers with different soil nutrient management practices. The gross margin was varying with their different soil nutrient management practices. So, it was concluded that the sugarcane farmer will be able to gain the high yield and reasonable profitability in sugarcane production by carrying out an adequate balanced supply of nutrients and other soil nutrient managements. If the farmers do not practice any integrated soil nutrient management for a long time, this will have negative effects on soil fertility of sugarcane plots, sugarcane yield and finally on their environment condition and economic status. Therefore, ISNM technology is feasible and profitable for sugarcane farmers and is a strategy for higher sugarcane productivity, prevents soil degradation, and thereby helps meet future food supply needs and economic status level.

Table 4.15 Comparison of yield, TVC, total revenue and gross margin of different soil nutrient management practices

Fertilizer use	**No use**	**Urea**	**ISNM practices**		
			Urea + Biocomposer	Urea + Biocomposer + FYM	Compound + FYM
Average yield (t/ha)	43.09	44.79	48.34	54.90	58.01
TVC (kyats/ha)	421,560	504,428	506,801	561,064	549,478
Total revenue (kyats/ha)	775,580	800,280	870,146	988,225	1044,225
Gross margin (kyats/ha)	354,020	328,694	399,945	440,221	508,348

Source: Survey data (2011)

Note: 1 US$ = 813 kyats (May, 2011)

Sugarcane farmers must manage nutrients and soil fertility in an integrated way. In many sugarcane growing areas, the productivity of the soils has declined due to intensive cropping and lack of proper soil fertility management practices and thus the soil productivity can be restored through ISNM. In order to success ISNM will rely on the participation efforts of sugarcane farmers, researchers, extension agents, local governments and policy makers and non-government organizations.

4.6.4 Does Farmers' knowledge have effects on cane yield and profitability?

The different ISNM practices of sugarcane farmers in my study area were compared to show the different management practices of them in Table 4.16.

Table 4.16 Different farmers' knowledge levels and different ISNM practices

ISNM practices	Different knowledge levels					
	Low		Medium		High	
	Frequency	%	Frequency	%	Frequency	%
No use	9	7.5				
Urea	6	5.0	7	5.8		
Urea+Biocomposer	3	2.5	11	9.2	2	1.7
Urea+ Biocomposer + FYM	3	2.5	33	27.5	8	6.7
Compound+FYM	5	4.2	21	17.5	12	10.0
Total	26	21.7	72	60.0	22	18.3

Source: Survey data (2011)

According to Table 4.16, about 7% of sugarcane farmers with low knowledge level on ISNM did not use any fertilizer. About 5% of sugarcane farmers with low knowledge level on ISNM used only urea. More than 2% of those with low knowledge level on ISNM applied urea and biocomposer or urea, biocomposer and FYM. About 4% of farmers with low knowledge level applied compound and FYM.

About 5% of sugarcane farmers with medium knowledge level on ISNM used urea. More than 9% of those with medium knowledge level on ISNM applied urea and biocomposer. More than 27% of farmers with medium knowledge level applied urea, biocomposer and FYM. About 17% of farmers with medium knowledge level applied compound and FYM.

Near to 2% of those with high knowledge level on ISNM applied urea and biocomposer. More than 6% of farmers with high knowledge level applied urea, biocomposer and FYM. About 10% of farmers with high knowledge level applied compound and FYM.

The sugarcane yield with relevant to farmer knowledge level was computed to find out the effect of farmer knowledge on their profitability. Table 4.17 showed the maximum, minimum and average yield among sugarcane farmers with three knowledge levels. The average sugarcane yield of farmers with high knowledge level (57.14 t/ha) was higher than those with other knowledge levels.

Table 4.17 Sugarcane yield and different farmer knowledge levels

Fresh sugarcane yield categories	**Knowledge level**		
	Low	**Medium**	**High**
	------------------------------------t/ha------------------------------------		
Maximum	59.28	66.69	61.75
Minimum	41.99	41.99	44.46
Average	47.50	53.81	57.14
Standard deviation	12.23	17.47	12.23

Source: Survey data (2011)

Table 4.18 shows that sugarcane farmers with high knowledge level were able to gain average margin (494,380 kyats/ha) compared to farmers with medium knowledge level (431,015 kyats/ha) and farmers with low knowledge level (410,901 kyats/ha).

Table 4.18 Gross margin and different farmer knowledge levels

Gross margin level	Knowledge level		
	Low	Medium	High
	------------------------------------Kyat/ha----------------------------		
Maximum	800,280	1,111,500	744,847
Minimum	268,119	82,251	322,459
Average	410,901	431,015	494,380

Source: Survey data (2011)

Note: 1 US$ = 813 kyats (May, 2011)

4.6.5 Summary of gross margin analysis

This section identifies the average cost of sugarcane production per hectare of new plantation in the study area and different village areas, the average sugarcane yield, total variable cost, gross margin of different soil nutrient management practices. It compared the different yield and gross margin of sugarcane farmers according to their different knowledge levels on ISNM. Though the average total variable cost of urea, biocomposer and FYM use was higher than of compound and FYM use, the profitability of compound and FYM was higher than of urea, biocomposer and FYM.

In conclusion, the sugarcane farmers obtained the highest yield and profitability per hectare from new plantation by using compound fertilizers and FYM and farmers' knowledge affects the yield and profitability in the sugarcane production.