JARQ 41 (4), 325 – 332 (2007) http://www.jircas.affrc.go.jp

Characteristics of Precipitation in Nong Saeng Village, Khon Kaen Province, Northeast Thailand

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Abstract

From the results of observations in Nong Saeng Village, Khon Kaen Province, Northeast Thailand from May 2002 to February 2005, precipitation was concentrated from evening to early morning in the middle of the rainy season. However, at the end of the rainy season, the concentration of precipitation during these hours decreased and the precipitation ratio in the morning increased. Extraordinary precipitation in the dry season had the same tendency as at the end of the rainy season. The frequency of gusty rain against all rain was lower than the frequency of the previous and following month during the middle of the rainy season. These results are a reference for development of water control systems and erosion control with cropping systems that are adjusted for precipitation patterns.

Discipline: Watershed and regional resources management
Additional key words: farmland conservation, water resource, watershed

Introduction

The characteristics of precipitation in Northeast Thailand are a fluctuating distribution pattern and fluctuating amounts of precipitation.

The precipitation is concentrated mainly in the rainy season from mid May to early October and the rest of the year has very little rainfall. Floods and droughts frequently occur as a result of erratic rainfall[1]. Monthly rainfall fluctuates greatly from year to year[4].

These phenomena are affecting farmland and water resources usage. For example the date of transplanting in rainfed paddy fields is dependent on the precipitation pattern. The areas of planting are also affected by precipitation because transplanting is impossible without enough water for puddling. It is difficult to estimate the amount of water available for irrigation in the rainy and dry season and to draw up plans for cropping.

We observed precipitation to clarify the relation of precipitation, water usage and land resources in small watersheds in a rainfed area of Northeast Thailand. The observations were conducted under the JIRCAS research project "Increasing Economic Options in Rainfed Agriculture in Indochina through Efficient Use of Water Resources". The observations were conducted in the central part of Northeast Thailand from May 2002 to February 2005. So we intended to show time variation of precipitation in a relatively short time using these observation data. This report showed the characteristics of precipitation under stated conditions from the results of these observations.

Observation method

1. Location

The observation point was located in Nong Saeng Village, Khon Kaen Province, Northeast Thailand. This village is located about 400 km northeast of Bangkok and 30 km south of Khon Kaen City. Fig. 1 shows the location

This paper reports the results obtained by the JIRCAS research project "Increasing Economic Options in Rainfed Agriculture in Indochina through Efficient Use of Water Resources" Land Development Department, Ministry of Agriculture and Cooperation, Thailand, 2001–.

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Received 2 October 2006; accepted 1 March 2007.

of the observation point. The altitude is about 200 m above sea level and topographical features are a mixture of plateau and shallow valley. On the plateau, most of the area is used for upland fields where cassava, sugarcane and upland rice are planted. In the valley, land is used for paddy fields. Paddy fields stretch along the valley to halfway up the valley side.

The 30-year (1971–2000) average meteorological elements at Khon Kaen are as follows[2]. Average annual temperature is 26.8ºC, average maximum temperature is 36.4ºC in April and minimum is 16.7ºC in December. The annual precipitation is 1,209.3 mm and average number of rainy days is 106.7. The mean monthly precipitation is over 100 mm from May to October and the mean maximum monthly precipitation is 236.1 mm in September. On the other hand the mean number of rainy days is as few as 1 day in December and January.

2. Method

Precipitation was measured with a tipping-bucket rain gauge. The buckets were tipped by every 0.2 mm of precipitation. The tipping time was automatically recorded by a data logger. Data were transferred from the data logger to a computer and the behavior of the rain gauge was checked on a monthly basis. Original data were processed in 10-min intervals. The hourly and daily precipitation data were based on the 10-min data. Hourly precipitation indicates the amount of precipitation during each hour of the day. Daily precipitation is defined by the total precipitation from 00LT (Thailand local time) to 24LT. We discussed the following points with the obtained data.

1) Distribution pattern of 10-min and hourly precipitation in a day.
2) Distribution pattern of precipitation in each continuous rain.
3) Occurrences of gusty rain.

Fig. 1. Location of the observation point

Results and discussion

1. General condition of precipitation during observation term

Monthly precipitation throughout the observation term is shown in Table 1 with the existing 11-y average precipitation data (1991–2001) observed in Ban Haet. The distance between Ban Haet and the observation point in Nong Saeng is about 8 km. A precipitation event did not occur in January and February 2005.

The major part of Northeast Thailand is located in the climatic zone of 1,200–1,400 mm in annual precipitation. Comparing monthly precipitation of the observation point and the 11-y average precipitation at Ban Haet, characteristics of the precipitation during the observation period are as follows.

- Little precipitation occurred early in the rainy season (precipitation lower than the average precipitation in Ban Haet in June and July) in 2002 and 2003.
- Precipitation in September 2002 was the highest of September's precipitation records collected at Ban Heat.
- The rainy season ended early (no precipitation after 21 September) in 2004.
- The rainy season ended late (rainfall in November and December) in 2002.
- Abnormal precipitation (rainfall in January and February) occurred during the usual dry season.

Table 1. Monthly precipitation (mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Amount
2002					156*	89	64	222	411	178	13	29	1,162
2003	0	72	125	11	74	80	101	157	361	17	0	0	998
2004	23	67	2	129	91	165	167	186	122	0	0	0	951
BAN HAET**	0	9	30	68	133	157	126	165	244	76	15	2	1,025

*: Observations started on 2nd of May.
**: 8 km from observation point. Average of 11 years (1991–2001).

2. Distribution pattern of precipitation in a day

Fig. 2 shows the total hourly precipitation in all observation terms. The hourly precipitation increased from 15LT. Maximum precipitation was recorded at 00–01LT and minimum precipitation was recorded at 09–10LT. Seventy-two percent of total precipitation was recorded in twelve hours from 15LT to 03LT. In addition, the other lower peak of hourly precipitation appeared from 05LT to 08LT.

To clear up the monthly distribution pattern of precipitation in a day, the monthly precipitation ratio from 15LT to 03LT and from 06LT to 09LT is shown in Fig. 3. This figure shows a tendency of a high concentration of precipitation from 15LT to 03LT from May to August. The concentration of precipitation decreased in September and extraordinary precipitation in the dry season did not concentrate from 15LT to 03LT.

This figure also shows a tendency of little precipitation from 06LT to 09LT from June to August. However precipitation during these hours increased in September every year.

Fig. 4 shows the relation between monthly precipitation and concentration of precipitation between 15LT and 03LT and between 06LT and 09LT. The months whose precipitation ratios were less than 50% between 15LT and 03LT were confirmed as the months with monthly precipitation of less than 100 mm. On the other hand, the months whose precipitation ratios were more than 20% between 06LT and 09LT were limited to months whose precipitation was less than 200 mm. These months were limited to the usual dry seasons.

These tendencies suggested that precipitation was concentrated from evening to early morning in the middle rainy season. However, at the end of the rainy season, the concentration of precipitation during these hours decreased and the precipitation ratio in the morning increased. Furthermore, extraordinary precipitation in the dry season had the same tendency as the end of the rainy season.

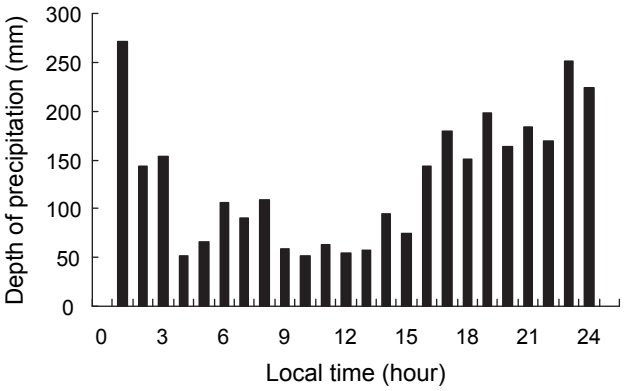

Fig. 2. Total hourly precipitation in all observation terms

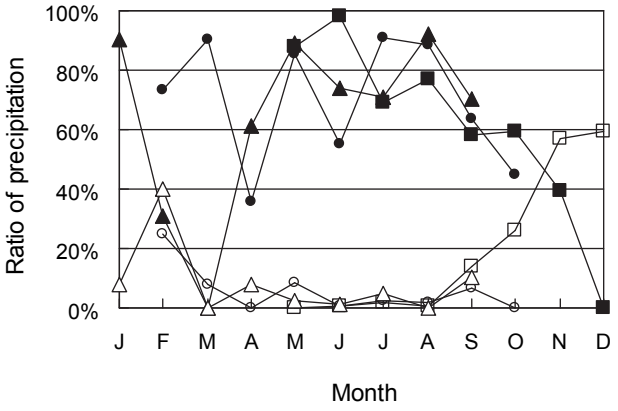

Fig. 3. Concentration of precipitation at 15–03LT and 06–09LT in each month

—■—: 2002 15–03, —●—: 2003 15–03, —▲—: 2004 15–03,
—□—: 2002 06–09, —○—: 2003 06–09, —△—: 2004 06–09.

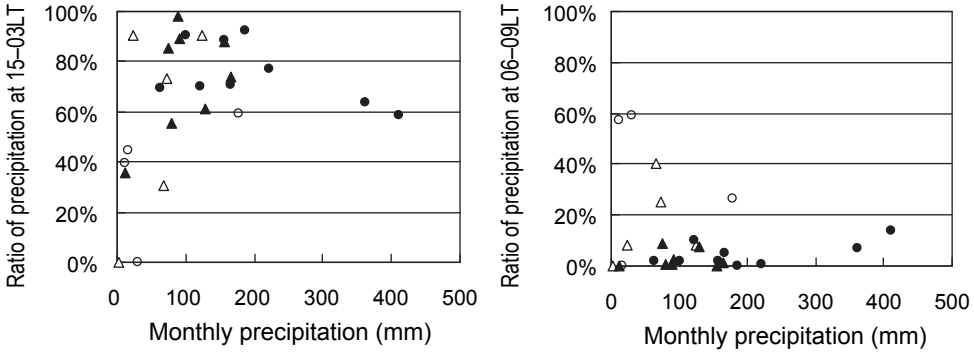

Fig. 4. Relation between monthly precipitation and precipitation concentration at 15–03LT and 06–09LT

△: Jan., Feb., Mar.; ▲: Apr., May, Jun.; ●: Jul., Aug., Sep.; ○: Oct., Nov., Dec.

3. Maximum precipitation appearance time

Fig. 5 shows the relation of appearance time of maximum hourly precipitation to daily precipitation. This graph shows the case of the precipitation over 10 mm per day and 1 mm per h.

Fifty percent of the maximum hourly precipitation in a day appeared from 18LT to 01LT. Especially, the occurrence of maximum hourly precipitation was concentrated at 00–01LT. When daily precipitation was lower than 20 mm, the ratio of maximum hourly precipitation from 18LT to 01LT was 39%. However, when daily precipitation was more than 20 mm, the ratio of maximum hourly precipitation in the same hours was 59%. When daily precipitation was 30 mm and 50 mm and above, the ratio of concentration was 57% and resulted in the almost same ratio in the case of 20 mm and above precipitation. From the rainfall data from 101 stations (in Bangladesh, Thailand, Vietnam,

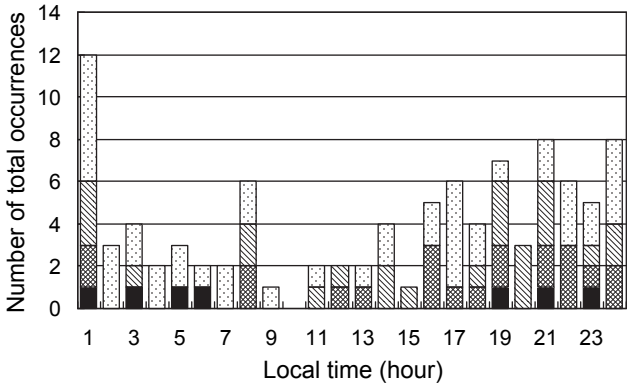

Fig. 5. Frequency of occurrence of maximum hourly precipitation by daily precipitation
Daily precipitation
■ : ≥ 50 mm, ▩ : 50 mm > and ≥ 30 mm,
▧ : 30 mm > and ≥ 20 mm, ⊡ : 20 mm > and ≥ 10 mm.
Daily precipitation shows total precipitation from 00LT to 24LT.

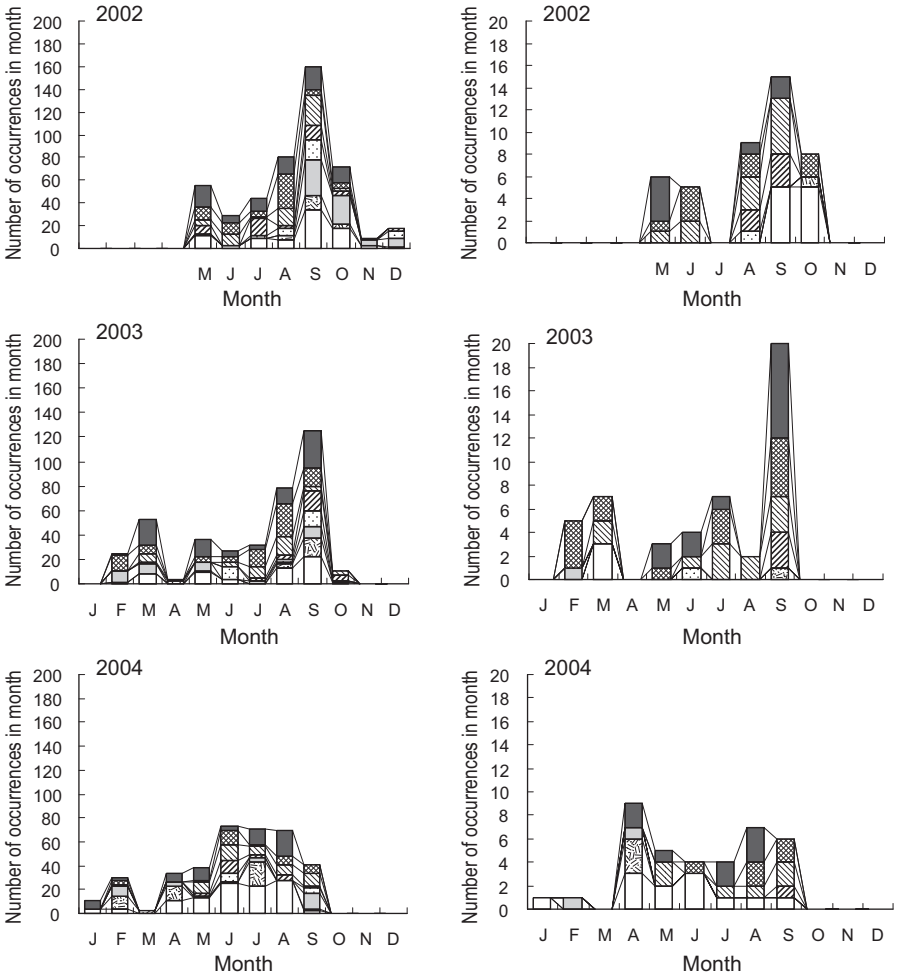

Fig. 6. Relation between 10-min precipitation occurrence and time
The graph on the left shows the case of precipitation with 3 mm/h and above and the graph on the right shows 30 mm/h and above. Y-axis indicates number of each 10-min precipitation interval.
Time of occurrence
□ : 00–03LT, ▨ : 03–06LT, ▩ : 06–09LT, ⊡ : 09–12LT,
▨ : 12–15LT, ▧ : 15–18LT, ▩ : 18–21LT, ■ : 21–24LT.

and Malaysia) from June to August, most of the stations exhibit the maximum rainfall in the afternoon or the early evening[3]. The maximum rainfall on the same basis exhibits the same tendency for all terms. Maximum rainfall in the middle of the rainy season at the observation point occurred later than around the point.

4. Variation in 10 min precipitation in a day

Fig. 6 shows the frequency of monthly 10-min precipitation occurrence shown for each 3-h interval. The graph on the left shows the case of precipitation with 3 mm/h and above and the graph on the right shows 30 mm/h and above.

There were prominent peaks of frequency in September of 2002 and 2003. However a peak did not appear in 2004. These tendencies of frequencies of 10-min precipitation of 3 mm/h and above were similar to the amount of monthly precipitation.

Occurrences of 10-min precipitation of 3 mm/h and above between 06LT and 09LT mostly appeared from the end of the rainy season to the dry season. However, 10-min precipitation of 30 mm/h and above did not occur during the same time. Distributions of the amount of precipitation during the same time and the same season were few as described above. These are summarized as follows.

These tendencies show that at the end of the rainy season, the frequency of low intensity precipitation from 06LT to 09LT increased, however high intensity rainfall occurrence during these hours did not increase at the end of the rainy season.

Fig. 6 shows the frequency of gusty rain (30 mm/h and above) was concentrated from 15LT to 03LT. The total number of 10-min precipitation of 30 mm/h and above was 128. The number of the same rainfall intensity precipitation that occurred between 15LT and 03LT was 109. So, almost all gusty rainfall occurred from evening to midnight.

The number of the same rainfall intensity precipitation that occurred between 12LT and 15LT was 9 and occurred only in August and September.

Fig. 7 shows the relation between continuous precipitation (18 mm/h and above) and start time of each precipitation event. Continuous 18 mm/h and above precipitation of 30 min or longer mainly occurred between 18LT and 03LT. However, continuous precipitation of over 50 min was not concentrated in any specific time period.

Gully erosion occurred in upland fields around the observation point. Broken levees also occurred in the paddy field. Gullies were found not only in fallow land but also in fields planted with cassava and upland rice after gusty rain in a year. Broken levees occurred in the rice planting season during the observation term.

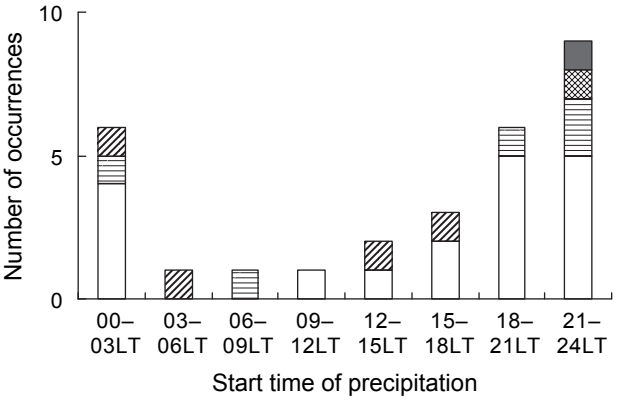

Fig. 7. Relation between occurrences of continuous precipitation (≥ 18 mm/h) and start time of precipitation
Duration of continuous precipitation (min)
□: 30, ▤: 40, ▨: 50, ▩: 60, ■: 70.

Gusty rain is one of the main factors of these disasters. Meanwhile, gusty rain is one of the appropriate opportunities to collect water resources. Many of the small water ponds were constructed in the watershed where the observation point is located. These ponds are supplementarily used for irrigation, livestock and fish cultivation for home consumption as well as other domestic uses. However, except in the ponds located on the bottom of the valley, surface water flowed in only after heavy rain even in the rainy season. Water inlet control systems are not set up in these ponds and the majority of ponds are not connected to any water canals. When pond water is used for irrigation, engine pumps or watering cans are used as needed.

Hereafter it is necessary to develop efficient water management and catchment technologies as well as water pond systems for rainfed areas. However, the results of these observations show that gusty rain occurred from evening to midnight. The majority of villages in Northeast Thailand are formed in agglomerated settlements. Farmers do not stay in farm areas from evening to morning, when gusty rains primarily occur. So, it is difficult for the systems to be operated by farmers. Hence, it is important to consider these points when developing new technologies for water collection and water control systems.

5. Seasonal characteristics of 10-min precipitation

Monthly frequency of occurrence and ratio of depth of gusty rain (5 mm and above/10 min) are shown in Table 2. Table 2 shows that the frequency of gusty rain against all rain (0.5 mm and above/10 min) was lower than the previous and the following month in July 2002, August 2003 and June–July 2004. Especially, gusty rain did not

Table 2. Monthly frequencies of precipitation occurrence and ratio of gusty rain

	2002			2003			2004		
	10 min precipitation frequency		Ratio of precipitation Volume	10 min precipitation frequency		Ratio of precipitation Volume	10 min precipitation frequency		Ratio of precipitation Volume
	≥ 30 mm/h	≥ 3 mm/h	≥ 30 mm/h	≥ 30 mm/h	≥ 3 mm/h	≥ 30 mm/h	≥ 30 mm/h	≥ 3 mm/h	≥ 30 mm/h
Jan.					0		1	11	31%
Feb.				5	24	53%	1	30	8%
Mar.				7	53	39%	0	2	0%
Apr.				0	4	0%	9	34	59%
May	6	55	34%	3	36	35%	5	38	36%
Jun.	5	29	39%	4	27	40%	4	73	20%
Jul.	0	44	0%	7	31	54%	4	71	16%
Aug.	9	80	37%	2	78	12%	7	69	34%
Sep.	15	160	31%	20	125	45%	6	41	42%
Oct.	8	72	32%	0	10	0%		0	
Nov.	0	9			0			0	
Dec.	0	18			0			0	

occur in July 2002. The ratio of precipitation depth by gusty rain was also low in the same months.

These results were obtained through observations conducted for only three years. However, if the phenomenon would be revealed clearly through further longer term observations, it is considered that erosion control can be done by cropping management. Provided that the cropping stage of low vegetation rate can correspond with this term, it will be possible to reduce water erosion in upland areas.

A clear dry spell appeared in the middle of the rainy season in Northeast Thailand. The longest spells of daily precipitation under 1 mm each year were as follows.

2002: From 18 July to 27 July

2003: From 15 July to 25 July

2004: From 17 June to 4 July

The months of infrequent gusty rain occurrence corresponded to these spells in 2002 and 2004. However, it did not correspond to the dry spell in 2003. So it is assumed that spells of infrequent gusty rain did not occur at the same time as dry spells.

6. Characteristics of every precipitation event

Precipitation events occurred 1,074 times during the observation term. Table 3 shows the number of precipitation events classified by rainfall duration and rain total. The maximum precipitation event was 74.0 mm that started at 20:40, 26 May 2002 and continued for 5 h 20 min. The longest precipitation event was 6 h 10 min that started at 9:40, 3 July 2002 and had a depth of 18.8 mm.

Fifty-nine percent of the precipitation events' durations were only 10 min and 68% of precipitation events were less than 1 mm.

Fig. 8 shows the relation between rainfall duration and average rainfall intensity of each event. Fig. 8A shows the month of occurrence and Fig. 8B shows the starting time of each event.

According to the general tendency of precipitation, as rainfall duration was longer, the average rainfall intensity of each event was lower. Most of the precipitation events of average rainfall intensity over 25 mm/h occurred in August and September. Rainfall durations of these events were shorter than 1 h. Start times of these precipitation events were from 12LT to 21LT. So, short duration and high density precipitation events occurred in August and September and started from afternoon to evening. However, precipitation events of long duration (over 4 h) almost all started from around 21LT to 24LT.

Fig. 9 shows the arrival time of maximum rainfall intensity of each precipitation event from the start of rainfall. Sixty-one percent of maximum rainfall intensity appeared within 20 min from the start of rainfall in the case of maximum rainfall of 15 mm/h and above. As maximum precipitation increased, the arrival time occurred later. However, the rainfall intensity data was accumulated every 10 min. When the unit of data accumulation is shortened, it can be estimated that the arrival factor would also be shortened.

Table 3. Number of precipitation events classified by rainfall duration and rain total

Rainfall duration	Rain total of each precipitation event							
h:min	> 0 mm < 1 mm	≥ 1 mm < 3 mm	≥ 3 mm < 5 mm	≥ 5 mm < 10 mm	≥ 10 mm < 20 mm	≥ 20 mm < 30 mm	≥ 30 mm < 40 mm	≥ 40 mm
0:10	620	10	3	0	0	0	0	0
0:20	76	23	7	3	2	0	0	0
0:30	20	24	14	18	1	0	0	0
0:40	9	25	5	5	6	1	0	0
0:50	0	23	5	8	4	3	1	0
1:00		18	3	3	4	1	1	0
1:10		6	2	5	3	3	0	0
1:20		6	5	4	2	2	0	0
1:30		7	3	4	2	1	1	0
1:40		0	1	4	2	1	2	1
1:50		0	1	1	1	1	0	1
2:00		0	3	2	3	2	0	1
2:10		0	1	8	0	1	0	0
2:20		0	0	3	0	1	0	0
2:30		0	1	0	2	0	0	2
2:40			0	2	0	2	0	0
2:50			1	1	0	0	1	2
3:00			0	1	1	0	0	0
>3:00			0	1	3	3	3	5
Total	725	142	55	73	36	22	9	12

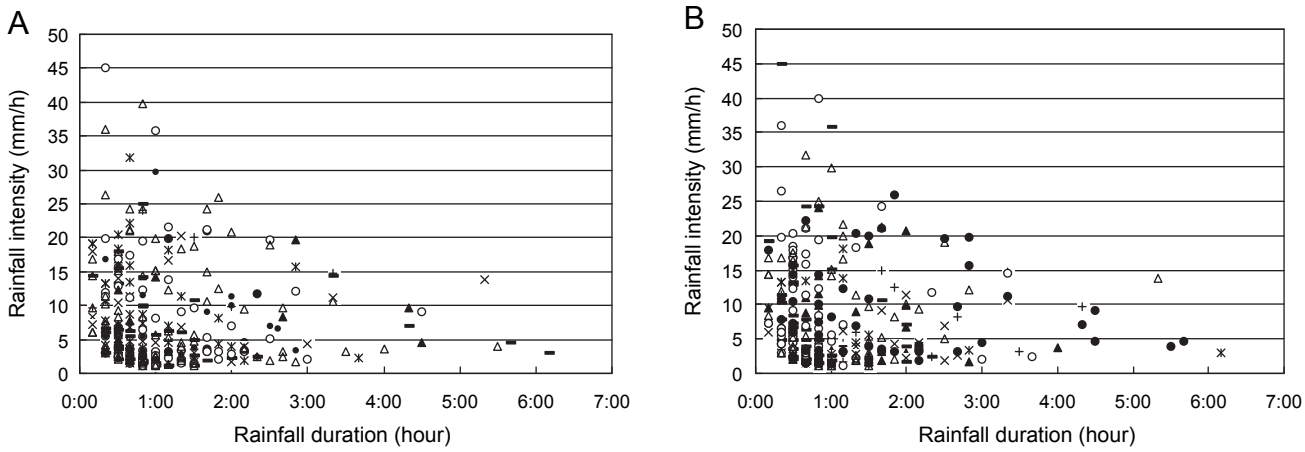

Fig. 8. Relation between rainfall duration and rainfall intensity
A shows the month of occurrence.
●: Mar., +: Apr., ×: May, ✳: Jun., ━: Jul.,
○: Aug., △: Sep., ▲: Oct., •: Other.
B shows the start time of each event.
▲: 00–03LT, +: 03–06LT, ×: 06–09LT,
✳: 09–12LT, −: 12–15LT, ○: 15–18LT,
△: 18–21LT, ●: 21–24LT.

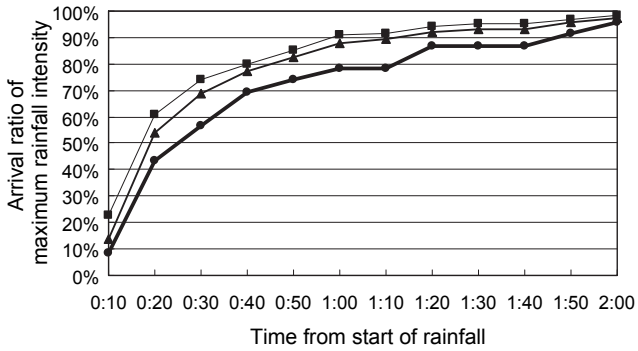

Fig. 9. Arrival time of maximum rainfall intensity of precipitation events from the start of rainfall
Maximum rainfall intensity
—■— : 15 mm/h ≤, —▲— : 30 mm/h ≤, —●— : 60 mm/h ≤.

Conclusions

The analysis of precipitation observations from May 2002 to February 2005 in Nong Saeng Village, Khon Kaen Province, Northeast Thailand showed the following characteristics.

Precipitation was concentrated from evening to early morning in the middle of the rainy season. However, at the end of the rainy season, the concentration of precipitation during these hours decreased and the precipitation ratio in the morning increased. Extraordinary precipitation in the dry season had the same tendency as the end of the rainy season.

Fifty percent of the maximum hourly precipitation in a day appeared from 18LT to 01LT. As daily precipitation was more, the ratio of maximum hourly precipitation at the same time period was high. The frequency of low intensity precipitation from 06LT to 09LT increased at the end of the rainy season.

Almost all the gusty rains occurred from evening to midnight. The frequency of gusty rain against all rain was lower than the frequency of the previous and following month that occurred in the middle of the rainy season.

Fifty-nine percent of the precipitation events' durations were only 10 min and 68% of precipitation events' depths were less than 1 mm. Short duration and high intensity precipitation events occurred in August and September and started from afternoon to evening. However, precipitation events of long duration (over 4 h) almost all started between 21LT and 24LT. Sixty-one percent of maximum rainfall intensity appeared within 20 min from the start of rainfall.

These results suggest the difficulty of development of a manual water control system. They suggest the possibility of erosion control with cropping systems that are adjusted to the precipitation pattern. However, these results were obtained at only 1 point for a 3-y term. It is important to accumulate and analyze precipitation data in other points for longer terms.

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