タイ国におけるロゼル(Hibiscus sabdariffa var.altissima L.)の栽培に関する研究(2):

誌名	日本作物學會紀事
ISSN	00111848
著者	村田, 吉男 Sermsri, N. Duyapat, C.
巻/号	56巻1号
掲載ページ	p. 64-69
発行年月	1987年3月

Japan. Jour. Crop Sci. 56(1) : 64—69 (1987)

Studies on Roselle (*Hibiscus sabdariffa* var. *altissima* L.) Cultivation in Thailand

II. Effect of planting time, harvesting time and climatic factors on fiber yield

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Received April 26, 1986

Currently, May is generally recommended in Thailand for planting roselle (Thai kenaf), *Hibiscus sabdariffa* var. *altissima* L. This is because the rainy season usually begins in this month enabling roselle seeds to germinate. In some years, however, the rain comes earlier than expected in March or April, giving enough time for its vegetative growth before the blooming stage, with corresponding cutting time in October or November. This is convenient for farmers to have sufficient water to ret and clean the kenaf. Previous researches on time of planting and harvesting kenaf found it advantageous to sow early in the rainy season[2] and the best time for harvesting it to be at the 50%-flowering stage#. In order to meet the practical needs it is essential to determine the most suitable planting and harvesting times for roselle crops in the North-eastern region of Thailand. Thus the following two-year field experiments were undertaken participated by four stations. In these experiments the influence of climatic factors on fiber yield was also analyzed, because very few, if any, papers have so far dealt with this problem.

Materials and Methods

In 1979 four field experiment stations, Mahasarakam, Khon Kaen, Ubolrathani and

Table 1. Geophysical and soil characteristics at each experimental location.

Location	Information of the site				
	Elevation (m)	Physiography & geomorphology	Parent material	Soil classification	Rainfalll (mm, 1979)
Mahasarakam (lat. 16°62′N, long. 102°45′E)	123	nearly flat to middle terrace	sandstone alluvial deposits	gray podzoic	1,260
Khon Kaen (lat. 16°26′N, long. 102°50′E)	123	nearly flat high terrace	〃	red yellow latosol	1,140
Ubolrathani (lat. 15°15′N, long. 104°52′E)	130	flat middle terrace	〃	gray podzolic	1,608
Roi-Et (lat. 16°20′N, long. 102°50′E)	120	nearly flat to middle terrace	〃	〃	—
Nonsoong (lat. 15°53′N, long. 103°50′E)	120	flat, low terrace	—	hydromorphic, alluvial	862

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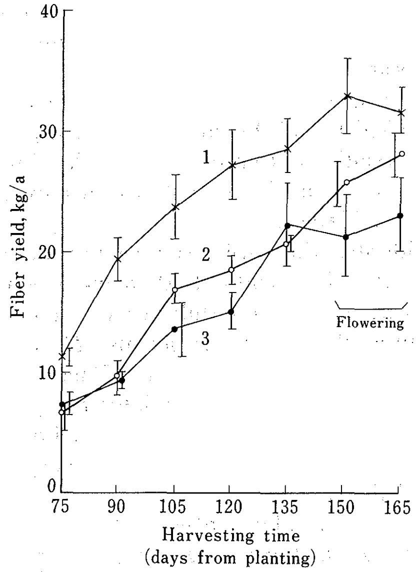

Fig. 1. Fiber yield averaged for four stations of "Ton-Kiew" variety as affected by time of harvest and time of planting, 1979.
1) Vertical bars indicate standard error.
2) Planting time : 1, late April ; 2, early May ; 3, late May.

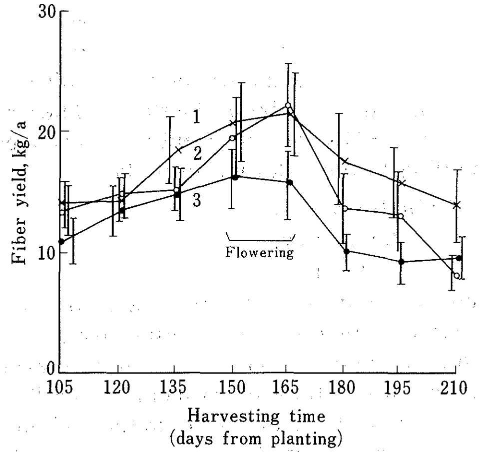

Fig. 2. Fiber yield averaged for four stations of "Ton-Kiew" variety as affected by time of harvest and time of planting, 1980.
1) Vertical bars indicate standard error.
2) Planting time : 1, late April ; 2, early May ; 3, late May.

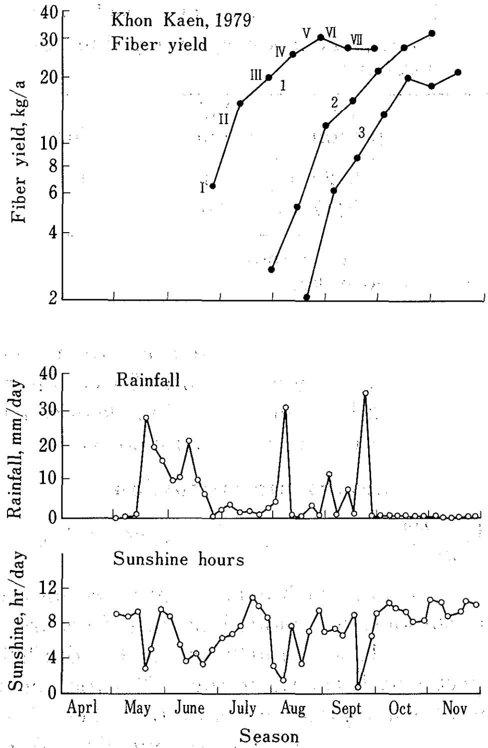

Fig. 3. Changes in fiber yield according to planting time and harvesting time at Khon Kaen in 1979, with distribution of rainfall and sunshine hours indicated in 5-day average. Actual planting date : 1, April 12 ; 2, May 4 ; 3, June 9.

Nonsoong, and in 1980 four stations with the last mentioned one replaced by Roi-Et were chosen as experimental sites. The geographical, topographical and soil conditions of these stations are shown in Table 1.

The variety used was "Ton-Kiew", which was planted on three different times beginning in late April when the first rain came, followed by two plantings with 20-day intervals. In 1979, harvesting was started at 75 days after planting and continued with 15-day intervals until 165 days after planting. In 1980, the first harvest was made at 105 days and the last one at 210 days after planting.

Each plot consisted of ten rows 5 m long with plants at a distance of 30 cm in the row. Chemical fertilizer containing 25-25-25 kg/ha of N, P_2O_5 and K_2O was applied at 20 days after planting. Harvesting of plants at each planting time was done by randomly choosing 5 rows, each 1 m long, with a total of five replications. To determine fiber dry yield, all

Table 2. Comparison of fiber yield among three planting series, averaged for four locations.

Year	1st planting	2nd planting	3rd planting
1979	100(25.1)	71	64
1980	100(17.1)	86	73

Figures in the parentheses are the actual yield in kg/a.

plant parts were submerged in water and covered with heavy wood. After 3 weeks fiber was removed by hand, washed in clean water, dried and bundled up on bamboo bars.

Results and Discussion

1. *Effect of time of planting and cutting on fiber yield*

Fiber yield at each harvest, averaged for the four stations, are plotted against days from planting in Figs. 1 and 2 for 1979 and 1980, respectively. It is clear in the 1979 experiment that at each planting series the fiber yield increased linearly with increasing days from planting, reaching the highest values at 165 or 150 days after planting. Although in 1980 harvesting was begun one month later than the 1979 experiment, the maximum yield was also found at 165 days or 150 days after planting. These are in good agreement with the result obtained in India[1] that harvesting at flowering, 150 to 165 days after planting, gave the highest yield. The present results have confirmed that this is true under a wide variety of conditions differing in planting season, experimental year and location. It is reported both in *H. sabdariffa* var. *altissima*[2] and *H. cannabinus*[3] that the production of fiber in plants is most active from vegetative stage to the beginning of reproductive stage. This can explain the increasing trend of yield up to flowering.

However, for the decrease of fiber yield after 165 days from planting, responsible factors are left to be found. As the production of fiber is still continued after flowering[5], although on a much reduced speed, there should be some negative agents working not only to decrease the production of new fiber but also to decompose or degenerate the fiber already accumulated. Deterioration of fiber by the occurrence of collar-rot disease, decomposition of hemicellulose due to increased respiration caused by lodging, *etc.*, may be mentioned as possible agents.

As to the effect of planting date, the average fiber yield for all the cuttings in each planting series, relative to that for the first planting, was calculated from the data shown in Figs. 1 and 2 to give Table 2.

Evidently, the earlier the seeding date, the higher the fiber yield in both years. The actual flowering date did not differ very much among the three planting series because *H. sabdariffa* var. *altissima* is photosensitive[4]. Therefore, it is naturally expected that the later the planting date, the shorter the period up to flowering, thus decreasing the period for active production of fiber.

In the next place, fiber yield was plotted against actual harvesting date, together with the record of rainfall and sunshine hours, both on 5-day averages. A typical case, that at Khon Kaen is shown in Fig. 3. Here, fiber yield is expressed in a log-scale because the slope between two adjacent points can represent the relative growth rate for fiber production, making more reasonable comparison both among different periods and among stations possible.

2. *Effect of climatic factors on fiber production*

As is well-known, relative growth rate (RGR) is most conveniently used when growth rate is compared between different plants in which the size at the start is different. Therefore, RGR for fiber yield was calculated according to the following formula:

$$\text{RGR for fiber yield} = \frac{\ln w_2 - \ln w_1}{t_2 - t_1}$$

where w_1 and w_2 are the weight of fiber harvested at time t_1 and t_2, respectively.

Out of important climatic factors, the air-temperature in these experiments generally is believed to have remained within the optimum range for kenaf production throughout the whole growth period. At Khon Kaen, for example, the monthly average temperature from May to October was 30°C—27°C, so that it is difficult to suppose that the temperature should have given any serious effect on fiber production. Rainfall, on the other hand, was not only quite irregular in its distribution but also often seriously deficient for the normal growth of kenaf cultivated under non-irrigat-

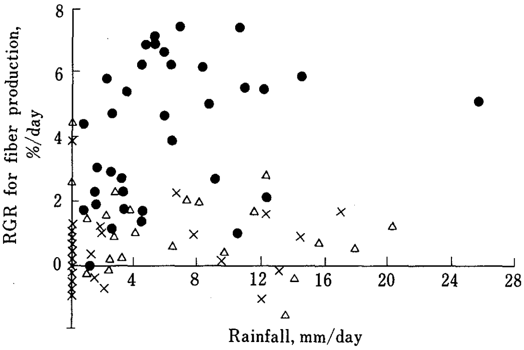

Fig. 4. Correlation between RGR for fiber production and rainfall, with all the points at the four stations included but classified by plant age, 1979 experiments.

● I—III : $r_{GR}=$ 0.230 (n=36),
△ IV—V
× VI—VII : $r_{GR}=-0.104$ (n=48).

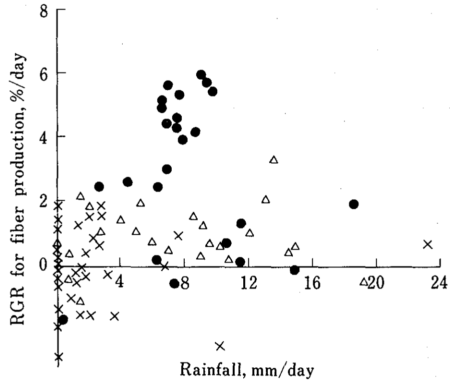

Fig. 5. Correlation between RGR for fiber production and rainfall, with all the points at the four stations included but classified by plant age, 1980 experiments.

● I—II : $r_{GR}=-0.031$ (n=24),
△ III—IV
× V—VIII : $r_{GR}=-0.012$ (n=63).

ed conditions. The sunshine hours were sometimes considerably reduced in the rainy season so that they may have limited the growth of kenaf. Thus, correlation of RGR with rainfall and sunshine hours was examined in the following.

1) Effect of rainfall

At the first step of analysis, correlation of RGR with rainfall (R) was calculated for each harvesting interval over different planting times and stations. No close correlationships were found both in 1979 and 1980 as shown in Figs. 4 and 5.

At the second step of analysis, correlation of RGR with R as well as S (sunshine hours) was calculated for each harvesting interval over the three planting times and the three stations, Mahasarakam, Khon Kaen and Ubolrathani where both R and S were recorded in the two years. Further, partial correlation coefficients of RGR with R or S when the effect of S or R, respectively, was removed, were calculated, as interactions are generally expected whenever they affect RGR. The result of calculation is shown in Table 3.

According to this table, no significant single correlations other than one point each in 1979 (VII, r=−0.731*) and in 1980 (I, r=0.653*) were observed. As for partial correlations, no remarkable improvements as compared with simple ones were obtained. However, an interesting relationship was found between the partial correlation values and the average R value for each period. Namely, as shown in Fig. 6, when the average R is smaller than 6 mm per day, the correlation takes positive values, except for a single case of period VII which corresponds to flowering stage in 1979, approaching to zero and further to negative values as the level of rainfall increases. As for the exceptional case, it was already shown in Figs. 1 and 2 that fiber yield turned to decrease after 165 days from sowing and it was discussed that the decrease had been most probably caused by the occurrence of lodging and collar-rot disease after flowering. The negative correlation in period VII, 150—165 days from sowing, may indicate that rainfall accelerates the occurrence of both lodging and collar-rot disease, thus decreasing the fiber yield.

2) Effect of sunshine hours

As already indicated in Table 3, the partial correlation of RGR with S, free from the influence of R, takes significant, positive values in later growth periods. This is more clearly shown in Fig. 7 where correlation, $r_{GS.R}$ is plotted against growing days from planting. Here, it is seen that the correlation changes from negative to positive values as the gowth stage approaches flowering. This may be because the greater the standing crop, the more sunshine is needed for the photosynthesis of the crop.

Table 3. Simple and partial correlation coefficients of RGR for fiber yield (G) with rainfall (R) and sunshine hours (S) in each period over the three sowing series and three stations in 1979 and 1980.

	Period (days from sowing)	G %/day	R mm/d.	S hr/d.	Simple cor. coef.		Partial cor. coef.	
					r_{GR}	r_{GS}	$r_{GR}\cdot S$	$r_{GS}\cdot R$
1979								
I	0～75	6.20	8.4	6.4	−.178	.661	−.092	.651
II	76～90	4.00	6.2	6.9	.160	−.341	−.053	−.271
III	91～105	2.92	6.1	7.0	.090	−.221	−.192	−.276
IV	106～120	0.74	9.7	6.5	.004	−.530	−.369	−.615
V	121～135	1.37	5.0	7.6	−.511	.768*	.323	.709*
VI	136～150	0.67	3.4	9.0	.318	.180	.984***	.944***
VII#	151～165	0.22	4.0	8.6	−.731*	.466	−.695*	−.362
1980								
I	0～105	5.19	7.7	6.6	.653*	−.433	.462	−.120
II	106～120	0.69	8.8	4.6	.227	.254	.245	.270
III	121～135	0.87	9.4	5.5	−.574	.415	−.472	−.203
IV	136～150	0.81	7.5	6.1	.427	.022	.484	.253
V#	151～165	−0.05	5.7	6.5	−.013	.448	.297	.520

* Significant at 5% level, ** at 1% level and *** at 0.1% level (n=9).
# Flowering. In 1980, data on sunshine hours in periods VI to VIII were not available at one of the three stations.

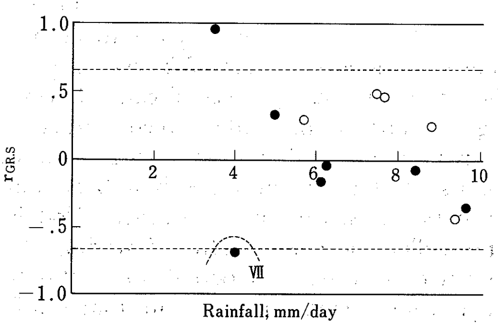

Fig. 6. Relationship between partial correlation coefficient ($r_{GR.S}$) and the level of rainfall.
● 1979, ○ 1980, ……5% significant level.

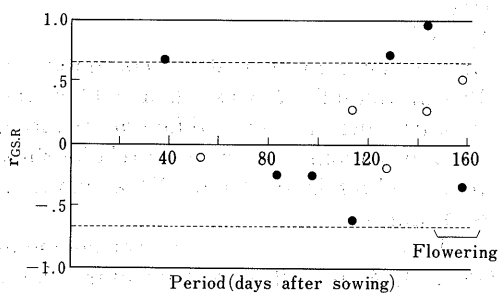

Fig. 7. Relationship between partial correlation coefficient ($r_{GS.R}$) and growth period.
● 1979, ○ 1980, ……5% significant level.

Summary

In a two-year field experiment participated by four stations in the Northeastern region of Thailand, roselle, variety "Ton-Kiew", was planted three times, late April, early May and late May. Harvesting was started at 75 days after planting and continued until 210 days with 15-day intervals.

It was revealed in the first place that the earlier the planting time, the higher the fiber yield. As to the harvesting time, cutting at flowering stage, around 165 days after planting, gave the best yield of 2,775 kg/ha in 1979 and 1,965 kg/ha in 1980 both in an average for the 3 plantings and 4 stations. Fiber yield decreased more than 30% when cutting time was delayed to 210 days after planting.

In the next place the effect of climatic factors was examined mainly by analyzing correlation coefficients, simple and partial, between

relative growth rate for fiber production and individual climatic factors in each harvesting interval. As a result it was found that rainfall gave a promoting effect on fiber production but a decreasing effect when it increased beyond a certain level. On the other hand, sunshine hours seemed to give a positive effect around the flowering stage when the standing crop became very large.

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〔和 文 摘 要〕

タイ国におけるロゼル (*Hibiscus sabdariffa* var. *altissima* L.) の栽培に関する研究

第2報 播種期，刈取期および気象要因が繊維収量に及ぼす影響

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タイ国東北部の4試験地において，品種 Ton-Kiew を用い，2年間圃場試験を行った．4月下旬を第1回として20日おきに3回播種し，それぞれ播種後75日を第1回として15日おきに210日後まで刈取りを行ない，繊維収量と気象条件を調べ，次の結果を得た．

1. 播種期が早いほど繊維収量は高かった．収穫期に関しては，播種後165日の開花期ころの刈取りが最高収量（3播種期，4試験地の平均で，1979年2,775 kg/ha, 1980年1,965 kg/ha）を示し，210日刈取りでは30% 以上減収した．

2. 各刈取間隔15日間の収量相対生長率と気象要因との単および偏相関を調べた結果，雨量はあるレベルまでは収量に対して促進的に働くが，それを越えると減収方向に働くこと，また日照時数は現存量の著しく大きくなる開花期前後には多いほど収量を増すことが推定された．