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

IV. Effect of row spacing in a roselle-peanut intercropping system on the yield of both species

Nawarat SERMSRI, Seriwat JATUPORUNPONGSE and Yoshio MURATA*

(Field Crops Research Institute, Thailand ;* NODAI Research
Institute, Tokyo University of Agriculture, Tokyo 156 Japan)

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In tropical regions various crops are often grown by intercropping with other species, but very few experiments are so far reported on intercropping systems involving roselle. In Thailand, although some trials on roselle-legume intercropping systems were conducted in the past**, they were not successful in getting a high efficiency in terms of combined yield or land use. The low efficiency in these experiments might have been due to inadequate population density of the legumes, on one hand, and to the strong shading effect, on the other, of roselle which grows sometimes more than 3m high. Then, it was supposed that the paired row technique—to plant each crop in paired rows alternately—might be able to improve the efficiency through compromising these two factors. From these considerations, it was planned to examine the effect of paired row planting on the combined yield and land use efficiency by a series of field experiments using roselle and peanut which was chosen both from the view point of marketability and maintaining the soil fertility. The experiments, the results of which are reported here, were conducted for three years, 1979 to 1981, at several locations in Northeast region of Thailand. Here roselle is usually planted at the beginning of wet season, May to September, and harvested at flowering, 5–6 months later in early part of dry season.

Materials and Methods

The variety used for roselle was Ton-Kiew, a late maturing one needing 177 days from planting to mid-flowering, the harvesting

time, with a plant height of 220—300cm and that for peanut was Tainan 9, a bunched type needing 95—110 days from planting to seed maturity.

In 1979 and 1980, both roselle and peanut rows in unit cell of 100cm were paired as shown in Fig. 1. Separation distance between paired peanut rows was kept at 10cm, while the distance between paired roselle rows was varied from 5cm to 30cm. Hill spacing was 5cm for roselle and that for peanut 10cm, both with one plant per hill. Planting density per square meter was 40 plants of roselle plus 20 plants of peanut for A, B, C, D, E and H in the intercropped plots and 66 plants of roselle for F and 66 plants (33 hills) of peanut for G in the sole cropped plots. Thus, the eight treatments were ;

Intercropped plots : roselle paired rows apart

Fig. 1. Diagram for planting pattern in 1979 and 1980. r=roselle, p=peanut.

** Department of Agriculture, Thailand 1982. Progress of crop improvement. Field Crops Division Report, Department of Agriculture, 27—36.

Table 1. Dried yields(kg/ha) of roselle fiber(retted) and peanut pods in roselle-peanut intercropping systems in 1979 and 1980.

	Treatment		Location						Ave.
	Dist.	Species	KS	KK	NS	RE	MK	UB	
1979	cm					kg/ha			
A	5	roselle	4170	2370	—	—	3610	1890	3010
		peanut	225	150	—	—	213	169	188
B	10	roselle	4000	1850	—	—	3640	2070	2890
		peanut	281	269	—	—	194	169	231
C	15	roselle	3630	2210	—	—	3750	2290	2970
		peanut	163	100	—	—	156	150	144
D	20	roselle	4600	2070	—	—	3840	2190	3180
		peanut	150	219	—	—	150	106	156
E	30	roselle	5530	2310	—	—	3920	1870	3410
		peanut	175	250	—	—	169	75	169
H	50	roselle	5340	2140	—	—	3450	2160	3300
		peanut	225	381	—	—	225	88	231
F	30	roselle	3380	2720	—	—	4650	2280	3260
G	30	peanut	1220	1510	—	—	1100	1100	1230
1980									
A	5	roselle	1920	3300	1760	3510	1980	2830	2550
		peanut	888	244	681	694	381	256	525
B	10	roselle	1810	3440	1830	4100	2170	2740	2680
		peanut	894	231	625	594	450	325	519
C	15	roselle	1860	3770	1920	3800	2070	2850	2710
		peanut	988	188	569	625	331	231	488
D	20	roselle	1900	3540	1890	3600	2310	2800	2680
		peanut	856	256	675	594	394	163	488
E	30	roselle	2100	3630	1560	4170	2320	3350	2860
		peanut	781	175	763	1040	419	613	631
H	50	roselle	2490	3610	1560	4020	2360	2440	2740
		peanut	994	206	1410	675	356	463	681
F	30	roselle	2190	3610	2660	4530	2700	3960	3280
G	30	peanut	1780	1360	2470	1880	1500	656	1610

Note : Dist., Distance between paired (A-E) or single (H) rows of roselle or peanut (G). KS= Kalasin, KK= Khon Kaen, NS= Nonsoong, RE= Roi-Et, MK= Mahasarakam, UB= Ubolrathani. F and G, sole cropped plots. All plots received 25-25-25 kg/ha of NPK in chemical fertilizer.

by 5cm (A), 10cm (B), 15cm (C), 20cm (D) or 30cm (E) with peanut paired rows apart by 10cm; and roselle paired rows apart by 50cm with peanut single rows apart by 50cm (H).

Sole cropped plots : roselle single rows apart by 30cm with 5cm hill spacing (1 plant/hill) (F), and peanut single rows apart by 30cm with 10cm hill spacing (2 plants/hill) (G).

Each plot was given 25-25-25 kg/ha of NPK as chemical fertilizer. The experimental locations were five in 1979 at Khon Kaen,

Mahasarakam, Ubolrathani, Nonsoong and Kalasin and six in 1980 by adding Roi-Et. Out of these, the geographical and geophysical conditions at Kalasin were : lat. 16°25'N, long. 103°23'E, flat to middle terrace with gray podsollic alluvial soil and a yearly rainfall of 1,300 mm. Conditions at other five locations were already reported in the previous paper²⁾.

The actual planting date at these locations differed from early May to early June and harvesting date for peanut from late August to

late September and that for roselle from late October to middle November, depending on the year and location.

In 1981 the variation of row distance was somewhat simplified and instead no nitrogen fertilizer (-N) plots were introduced. Thus, the following 10 treatments were adopted.

Intercropped plots: roselle paired rows apart by 10 cm (A), 20 cm (B) or 30 cm (C) with peanut paired rows apart by 10 cm with 25-25-25 kg/ha of NPK; roselle paired rows apart by 50 cm with peanut single rows 50 cm apart with the same NPK as above (D); roselle

paired rows apart by 10 cm (E), 20 cm (F) or 30 cm (G) with peanut paired rows apart by 10 cm with 0-25-25 kg/ha of NPK; and roselle single rows apart by 50 cm with peanut single rows apart by 50 cm with the same NPK as above (H).

Sole cropped plots: roselle (I) or peanut (J) single rows apart by 30 cm with 25-25-25 kg/ha of NPK.

Results and Discussion

All the original yield data obtained in the three years are presented in Tables 1 and 2

Table 2. Dried yields(kg/ha) of roselle fiber(retted) and peanut pods in roselle-peanut intercropping systems in 1981.

	Treatment			Location			
	Dist., cm	Ferti-lizer	Species	MK	KS	KK	Ave.
A	10	+N	roselle	1700	2170	2080	1980
			peanut	650	275	369	431
B	20	+N	roselle	2390	1930	2210	2180
			peanut	688	269	338	431
C	30	+N	roselle	2280	2560	2630	2490
			peanut	763	163	194	375
D	50	+N	roselle	2970	2940	2340	2750
			peanut	363	231	319	306
E	10	-N	roselle	1890	1680	2070	1880
			peanut	717	419	513	550
F	20	-N	roselle	1930	2040	2260	2080
			peanut	975	388	406	588
G	30	-N	roselle	2290	1210	2180	1890
			peanut	888	650	325	619
H	50	-N	roselle	1960	1510	2260	1910
			peanut	1180	475	269	638
I	30	+N	roselle	1890	3220	2550	2550
J	30	+N	peanut	1430	725	1750	1300

Note: I & J, sole cropped plots. Fertilizer, 25-25-25 kg/ha of NPK for +N and 0-25-25 kg/ha of NPK for -N.

Table 3. Comparison of yields(kg/ha) between roselle and peanut in their average for locations in each year.

Year	No. of locations	Intercropped(Int)		Sole cropped(Sol)		Int/Sol, %	
		Roselle	Peanut	Roselle	Peanut	Roselle	Peanut
1979	4(+N)	3120(100)	188(6)	3260(100)	1230(38)	96	15
1980	6(+N)	2700(100)	531(20)	3280(100)	1610(49)	82	33
1981	3(+N)	2340(100)	388(17)	2550(100)	1300(51)	92	30
	3(-N)	1940(100)	600(31)	—	—	—	—

() : Values relative to roselle yield taken as 100.

Fig. 2. Changes in peanut/roselle yield ratio (p/r) according to year, N condition and row spacing.

and the yearly average yields of roselle and peanut for both intercropped and sole cropped plots are shown in Table 3.

1) General tendency

It is indicated in Table 3 that peanut yield in 1979 was as low as nearly one third that in 1980. This is considered to be the reflection of failure of peanut to compete with roselle in the former year. Further, in the sole cropped plots peanut yield was about 50% that of roselle, while it decreased to less than 20% in the intercropped plots. Under nitrogen deficiency, however, it increased to 31%. This is supposed to be due to the relatively unaffected growth of peanut which has N-fixing ability and the reduced growth of roselle. Viewing from the stand point of adaptability to intercropping, the yield of roselle is reduced only 4–18% by intercropping with peanut, while the yield of peanut is reduced as much as 67–85% by intercropping with roselle, compared with the yield of each species in sole cropping.

2) Changes in the yield ratio of peanut to roselle

As peanut and roselle are in a competitive relationship, their yield ratio is also considered to be in a state of delicate balance, with an increase in the growth of one side causing a decrease in the other side and vice versa. Therefore, the peanut/roselle yield ratio (p/r) was calculated from the data of Tables 1 and 2 and their average values by plots and years were plotted against the row spacing in Fig. 2. From this figure the following points were

Fig. 3. Yields of roselle and peanut, each in average for 5 and 6 locations in 1979 and 1980, respectively, in the roselle-peanut intercropping system in relation to inter-row spacing.

Yields are expressed in relative values to the mean of roselle at each location in each year. Small vertical bars indicate standard error. Numerals above each plot name indicate distance in centimeter between paired rows or single rows.

recognized: in 1979 the p/r ratio was kept in a constant range of 5–8% throughout the whole row spacing. However, in 1980 the ratio was lowest at 15 cm spacing. In 1981 the ratio showed almost opposite responses, decreasing with increasing spacing in normal fertilized plots. The ratio in -N plots remained, on the contrary, at a far higher, nearly constant level of 28–36% throughout the whole spacing range. Thus, it has been made clear that the p/r ratio is affected not only by row spacing but also by growing years and nitrogen supply.

3) Effect of row spacing in intercropping

As already mentioned, the original data showed rather large variation among both years and locations (Tables 1 and 2), giving hardly any statistical significance to the difference between treatments. In order, therefore, to eliminate the influence of years and locations, all the yield data were expressed in percentage of the mean roselle yield of intercropped plots at each location. In this way the effect of row spacing on the yield of both species in the intercropping system was compared in Fig. 3 for 1979 and 1980 and in

Fig. 4 for 1981. The yields in sole cropping are given on the right side of the same figure, also in relative values to the mean roselle yields of intercropped plots.

Here, it may be recognized that the standard error in each plot is sufficiently small to allow a meaningful comparison between the treatments. In 1979 (Fig. 3) both roselle yield and combined yield increased with increasing row spacing whether the rows were paired or not. In 1980 the same trend is recognized. In 1981 (Fig. 4) the increasing trend is most conspicuous in the normal fertilized plots. However, in -N plots such a trend is completely disappeared. The yield of peanut in intercropped plots, on the other hand, tends to become minimum at 10–20 cm spacing throughout the three years.

From these results an interesting conclusion has been drawn out that, under normal nitrogen supply, the more uniform the overall row arrangement of the two species, the higher their combined yield. Roselle yield also followed the same principle, but peanut yield did not. Thus, the paired row system does not seem to have any special merits over the usual single row system.

4) Land equivalent ratio (LER)

Fig. 4. Yields of roselle and peanut, each in average for 3 locations in 1981, in the roselle-peanut intercropping system in relation to inter-row spacing and N fertilizer application.

Yields are expressed in relative values as in Fig. 3. Small vertical bars indicate standard error.

Land equivalent ratio is used to evaluate the productivity of mixed cropping. It is defined as the sum of two ratios, namely, the ratio of yield of species A at mixed cropping to that at sole cropping and the ratio of yield of species B obtained in the same way*. In the present experiments, LER values exceeding 1.0 were obtained in all the intercropped plots as shown in Table 4. Intercropping by single rows with 50 cm spacing gives the highest LER of 1.25. This implies that the more uniform the row arrangement of the two species as a whole, the higher the land utilization efficiency of the intercropping system. However, the LER value of 1.25 did not seem to be sufficiently high to be adopted as a practical cropping system.

Considering from a more ecological view point, HARPER¹⁾ called LER the *relative yield total* (RYT) to use for analyzing the nature of interference between two species grown in a mixed stand. According to him, RYT values greater than 1.0 suggest that the species avoid competition, make different demands on resources, or maintain a symbiotic relationship. Incorporating this concept, it may be concluded that the more uniform the overall row arrangement in a roselle-peanut intercropping system, the more strengthened are such beneficial relationships. However, in what way this is actually related to competition for light and other resources has not been made clear, as information on light relations and biomass distribution within the stand is lacking in this report. It is left to be studied in the future.

Summary

In three-year field experiments with 3–6 locations in Northeast region of Thailand involved in each year, roselle and peanut were intercropped under varying row spacing, incorporating the paired row technique under different nitrogen conditions. Yield responses of the two crops were compared from various aspects. Main results obtained are as follows:

1) Compared with sole cropping, the yield of intercropped roselle showed relatively small decreases of 4–18%, while that of peanut showed drastically large decreases of 67

* HARWOOD, R. R. 1973. Crop inter-relationships in intensive cropping systems. IRRI Seminar, Philippines, 102–105.

Table 4. Land equivalent ratio (LER) in the roselle-peanut intercropping system in 1979.

Plot	Partial LER		LER
	Roselle	Peanut	
A	0.91	0.20	1.11
B	0.86	0.22	1.08
C	0.89	0.18	1.07
D	0.95	0.18	1.13
E	0.98	0.21	1.19
H	0.99	0.26	1.25

$$\text{LER} = \frac{\text{roselle yield in intercropped plot}}{\text{roselle yield in sole cropped plot}} + \frac{\text{peanut yield in intercropped plot}}{\text{peanut yield in sole cropped plot}}$$

—85%, in the three-year average for different spacings.

2) The ratio of yield between peanut and roselle changed not only with row spacing, but also with year and nitrogen supply.

3) The combined yield in the roselle-peanut

intercropping system increased with increasing row spacing up to 50 cm whether the rows were paired or not. Roselle yield also showed the same trend. Without nitrogen fertilizer, however, such a trend was completely lost.

4) Out of the whole experimental plots, the single rowed one with the largest spacing of 50 cm proved to be highest in the land equivalent ratio. Thus, it was concluded that the paired row arrangement does not have any special merits over the ordinary single row arrangement in an intercropping system composed of roselle and peanut.

References

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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4報 ロゼルーラッカセイ間作体系における条間距離が両者の収量に及ぼす影響

Nawarat SERMSRI・Seriwat JATUPORUNPONGSE・村田 吉 男*

(タイ国畑作物研究所・*東京農業大学総合研究所)

タイ国東北地域の3—6試験地において、3年間にわたりロゼルーラッカセイの間作試験を実施した。ロゼルのラッカセイに対する遮光の影響を緩和する意図で、複条 (paired row) 法を導入して個体密度一定の下にロゼルの複条距離をかせ、窒素 (N) 条件を組合わせて収量の反応を比較し、次の結果を得た。

1) 間作ロゼルの乾燥繊維収量は全区3年間の平均で、単作の場合より僅かしか (4—18%) 低下しなかったが、ラッカセイの莢実収量は大幅な (67—85%) 低下を示した。

2) ラッカセイ/ロゼルの収量比は条間距離のみならず、年次、N供給量によっても大幅に変動した。

3) 複条区と単条区を通じて、合計収量は条間距離が増大するほど、すなわち全体としての条間距離が均一化するほど、増大する傾向を示し、50 cm 単条区で最高で、ロゼルの収量も同じ傾向を示した。しかし-N 条件下ではこのような傾向は消失した。

4) Land equivalent ratio (LER) も上と同じ傾向を示し、50 cm 単条区で最高となった。

以上のことから、ロゼルーラッカセイ間作体系への複条法の導入は単条法に比べて特別な利点を持たないことがわかった。