EFFECT OF DATE OF PLANTING AND RAINFALL DISTRIBUTION ON THE YIELD OF FIVE CASSAVA VARIETIES IN LAMPUNG, INDONESIA

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ABSTRACT

Improved cassava varieties have been widely disseminated to farmers in Lampung and this has resulted in substantial economic gains to both factories and farmers. But, considering that the rainfall distribution in Lampung province is not uniform and that there is a prolonged dry period about every three years, it is important to know the response of each variety to drought during its growth cycle. In this way, varieties with greater drought tolerance can be selected before being disseminated to farmers and planted throughout the year. Thus, an experiment was conducted to study the effect of dry periods during different stages of the growth cycle on cassava yield and starch production of five selected varieties in Umas Jaya Farm (UJF).

Five selected varieties, i.e. Adira 4, Rayong 60, Rayong 90, Kasetsart 50, and CMR30-56-1, were planted in plots with an effective plot size of 0.1 ha, without replication. Subplots of each variety were planted every month starting in July, 1996. At harvest, fresh root yields and root starch contents (using the Reimann scale) were determined, and from those starch production was calculated.

The effect of planting dates and rainfall on the root yield, starch content and starch yield of the various varieties showed a decrease in root yield when the crop was subjected to a dry period, defined here as a period of two or more months with less than 100 mm rainfall; the decrease ranged from 14.88 t/ha for Kasetsart 50 to 20.11 t/ha for Rayong 60. Without a dry period during the growth cycle, the average fresh root yields did not differ significantly among varieties, ranging from 38.39 to 44.02 t/ha.

The average starch content was higher without than with a dry period. However, in four of the five varieties (Kasetsart 50 being the exception) the highest starch content was observed when cassava was subjected to two or three dry months just prior to harvest.

Average starch yields of all varieties were reduced by about 50% when plants were subjected to a dry period during the growth cycle, as compared to those receiving uniform rainfall without a dry period. When subjected to drought stress, the lowest starch yield was obtained with Adira 4, and the highest with CMR30-56-1.

In conclusion, when subjected to a long dry period during the growth cycle, both the fresh root yield and starch yield of all tested varieties decreased. But, under non-uniform rainfall distribution, the fresh root yields of Rayong 60, Kasetsart 50 and CMR30-56-1 were much higher than that of Adira 4, and the starch yields of all four varieties were also higher than that of Adira 4. Under uniform rainfall distribution, starch yields of Rayong 90, Kasetsart 50 and CMR30-56-1 were higher than those of Adira 4 and Rayong 60. A dry period from the 3rd to the 8th month after planting is the most critical in reducing both the root and starch yields as well as the starch content of all tested varieties.

INTRODUCTION

Lampung province is the main producer of cassava starch in Indonesia. In 1996 the area planted to cassava in the province was about 183,000 ha (Puspitorini *et al*., 1996). Even in 1997 when Indonesia suffered a severe drought, the cassava planted area increased as compared to previous years. The expansion of area was not accompanied by an increase

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in the average national yield, which remained stable at 11.4 t/ha (Koeshartoyo and Wargiono, 1999).

Due to the disuniform rainfall distribution throughout the year, farmers usually plant cassava at the beginning of the wet season and harvest during the dry season. As a consequence, there is an eneven availability of raw material for starch processing and great fluctuations in the fresh root price occur almost every year.

Improved cassava varieties have quickly been disseminated to farmers in Lampung and this has resulted in substantial economic gains to both factories and farmers (Puspitorini *et al*., 1996). Considering that the rainfall distribution is not uniform and that there is a prolonged dry period about every three years, it is important to know the response of each variety to drought during its growth cycle. In this way, varieties with greater drought tolerance can be selected before being disseminated to farmers and planted throughout the year. Thus, an experiment was conducted to study the effect of dry periods during different stages of the growth cycle on cassava yield and starch production of five selected varieties in Umas Jaya Farm (UJF).

MATERIALS AND METHODS

The experiment was conducted at the Umas Jaya Farm (UJF) Research Station in Central Lampung located at $4^0$49' S and $105^0$13' E, and at an altitude of 25 m above sea level. The soil is classified as a loamy Aquic Dystropept and has a pH of 4.5. The agroclimate of the area is classified as type C-2 (Oldeman *et al*., 1979), i.e. it has 5-6 wet months and 2-3 dry months in the years, where a wet month is defined as having >200 mm rainfall and a dry month as having <100 mm rainfall.

Five selected varieties, i.e. Adira 4, Rayong 60, Rayong 90, Kasetsart 50 and CMR30-56-1, were planted in plots with an effective plot size of 0.1 ha, without replication. Subplots of each variety were planted every month starting in July 1996; fertilizers were applied at a rate of 200 kg urea, 100 TSP and 100 KCl/ha. Each subplot was harvested ten months after planting. Up to May 1999 there had been 25 planting and harvesting times. At harvest, fresh root yields and root starch contents (using the Reimann scale) were determined, and from those the starch yield was calculated.

RESULTS AND DISCUSSION

1. Effect of Rainfall on Fresh Root Yield

The effect of planting dates and rainfall on the root yield, starch content and starch yield of the various varieties are shown in **Table 1**. Although cassava can adapt well to a water shortage by reducing its leaf canopy, when it is subjected to a long dry period during its growth cycle, this will usually lead to a reduction in root yield. Of the 25 cropping cycles, in 23 cycles cassava was subjected to two or more months of drought (<100 mm rainfall), while in the other 2 cycles there was no such dry period and the rainfall distribution was thus considered uniform.

Table 1. Effect of date of planting and rainfall during the growth cycle on the fresh root yield, starch content and starch yield of five varieties grown in Umas Jaya Farm, Lampung, Indonesia from 1996 to 1999.

Planting month	Harvest month	Rainfall (mm)[1)]	No. dry months (<60mm)	Fresh root yield (t/ha)					Starch content (%)					Starch yield (t/ha)				
				Adira 4	Rayong 60	Rayong 90	Kasetsart 50	CMR 30-56-1	Adira 4	Rayong 60	Rayong 90	Kasetsart 50	CMR 30-56-1	Adira 4	Rayong 60	Rayong 90	Kasetsart 50	CMR 30-56-1
Jul-96	May-97	2,092	0	43.06	46.13	48.68	34.38	43.87	26.82	24.46	24.96	30.56	27.34	11.55	11.28	12.15	10.51	11.99
Aug-96	Jun-97	1,989	1	39.30	41.91	37.19	42.39	42.10	28.90	25.95	31.54	32.10	28.40	11.36	10.88	11.73	13.61	11.96
Sep-96	Jul-97	1,780	2	23.13	17.24	24.79	18.04	22.57	27.40	28.20	30.12	29.20	28.80	6.34	4.86	7.47	5.27	6.50
Oct-96	Aug-97	1,656	3	17.68	22.42	25.13	26.88	34.87	29.20	28.32	31.50	27.87	28.26	5.16	6.35	7.91	7.49	9.85
Nov-96	Sep-97	1,561	4	21.34	28.07	21.30	27.01	29.82	24.94	26.18	25.44	24.72	24.22	5.32	7.35	5.42	6.68	7.22
Dec-96	Oct-97	1,412	5	18.68	19.76	18.80	22.00	23.58	22.86	25.28	22.24	21.88	20.94	4.27	5.00	4.18	4.81	4.94
Jan-97	Nov-97	1,059	5	11.83	18.49	13.94	18.00	21.67	16.86	19.68	17.04	18.22	12.15	1.99	3.64	2.38	3.28	2.63
Feb-97	Dec-97	1,094	5	8.86	14.77	14.00	15.70	17.38	11.08	20.00	17.06	16.44	15.18	0.98	2.95	2.39	2.58	2.64
Mar-97	Jan-98	789	5	9.36	17.91	11.54	12.24	14.30	11.86	16.22	19.36	17.90	14.47	1.11	2.91	2.23	2.19	2.07
Apr-97	Feb-98	1,407	5	28.98	27.98	16.07	15.73	21.44	12.20	21.25	19.10	22.25	19.50	3.54	5.95	3.07	3.50	4.18
May-97	Mar-98	1,719	5	12.05	26.49	14.39	17.33	25.93	18.90	19.50	21.70	20.70	20.10	2.28	5.17	3.12	3.59	5.21
Jun-97	Apr-98	1,869	4	29.26	29.26	24.12	21.53	31.34	17.00	17.85	19.20	20.05	17.75	4.97	5.22	4.63	4.32	5.56
Jul-97	May-98	2,012	3	17.07	15.63	6.17	13.81	20.15	18.16	16.17	15.80	20.60	16.00	3.10	2.53	0.97	2.84	3.22
Aug-97	Jun-98	2,080	3	12.91	16.74	17.74	17.54	20.35	17.86	19.16	20.46	19.40	18.86	2.31	3.21	3.63	3.40	3.84
Sep-97	Jul-98	2,212	2	20.64	14.07	12.37	24.11	24.72	16.20	17.80	16.80	18.00	20.00	3.34	2.50	2.08	4.34	4.94
Oct-97	Aug-98	2,322	2	25.27	19.31	19.95	13.15	26.90	21.10	26.30	22.50	18.00	23.50	5.33	5.08	4.49	2.37	6.32
Nov-97	Sep-98	2,385	3	25.21	20.00	25.79	24.19	36.74	20.20	24.00	24.50	21.40	22.90	5.09	4.80	6.32	5.18	8.41
Dec-97	Oct-98	2,157	3	27.23	29.16	26.25	28.94	25.29	18.80	22.70	20.60	21.30	22.50	5.12	6.62	5.41	6.16	5.69
Jan-98	Nov-98	1,928	3	30.00	24.92	21.05	27.84	12.00	21.40	23.60	24.10	24.90	26.30	6.42	5.88	5.07	6.93	3.16
Feb-98	Dec-98	1,285	3	27.26	25.91	21.01	27.41	27.94	22.20	21.70	24.50	24.30	23.50	5.99	6.06	4.87	5.76	6.57
Mar-98	Jan-99	2,063	3	34.49	33.72	33.10	33.31	34.49	22.20	21.70	24.50	24.30	23.50	7.66	7.32	8.11	8.09	8.11
Apr-98	Feb-99	1,992	3	32.23	25.00	23.75	30.67	36.79	20.90	23.40	23.50	24.00	23.30	6.74	5.85	5.58	7.36	8.57
May-98	Mar-99	2,025	3	29.81	32.55	45.53	34.17	46.34	26.33	24.18	25.42	26.95	25.02	7.85	7.87	11.57	9.21	11.59
Jun-98	Apr-99	2,086	2	23.89	31.17	48.94	30.63	37.01	22.70	25.10	26.40	24.70	25.30	5.42	7.82	12.92	7.57	9.36
Jul-98	May-99	2,095	2	32.27	39.28	44.25	40.54	35.60	25.70	27.30	26.70	29.10	26.50	8.29	10.72	11.81	11.80	9.43
Avg.				**24.07**	**25.52**	**24.63**	**24.70**	**28.53**	**20.87**	**22.64**	**23.00**	**23.15**	**22.17**	**5.26**	**5.91**	**5.98**	**5.95**	**6.56**

[1)] During growth period [2)] Dry period = two or more dry months (<60 mm rainfall)

All tested varieties showed a significant decrease in root yield when subjected to a long dry period (**Table 2** and **Figure 1**). The extent of the decrease in average fresh root yield due to drought differed among varieties, ranging from 14.88 t/ha for Kasetsart 50 to 20.11 t/ha for Rayong 60. When subjected to a long dry period Adira 4 produced the lowest yields (22.58 t/ha) while CMR30-56-1 had the highest yield (27.27 t/ha). Without a dry period during the growth cycle the average fresh root yields did not differ significantly among varieties, ranging from 38.39 to 44.02 t/ha.

Table 2. The effect of a long dry period during the growth cycle on the average yield of five selected varieties grown in Umas Jaya Farm, Lampung, Indonesia, from 1996 to 1999.

Variety	Average fresh root yield (t/ha)		Decrease due to drought	
	With dry period[1)]	Without dry period	Root yield (t/ha)	(%)
Adira 4	22.58 a	41.18 b	18.60	45
Rayong 60	23.91 a	44.02 b	20.11	46
Rayong 90	23.04 a	42.94 b	19.90	46
Kasetsart 50	23.51 a	38.39 b	14.88	39
CMR30-56-1	27.27 a	42.99 b	15.72	37

[1)] two or more months with <100 mm rainfall.

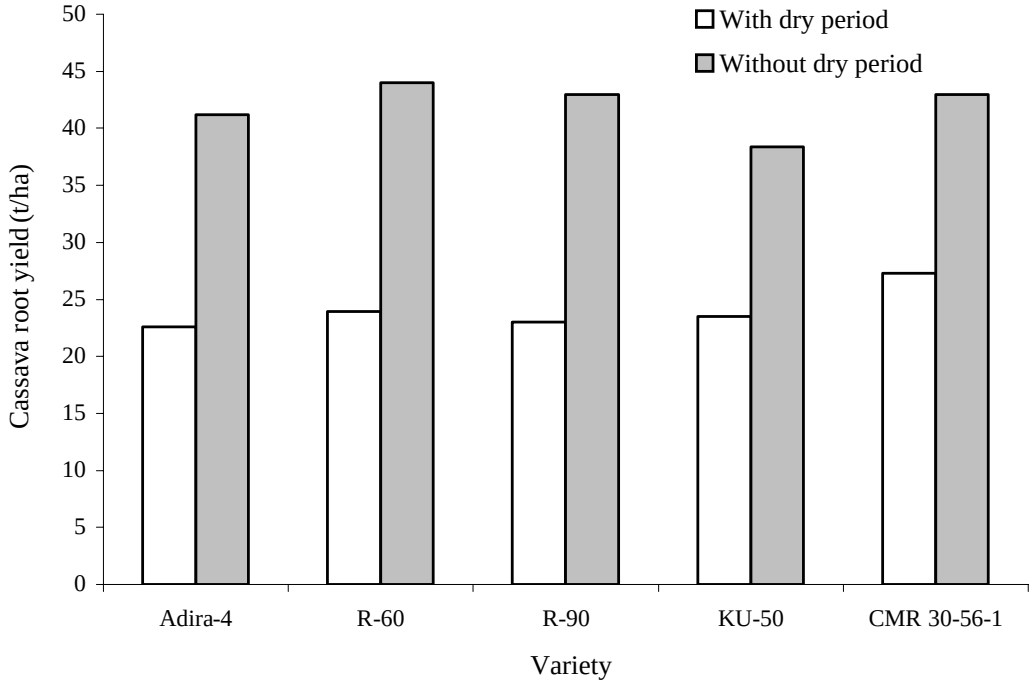

Figure 1. Effect of the presence of a prolonged dry period (two months or more of less than 100 mm rainfall) on the average root yields of five selected cassava varieties grown in Umas Jaya Farm, Lampung, Indonesia from 1996 to 1999.

The greatest decrease in yield of all varieties was found when the dry period occurred from the 3rd to the 7th month or from the 4th to the 8th month after planting; in that case the root yields ranged from 8.86 to 17.91 t/ha (**Table 3**). These yields were generally much lower than those obtained when the dry periods occurred at other times during the growth cycle. This indicates that adequate water availability between 3 and 8 months after planting is very important to maintain optimum plant metabolism and growth necessary for root bulking. Similar results were also reported by Zhang Weite *et al*. (1998) and by CIAT (1998).

Table 3. Fresh root yield of five selected varieties when affected by a dry period during various stages of the growth cycle.

Planting dates	Harvesting dates	Total rainfall (mm)	Dry months[1)] (month after planting)	Fresh root yield (t/ha)					
				Adira 4	Rayong 60	Rayong 90	Kasetsart 50	CMR 30-56-1	Average
29-Sep-96	21-Jul-97	1780	9,10	23.13	17.24	24.79	18.04	22.57	21.15
24-Oct-96	29-Aug-97	1656	8,9,10	17.68	22.42	25.13	26.88	34.87	25.40
18-Nov-96	17-Sep-97	1561	7,8,9,10	21.34	28.07	21.30	27.01	29.82	25.51
26-Dec-96	17-Oct-97	1412	6,7,8,9,10	18.68	19.76	18.80	22.00	23.58	20.56
24-Jan-97	11-Nov-97	1059	5,6,7,8,9	11.83	18.49	13.94	18.00	21.67	16.79
28-Feb-97	29-Dec-97	1094	4,5,6,7,8	8.86	14.77	14.00	15.70	17.38	14.14
24-Mar-97	19-Jan-98	789	3,4,5,6,7	9.36	17.91	11.54	12.24	14.30	13.07
29-Apr-97	26-Feb-98	1407	2,3,4,5,6	28.98	27.98	16.07	15.73	21.44	22.04
23-May-97	23-Mar-98	1719	1,2,3,4,5	12.05	26.49	14.39	17.33	25.93	19.24
25-Jun-97	25-Apr-98	1869	1,2,3,4	29.26	29.26	24.12	21.53	31.34	27.10
30-Jul-97	13-May-98	2012	1,2,3	17.07	15.63	6.17	13.81	20.15	14.57
5-Aug-97	5-Jun-98	2080	1,2,10	12.91	16.74	17.74	17.54	20.35	17.06
9-Sep-97	7-Jul-98	2212	1,9	20.64	14.07	12.37	24.11	24.72	19.18
25-Oct-97	27-Aug-98	2323	8,10	25.27	19.31	19.95	13.15	26.90	20.92
24-Nov-97	30-Sep-98	2385	7,9,10	25.21	20.00	25.79	24.19	36.74	26.39
28-Dec-97	27-Oct-98	2157	6,8,9	27.23	29.16	26.25	28.94	25.29	27.37
20-Jan-98	22-Nov-98	1928	5,7,8	30.00	24.92	21.05	27.84	12.00	23.16
28-Feb-98	28-Dec-98	1285	4,6,7	27.26	25.91	21.01	27.41	27.94	25.91
14-Mar-98	12-Jan-99	2063	3,5,6	34.49	33.72	33.10	33.31	34.49	33.82
1-Apr-98	5-Feb-99	1992	2,4,5	32.23	25.00	23.75	30.67	36.79	29.69
5-May-98	5-Mar-99	2025	1,3,4	29.81	32.55	45.53	34.17	46.34	37.68
5-Jun-98	5-Apr-99	2086	2,3	23.89	31.17	48.94	30.63	37.01	34.33
5-Jul-98	5-May-99	2095	1,2	32.27	39.28	44.25	40.54	35.60	38.39
Average		1782		22.58	23.91	23.04	23.51	27.27	24.06

[1)] <100 mm rainfall.

The fresh root yield of all varieties were significantly reduced with an increase in the length of the dry period, with r-values ranging from 0.79 to 0.80, except for Rayong 60 where r was only 0.31 (**Figure 2**). In general, the decrease in fresh root yield was greater when the dry period was longer.

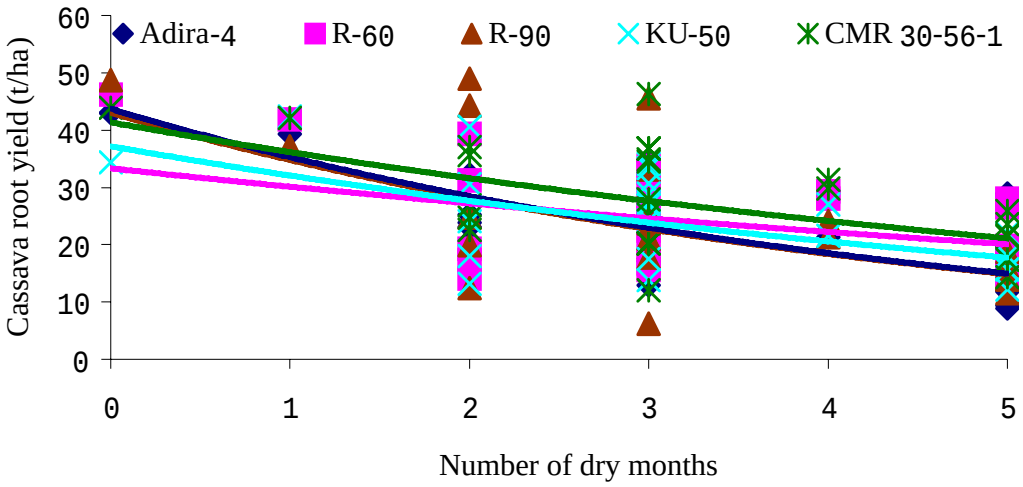

Figure 2. Effect of the duration of the dry period (less than 100 mm rainfall per month) on the fresh root yields of five selected varieties grown in Umas Jaya Farm, Lampung, Indonesia from 1996 to 1999.

However, when cassava grew under uniform rainfall conditions, the fresh root yield was not positively correlated with total rainfall during the growth cycle. Fresh root yields of all varieties were almost the same under these conditions (**Table 4**). Even though total rainfall was not so high, as long as the distribution was more or less uniform it was sufficient to meet the crop's requirement throughout the growth cycle. As a result, the yield did not differ significantly with differences in total rainfall.

Tabel 4. Fresh root yield of five selected varieties when not affected by a dry period during the growth cycle.

Planting dates	Harvesting dates	Total Rainfall (mm)	Dry months[1)] (month after planting)	Fresh root yield (t/ha)					
				Adira 4	Rayong 60	Rayong 90	Kasetsart 50	CMR 30-56-1	Average
24-Jul-96	25-May-97	2092	None	43.06	46.13	48.68	34.38	43.87	43.22
24-Aug-96	20-Jun-97	1989	10	39.30	41.91	37.19	42.39	42.10	40.58
Average		2041		41.18	44.02	42.94	38.39	42.99	41.90

[1)] <100 mm rainfall.

2. Effect of Rainfall on Starch Content

If the price of fresh roots is also determined by its starch content, the higher the starch content of the cassava variety the more profitable for both farmers and factories. For that reason, root starch content is a very important criterion in varietal selection, especially when cassava is cultivated in upland areas with an uneven rainfall distribution.

Table 5 shows the effect of having a dry period or not on root starch content. With a dry period of two months or more the starch content varied from 20.26% in Adira 4 to 22.44% in Kasetsart 50. Without a dry period the starch content varied from 25.21% in Rayong 60 to 31.33% in Kasetsart 50. The starch content of all varieties was higher in the absence of a dry period and these differences were highly significant.

Table 5. The effect of a long dry period during the growth cycle on the average starch content of five selected varieties grown in Umas Jaya Farm, Lampung, Indonesia, from 1996 to 1999.

	Average starch content (%)		Decrease due to drought	
Variety	With dry period[1)]	Without dry period	Starch content (%)	(%)
Adira 4	20.26 a	27.86 b	7.60	27
Rayong 60	22.42 a	25.21 b	2.79	11
Rayong 90	22.55 a	28.25 b	5.70	20
Kasetsart 50	22.44 a	31.33 b	8.89	28
CMR30-56-1	21.68 a	27.87 b	6.19	22

[1)] two or more months with <100 mm rainfall.

Tables 6 and **7** show that in all varieties except Kasetsart 50 the highest starch content was encountered when there was a dry period during the last 1-3 months before harvest. This was also observed in China (Zhang Weite, 1996; Zhang Weite *et al*., 1998) and in two experiments conducted in Thailand (Tongglum *et al*., 1992; CIAT Annual Report, 1998). The starch content decreased, however, when the dry period before harvest extended for more than 2-3 months. The starch content was lowest when the dry period extended for five months, especially if this occurred towards the middle of the growth cycle, i.e. from the 3rd to the 7th or 8th month. When there was no dry period during the growth cycle the starch content was not much affected by date of planting (**Table 7**); on average, the starch content ranged from 25.21% for Rayong 60 to 31.33% for Kasetsart 50.

3. Effect of Rainfall on Starch Yield

Average starch yields of all varieties were reduced by about 50% when plants were subjected to a prolonged dry period during the growth cycle, as compared with those receiving uniform rainfall without a long dry period (**Table 8** and **Figure 3**). When the crop was subjected to a long dry period, the lowest starch yield was obtained with Adira 4, and the highest with CMR30-56-1; without a dry period the lowest starch yield was obtained with Rayong 60 and the highest with Kasetsart 50.

Table 6. Starch content of five selected varieties when affected by a dry period during various stages of the growth cycle.

Planting date	Harvesting date	Total rainfall (mm)	Dry months[1] (month after planting)	Starch content (%)					
				Adira 4	Rayong 60	Rayong 90	Kasetsart 50	CMR 30-56-1	Average
29-Sep-96	21-Jul-97	1,780	9,10	27.40	28.20	30.12	29.20	28.80	28.74
24-Oct-96	29-Aug-97	1,656	8,9,10	29.20	28.32	31.50	27.87	28.26	29.03
18-Nov-96	17-Sep-97	1,561	7,8,9,10	24.94	26.18	25.44	24.72	24.22	25.10
26-Dec-96	17-Oct-97	1,412	6,7,8,9,10	22.86	25.28	22.24	21.88	20.94	22.64
24-Jan-97	11-Nov-97	1,059	5,6,7,8,9	16.86	19.68	17.04	18.22	12.15	16.79
28-Feb-97	29-Dec-97	1,094	4,5,6,7,8	11.08	20.00	17.06	16.44	15.18	15.95
24-Mar-97	19-Jan-98	789	3,4,5,6,7	11.86	16.22	19.36	17.90	14.47	15.96
29-Apr-97	26-Feb-98	1,407	2,3,4,5,6	12.20	21.25	19.10	22.25	19.50	18.86
23-May-97	23-Mar-98	1,719	1,2,3,4,5	18.90	19.50	21.70	20.70	20.10	20.18
25-Jun-97	25-Apr-98	1,869	1,2,3,4	17.00	17.85	19.20	20.05	17.75	18.37
30-Jul-97	13-May-98	2,012	1,2,3	18.16	16.17	15.80	20.60	16.00	17.35
5-Aug-97	5-Jun-98	2,080	1,2,10	17.86	19.16	20.46	19.40	18.86	19.15
9-Sep-97	7-Jul-98	2,212	1,9	16.20	17.80	16.80	18.00	20.00	17.76
25-Oct-97	27-Aug-98	2,323	8,10	21.10	26.30	22.50	18.00	23.50	22.28
24-Nov-97	30-Sep-98	2,385	7,9,10	20.20	24.00	24.50	21.40	22.90	22.60
28-Dec-97	27-Oct-98	2,157	6,8,9	18.80	22.70	20.60	21.30	22.50	21.18
20-Jan-98	22-Nov-98	1,928	5,7,8	21.40	23.60	24.10	24.90	26.30	24.06
28-Feb-98	28-Dec-98	1,285	4,6,7	22.20	21.70	24.50	24.30	23.50	23.24
14-Mar-98	12-Jan-99	2,063	3,5,6	22.20	21.70	24.50	24.30	23.50	23.24
1-Apr-98	5-Feb-99	1,992	2,4,5	20.90	23.40	23.50	24.00	23.30	23.02
5-May-98	5-Mar-99	2,025	1,3,4	26.33	24.18	25.42	26.95	25.02	25.58
5-Jun-98	5-Apr-99	2,086	2,3	22.70	25.10	26.40	24.70	25.30	24.84
5-Jul-98	5-May-99	2,095	1,2	25.70	27.30	26.70	29.10	26.50	27.06
Average		1,782		20.26	22.42	22.55	22.44	21.68	21.87

[1] <100 mm rainfall.

Table 7. Starch content of five selected varieties when not affected by a long dry period during the growth cycle.

Planting date	Harvesting date	Total rainfall (mm)	Dry months[1] (month after planting)	Starch content (%)					
				Adira 4	Rayong 60	Rayong 90	Kasetsart 50	CMR 30-56-1	Average
24-Jul-96	25-May-97	2,092	None	26.82	24.46	24.96	30.56	27.34	26.83
24-Aug-96	20-Jun-97	1,989	10	28.90	25.95	31.54	32.10	28.40	29.38
Average		2,041		27.86	25.21	28.25	31.33	27.87	28.10

[1] <100 mm rainfall.

Table 8. The effect of a long dry period during the growth cycle on the average starch yield of five selected varieties grown in Umas Jaya Farm, Lampung, Indonesia from 1996 to 1999.

Variety	Average starch content (t/ha)		Decrease due to drought	
	With dry period[1)]	Without dry period	Starch yield (t/ha)	(%)
Adira 4	4.72 a	11.46 b	6.74	59
Rayong 60	5.46 a	11.08 b	5.62	51
Rayong 90	5.46 a	11.94 b	6.48	54
Kasetsart 50	5.42 a	12.06 b	6.64	55
CMR30-56-1	6.09 a	11.98 b	5.89	49

[1)] two or more months with <100 mm rainfall.

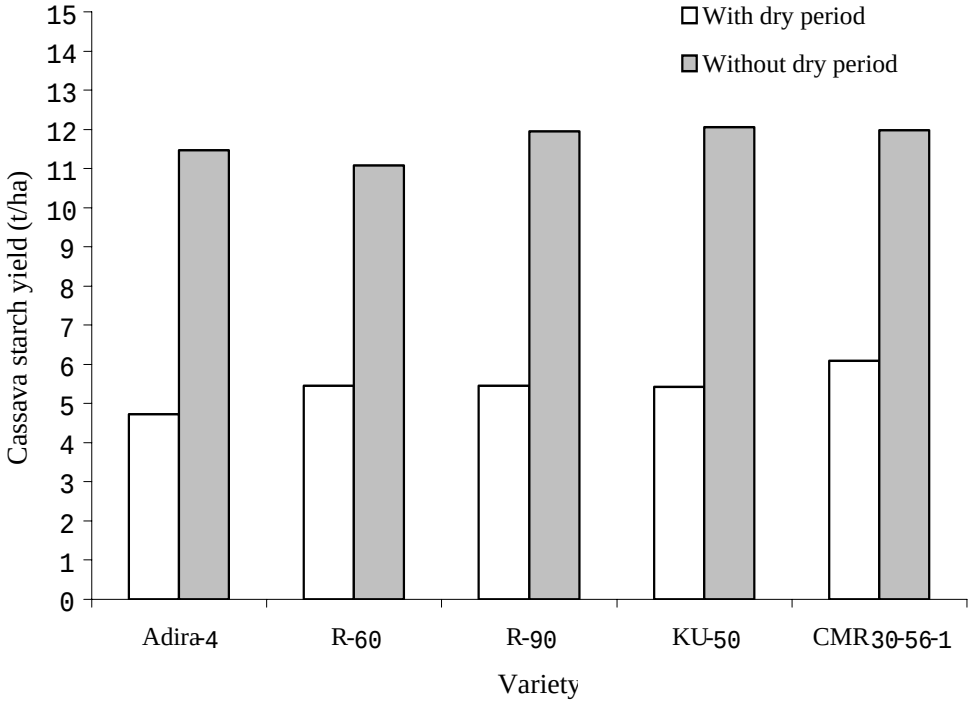

Figure 3. Effect of the presence of a prolonged dry period (two months or more of less than 100 mm rainfall) on the average starch yield of five selected cassava varieties grown in Umas Jaya Farm, Lampung, Indonesia from 1996 to 1999.

When affected by a dry period, CMR30-56-1 produced 29% more starch (1.37 t/ha) than Adira 4; under uniform rainfall distribution, the starch yield of CMR30-56-1 was only 4.5% higher (0.52 t/ha) than that of Adira 4. The starch yields of all four varieties were higher than those of Adira 4 when subjected to a dry period (**Table 8**). This indicates that Adira 4 was the least drought tolerant, while CMR 30-56-1 was the most drought tolerant variety.

The greatest reduction in starch yield was found when plants were subjected to a 5-month dry period, either from the 3rd to the 7th month or from the 4th to the 8th month after planting. When a prolonged drought occurred during these periods, starch yields were very low, ranging from 0.98 to 2.95 t/ha (**Table 9**). These yield were much lower than those obtained under a uniform rainfall distribution; these ranged from 10.88 to 13.61 t/ha (**Table 10**). Starch yields of Adira 4 were usually lower than those of the other tested varieties when subjected to a dry period of 2 to 5 months (**Table 9**).

Similar to fresh root yields, starch yields were also significantly reduced by an increase in the length of the dry period. There was a negative correlation between the length of the dry period and starch yields, with r-values ranging from 0.751 to 0.997 (**Figure 4**). Starch yields of Adira 4 were usually lower than those of other varieties when subjected to a dry period of more than two months.

Table 9. Starch yield of five selected varieties when affected by a dry period during various stages of the growth cycle.

Planting Date	Harvesting date	Total rainfall (mm)	Dry months[1] (month after planting)	Starch yield (t/ha)					
				Adira 4	Rayong 60	Rayong 90	Kasetsart 50	CMR 30-56-1	Average
29-Sep-96	21-Jul-97	1780	9,10	6.34	4.86	7.47	5.27	6.50	6.09
24-Oct-96	29-Aug-97	1656	8,9,10	5.16	6.35	7.91	7.49	9.85	7.35
18-Nov-96	17-Sep-97	1561	7,8,9,10	5.32	7.35	5.42	6.68	7.22	6.40
26-Dec-96	17-Oct-97	1412	6,7,8,9,10	4.27	5.00	4.18	4.81	4.94	4.64
24-Jan-97	11-Nov-97	1059	5,6,7,8,9	1.99	3.64	2.38	3.28	2.63	2.78
28-Feb-97	29-Dec-97	1094	4,5,6,7,8	0.98	2.95	2.39	2.58	2.64	2.31
24-Mar-97	19-Jan-98	789	3,4,5,6,7	1.11	2.91	2.23	2.19	2.07	2.10
29-Apr-97	26-Feb-98	1407	2,3,4,5,6	3.54	5.95	3.07	3.50	4.18	4.05
23-May-97	23-Mar-98	1719	1,2,3,4,5	2.28	5.17	3.12	3.59	5.21	3.87
25-Jun-97	25-Apr-98	1869	1,2,3,4	4.97	5.22	4.63	4.32	5.56	4.94
30-Jul-97	13-May-98	2012	1,2,3	3.10	2.53	0.97	2.84	3.22	2.53
5-Aug-97	5-Jun-98	2080	1,2,10	2.31	3.21	3.63	3.40	3.84	3.28
9-Sep-97	7-Jul-98	2212	1,9	3.34	2.50	2.08	4.34	4.94	3.44
25-Oct-97	27-Aug-98	2323	8,10	5.33	5.08	4.49	2.37	6.32	4.72
24-Nov-97	30-Sep-98	2385	7,9,10	5.09	4.80	6.32	5.18	8.41	5.96
28-Dec-97	27-Oct-98	2157	6,8,9	5.12	6.62	5.41	6.16	5.69	5.80
20-Jan-98	22-Nov-98	1928	5,7,8	6.42	5.88	5.07	6.93	3.16	5.49
28-Feb-98	28-Dec-98	1285	4,6,7	5.99	6.06	4.87	5.76	6.57	5.85
14-Mar-98	12-Jan-99	2063	3,5,6	7.66	7.32	8.11	8.09	8.11	7.86
1-Apr-98	5-Feb-99	1992	2,4,5	6.74	5.85	5.58	7.36	8.57	6.82
5-May-98	5-Mar-99	2025	1,3,4	7.85	7.87	11.57	9.21	11.59	9.62
5-Jun-98	5-Apr-99	2086	2,3	5.42	7.82	12.92	7.57	9.36	8.62
5-Jul-98	5-May-99	2095	1,2	8.29	10.72	11.81	11.80	9.43	10.41
Average		1782		4.72	5.46	5.46	5.42	6.09	5.43

[1] <100 mm rainfall.

Tabel 10. Starch yield of five selected varieties when not affectedby a dry period during the growth cycle.

Planting date	Harvesting date	Total rainfall (mm)	Dry months[1] (month after planting)	Starch yield (t/ha)					
				Adira 4	Rayong 60	Rayong 90	Kasetsart 50	CMR 30-56-1	Average
24-Jul-96	25-May-97	2092	None	11.55	11.28	12.15	10.51	11.99	11.50
24-Aug-96	20-Jun-97	1989	10	11.36	10.88	11.73	13.61	11.96	11.91
Average		2041		11.46	11.08	11.94	12.06	11.98	11.70

[1] <100 mm rainfall.

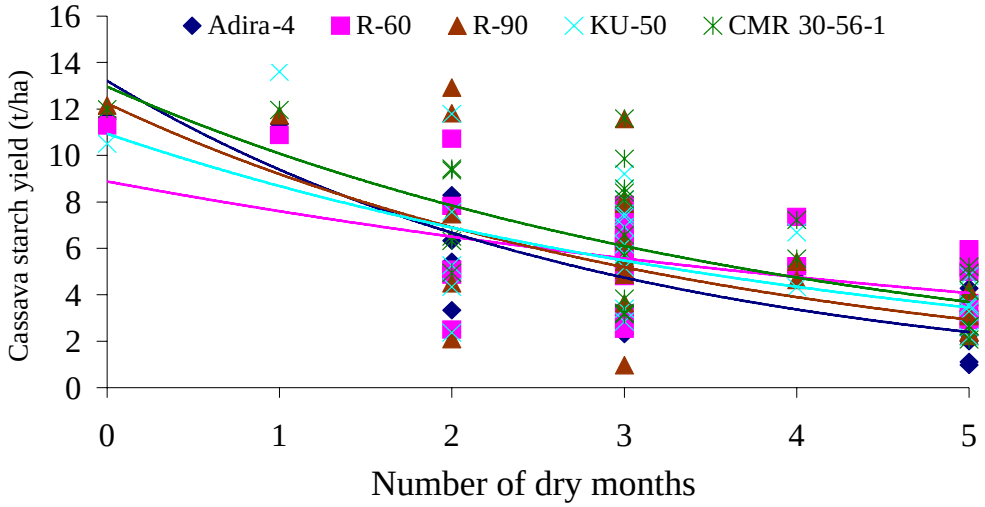

Figure 4. Effect of the duration of the dry period (less than 100 mm rainfall per month) on the starch yields of five selected cassava varieties grown in Umas Jaya Farm, Lampung, Indonesia from 1996 to 1999.

CONCLUSIONS

1. When subjected to a dry period during the growth cycle, both the fresh root yield and starch yield of all tested varieties decreased; when subjected to a long dry period, especially during the middle of the growth cycle, the root starch content also decreased.
2. Under non-uniform rainfall distribution, the fresh root yield of Rayong 60, Kasetsart 50 and CMR30-56-1 were much higher than that of Adira 4, and the starch yields of all four varieties were higher than that of Adira 4. Under uniform rainfall distribution, starch yields of Rayong 90, Kasetsart 50 and CMR30-56-1 were higher than these of Adira 4 and Rayong 60.
3. A dry period from the 3rd to the 7th month after planting is the most critical in reducing both the root and starch yields of all tested varieties.

4. The average root starch content of all varieties was generally higher when the crop was subjected to 1-3 dry months before harvest than when there was no dry period; this was not the case, however, for Kasetsart 50.
5. Among the five varieties tested, Adira 4 was found to be the least drought tolerant, while CMR 30-56-1 was considered the most drought tolerant variety.

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