KENAF OBSERVATIONS 1951-1952 AT THE LOWLANDS AGRICULTURAL EXPERIMENT STATION, EPO.

BY T. SORENSEN, B.Sc. (Agr.).*

IN view of the Territory wide interest in Kenaf (*Hibiscus cannabinus*) as a fibre crop, a small trial was carried out in the 1951-1952 season at the Lowlands Agricultural Experiment Station, Epo. The aim of the trial was to gather as much information as could be obtained from the limited resources, on the basic cultural requirements of Kenaf as a crop in this district. The following is an account of the trial and its results :—

An experiment of this nature must of necessity be carried out over several seasons in order to properly assess the relative importance of the various agronomic practices under consideration and their effect on economic Kenaf production. These results cover a period of one season only, and can only be regarded as an initial survey.

From a perusal of the available literature, it would appear that throughout the world there is considerable difference of opinion as to the most favourable sowing rates and planting distances of Kenaf as an economic crop. Watkins (12) in his observations in El Salvadore concluded that a spacing of 12 inches x 12 inches (54 plants/square yard) was the best of all those tried, and his results are approximated by those of David (7) who recommends that 50 plants/ square metre is the best sowing rate for conditions in the Philippines. Crane (2) makes the recommendation of a sowing rate of 25 to 30 lb. per acre in 12 inch rows for Cuba, and Crane et al (6) also for Cuba recommends 30 to 35 lb. per acre but in eight inch rows. Walker and Sierra (11) found that the fibre yield increases as the widths between the rows are lowered from 16 inch through 8 inch to 4 inch. They further state that extre row spacings of 5 to 10 plants per row foot brought about no differences to the productivity of the crop. From this evidence it would appear that the factor of plant density is more important than absolute and definite inter and intra-row spacings.

An attempt was made here to evaluate the agronomic effects of the spacing factor under Epo conditions.

Method.—

The size and scope of this trial was severely limited by the amount of seed available. As seed was in poor supply the experimental design as planned was that of a randomized block containing six treatments and four replications, but with the plots arranged in such a manner so that the experiment could be converted into a split plot design, should a further supply of seed be procured, with the date of planting as the major treatment. A further seed supply was later obtained and a second plot sowing made, but this was carried out far too late in the season, and at a time when the photoperiod requirements of an economic crop could not be met. Thus the results, though presented, have little practical interest.

The first planting was made over the period 22nd to 27th November, 1951, and the second, carried out only for seed, from the 15th to 26th February, 1952. Each of these plantings covered 24 plots of 1/40th acre area covering six spacing treatments with four replications. All plots were randomized. The spacing treatments were 7 in. x 2 in., 14 in x 2 in., 14 in. x 4 in., 21 in. x 2 in., 21 in. x 4 in. and 28 in. x 8 in. respectively. As the seed viability was first ascertained to be only 41 per cent., 4 to 5 seeds were planted per hole and the excess plants thinned out when their height was 6 to 8 inches.

* Agronomist-in-Charge, Agricultural Experiment Station, Epo, Papua.

However, although the sowings were first commenced following a heavy fall of rain, no further rain was recorded for a period of six weeks and the germination was affected. The final germination obtained was only of the order of 11-12 per cent., which produced a great number of gaps in the stand for which no further seed was available for replanting. The intended spacings could not be achieved, and the analysis and interpretations of the results, recourse is had to the average density of plants per square yard of the plots as the criterion for comparison. The second planting made with newer seed and under more favourable conditions for germination, gave a germination percentage of 86 per cent., and this difficulty was not encountered.

The land selected for the trial had only one crop of rice grown on it in the previous season, before which it was virgin country. It was given a preparation consisting of two deep ploughings to 9 inches and two horrowings with a tandem disc machine prior to sowing in the case of the November sowing, and a further two harrowings to keep down weeds in the case of the February sowing. Planting was carried out by hand, and at the same time the few small weeds on the plots were likewise removed. No subsequent treatment was given to the crop until the time to harvest.

In the case of the crop of the first planting date, the plots at maturity were divided into two, one-half being harvested for fibre production, and the other half left for later seed production. The February planting, however, was harvested for seed only, the Experimental Station at that time requiring all the seed it could produce.

No fertilizer treatment was given to the plots.

Results.—

The November planting was commenced following a heavy fall of rain, but no further precipitation occurred for the following six weeks and the rapid drying of the land hindered germination. The surface soil became completely dry and these unfavourable climatic conditions early in the life of the crop are shown clearly in the growth figures. For instance, the average height in the plots of the 7 inch row spacing was only 18 inches at 30 days of age, 46 inches at 50 days, 69 inches at 65 days and the plots finally reached a maximum height of 93 inches. A slight wilting of the plant apices was noticed on the many hot and clear days. The February sown plots gave very satisfactory germination within three days from sowing and the crop, with the exception of the photoperiod, had ideal weather conditions for growth right thoroughout its life. In spite of the denser stand, which should have favoured taller growth, these plots only reached a maximum height of 68 inches, which is highly unsatisfactory, and which is considered a result of the unfavourable photoperiod.

Both crops experienced waterlogged conditions for periods of up to three weeks. without showing any noticeable effect.

SUMMARY OF RESULTS : PLOTS OF THE NOVEMBER PLANTING. TABLE 1

Block	Treatment	Inter-row spacing inches	Average intra-row spacing inches	Average plant height at 50 days inches	Average plant height at maturity inches	Density plants/ sq. yard	No. of plants in plot	No. of plants branching	No. of plants borer attacked	No. of plants branching naturally	Total percentage branching	Total percentage borer attacked	Adjusted percentage natural branching	Seed Yield ozs/plot	Yield green weight lbs/ 1/80 acre	Percentage fibre recovery	Yield of fibre tons/acre
1	J	28	18.64	12	75	2.55	309	66	42	24	21.36	13.59	11.03	8	495	3.54	0.62
4	J	28	10.72	15	75	4.45	539	193	113	80	35.75	20.67	31.67	5	388	4.37	0.61
2	J	28	10	19	75	4.74	573	237	162	75	40.01	28.27	34.29	7	409	5.21	0.76
3	I	21	12.47	22	75	5.03	608	208	156	52	34.21	25.66	17.68	31	449	3.75	0.60
2	F	21	12.63	26	75	5.03	608	248	160	88	40.8	26.32	37.63	64	446	6.25	1.59
3	J	28	9.41	15	75	5.05	612	168	99	69	27.45	14.54	22.43	28	492	4.17	0.73
2	I	21	12.47	24	75	5.09	616	284	236	48	46.1	38.31	26.18	7	591	4.58	0.97
4	F	21	13.06	19	75	5.26	636	256	168	88	40.25	26.26	37.07	12	475	2.29	0.04
3	F	21	10.11	28	75	6.28	760	208	100	108	27.37	13.16	28.42	43	553	2.50	0.49
1	F	21	11.25	18	81	5.65	684	104	64	40	15.2	9.36	9.59	12	513	5.42	0.99
1	G	14	16	24	84	5.95	720	138	66	72	19.17	9.3	16.60	15	521	5.00	0.93
1	I	21	11.78	18	78	6.21	75.2	172	88	84	22.87	11.57	21.00	4	490	6.04	1.06
2	G	14	11.16	26	81	8.53	1032	222	150	72	21.51	14.54	17.44	20	573	3.33	0.68
4	I	21	8.07	16	75	6.48	784	256	180	76	32.65	22.96	27.14	19	530	6.25	1.18
4	G	14	6	28	81	11.80	1428	240	174	66	16.81	12.18	12.66	15	533	5.21	0.99
3	G	14	5.3	38	78	15.87	1920	132	78	54	6.88	4.06	5.01	44	491	5.00	0.88
1	H	14	9.8	28	84	17.20	2081	339	201	138	16.29	9.61	19.96	13	563	6.63	1.13
2	H	14	4.42	17	81	21.55	2608	456	344	112	17.48	13.19	18.99	6	746	4.58	1.22
4	H	14	4.01	27	78	23.75	2874	522	414	108	18.16	14.40	19.31	6	649	6.04	1.40
3	H	14	3.29	36	78	28.96	3504	246	150	96	7.04	4.25	6.85	15	581	6.88	1.43
4	E	7	5.12	32	81	36.41	4406	517	352	165	11.28	7.99	16.92	21	603	7.08	1.53
3	E	7	5.26	42	74	40.40	4889	364	270	94	7.45	5.25	7.03	42	682	6.88	1.68
2	E	7	4.26	35	90	43.80	5299	670	400	270	12.63	7.55	21.70	24	635	11.26	2.53
1	E	7	3.94	46	93	47.26	5718	94	82	12	1.64	1.43	0.38	10	635	6.46	1.46

SUMMARY OF RESULTS : PLOTS OF THE FEBRUARY PLANTING. TABLE 2

Block	Treatment	Row spacing	Average number plants per row	Average spacing plants in row	Average height plants at maturity	Density (plants sq. yard)	Number plants in plot	Number plants branching	Number plants borer attacked	Number plants branching naturally	Yield Seed ozs. 1/40th acre
1	G	14 in.	291	1.64 in.	61 in.	57.72	6984	840	672	168	11
2	G	14 in.	450	1.06 in.	55 in.	89.25	10800	240	72	168	23
3	G	14 in.	492.7	0.97 in.	53 in.	97.7	118.24	288	72	216	22
4	G	14 in.	450	1.06 in.	48 in.	89.25	10800	192	96	96	24
1	E	7 in.	308.37	1.55 in.	59 in.	119.8	14491	1175	799	376	13
2	E	7 in.	427.6	1.12 in.	58 in.	166.2	20100	188	94	94	21
3	E	7 in.	446.7	1.07 in.	54 in.	173.5	20993	282	94	188	16
4	E	7 in.	347	1.38 in.	54 in.	134.8	16309	282	94	188	15
1	F	21 in.	430.62	1.11 in.	59 in.	56.94	6890	288	192	96	9
2	F	21 in.	526.6	0.91 in.	60 in.	69.63	8426	336	80	256	32
3	F	21 in.	423.6	0.91 in.	61. in.	69.23	8378	128	32	96	16
4	F	21 in.	482.3	0.99 in.	58 in.	63.78	7717	80	48	32	8
1	J	28 in.	691	0.69 in.	62 in.	68.53	8292	552	228	324	11
2	J	28 in.	426.7	0.98 in.	54 in.	48.26	5840	396	108	288	35
3	J	28 in.	518	0.92 in.	56 in.	51.37	6216	156	24	132	22
4	J	28 in.	468.7	1.02 in.	60 in.	46.47	5624	48	24	24	11
1	H	14 in.	625	0.76 in.	56 in.	118.3	14375	782	322	460	20
2	H	14 in.	342	1.40 in.	57 in.	67.82	8208	552	120	432	49
3	H	14 in.	375.7	1.27 in.	56 in.	74.50	9016	168	48	120	5
4	H	14 in.	545.7	0.87 in.	63 in.	108.1	13096	168	96	72	32
1	I	21 in.	546.3	0.87 in.	54 in.	108.3	13112	1296	96	1200	15
2	I	21 in.	388.6	1.23 in.	55 in.	51.4	6218	432	64	368	29
3	I	21 in.	492	0.97 in.	49 in.	65.06	7872	64	48	16	5
4	I	21 in.	541	0.88 in.	56 in.	71.53	8656	176	112	64	21

A. YIELD OF SEED IN RELATION TO TIME OF PLANTING

The total yield of seed from all plots of the first, or late November plantings, was 470 ounces from three-tenths of an acre, whereas the seed yield from all plots of the second, or late February planting was 465 ounces, but from six-tenths of an acre. (In the November planting one-half of each plot was harvested for fibre.) Thus it can be clearly seen that the seed yield from the first planting was approximately double that obtained from the second, in spite of the fact that a much better and much more uniform stand of plants was obtained from the plots of the latter. The superiority in this regard of the November planting is outstanding so much so in fact that an analysis of this aspect of the experiment was not considered necessary.

The evenness of seed maturity did not seem to be effected by the planting dates, and both groups of plots matured their capsules over a period of approximately two months. The capsules clung well to the plant and did not shatter, even when lashed by heavy rains, but they suffered considerable damage from the depredations of the cotton staining insects, which were extremely numerous.

The plots of the first planting were harvested for seed as soon as all capsules were dry, and harvesting commenced on the 17th June, 1952, or 200 days after the completion of germination. The plots of the second planting were ready for seed harvesting on the 30th July, 1952, or 152 days after completion of germination, but they were not harvested until a fortnight later. Thus the effect of the photoperiod was clearly apparent, the difference in maturity being approximately 50 days.

The total seed yield was extremely poor and averaged only 83.6 lb./acre. The first planting averaged 97.9 lb./acre, over all the plots, and the second planting only 48.5 lb./acre. This is very unsatisfactory and in the case of some of the plots in the second planting was even less than the amount sown. The failure of the crop to yield seed is a serious drawback to a possible kenaf industry in this area and unless a much greater yield can somehow be obtained the possibility of commercial production will be hindered somewhat by the cost of seed importation.

The harvesting for seed was carried out by hand cutting the stems of the Kenaf at ground level and feeding them into a hand-driven Lewis Grant Rice Thresher, the operation being similar to that in the heckling of broom millet. This was followed by winnowing. The operation was satisfactory, but labour consuming.

B. YIELD OF SEED IN RELATION TO PLANT DENSITY.

The results of the two planting dates will be discussed separately as the respective plant densities do not allow for comparison.

1. *Late November Planting.—*

The results of the individual plots are set out in Table 3. As half of each of these plots were harvested for fibre the figures are expressed in ounces per one-eightieth of an acre.

TABLE 3

TREATMENT.

Block		G	E	F	J	H	I	Total	Mean
	Inter-row spacing	14″	7″	21″	28″	14″	21″		
	Mean Intra-row spacing	10.31″	4.65″	11.76″	12.19″	4.26″	11.67″		
	Mean Plant Density	10.54	41.97	5.56	4.20	22.37	5.70		
1		15	10	12	8	13	4	62	10.33
2		20	24	64	7	6	7	128	21.33
3		44	42	43	28	15	31	203	33.83
4		15	21	12	5	6	19	78	13
Total		94	97	131	48	40	61	471	
Mean		23.5	24.25	32.75	12	10	15.25		19.625

Table 4 is the summary of the statistical analysis of Table 3.

TABLE 4

ANALYSIS OF VARIANCE.

Factor	Sum of Squares	Degrees of Freedom	Variance	F.
Treatments	1515	5	303	2.37
Blocks	2010	3	670	5.22
Error	1927	15	128.5	....
Total	5452	23	....	....

Thus the differences between the blocks is critical and approaches the 0.1 per cent. level, whereas the differences due to the treatment just fails to reach significance. It must be supposed that the treatment effect is masked by that of the block, and this will be discussed more fully later. Although the Kenaf crop is usually affected by soil variability, by far the most important factor producing this variation between the blocks is that of insect attack, especially attack by the *Earies* tip borer.

When the yield of seed per plot is arranged in accordance with plant density (as on Table 1) and then grouped into the respective categories, the following is the result :—

When plant density is 1 to 10, mean seed yield = 39.29 ounces.
When plant density is 10 to 20, mean seed yield = 46 ounces.
When plant density is 20 to 30, mean seed yield = 16 ounces.

When plant density is 30 to 40, mean seed yield = 43 ounces.

When plant density is 40 to 50, mean seed yield = 50.67 ounces.

This gives a correlation co-efficient of 0.640 which though not of very high order, points out the fact that within the limits of the experiment, there is a small rise in the yield of seed with an increasing plant density. This supports the results of the analysis of variance (Table 5) where the treatment differences just failed to reach the level of significance. With a much greater increase in plant density the yield of seed would presumably fall again, but the plant densities just discussed did not reach the critical point.

2. *Late February Planting.*

The results of the individual plots are set out in Table 5. The yield figures are expressed in ounces per plot of one-fortieth of an acre.

TABLE 5

TREATMENT.

		G	E	F	J	H	I		
	Inter-row spacing	14″	7″	21″	28″	14″	21″		
	Mean Intra-row spacing	1.18″	1.38″	0.98″	0.90″	1.08″	0.99″	Total	Mean
Block	Mean Plant Density	83.47	148.6	64.91	53.69	92.28	78.21		
1		11	13	9	11	20	15	79	13.17
2		23	21	32	35	49	29	189.	31.5
3		22	16	16	22	5	5	86	14.33
4		24	15	8	11	32	21	111	18.5
Total		80	65	65	79	106	70	465	
Mean		20	16.25	16.25	19.75	26.5	17.5		19.38

Table 6 is the summary of the statistical analysis of Table 5.

Table 6.

ANALYSIS OF VARIANCE.

Factor	Sum of Squares	Degrees of Freedom	Variance	F.
Treatment	297.4	5	59.48	....
Blocks	1270.5	3	423.5	6.5
Error	981.7	15	65.44	....
Total	2549.6	23	....	....

Thus there are no significant differences between the treatments of the second planting, but the differences due to blocks are highly significant. It is assumed that the former is due mainly to the lateness of the planting, whereas the latter results from soil and insect damage variability.

C. YIELD OF FIBRE IN RELATION TO PLANT DENSITY.

Only the plots of the first planting were harvested for fibre, as the plots of the second plantings were required for seed. The first flowers were noticed on these plots on the outside rows on the 28th February, 1952, or 96 days after the first of the germination. Twenty days later the plots planted in 28 inch rows were flowering uniformly, and inside rows in the others were only just starting to come in. By the 23rd March the plots were ready to be harvested for fibre, 116 days after completion of the germination. It is quite apparent from the observations that maturity can be considerably hastened by increasing the available light to the plants by wider spacings and less plant densities.

Harvesting was carried out on the 24th March, the plants being slashed by hand at ground level.

The following table gives the yield of green weight and the figures are expressed in pounds per plot of one-eightieth of an acre. The weights were taken with the plants in a badly wilted condition.

TABLE 7

TREATMENT.

		G	E	F	J	H	I	
	Inter-row spacing	14″	7″	21″	28″	14″	21″	
	Mean Intra-row spacing	10.31″	4.65″	11.76″	12.19″	4.26″	11.67″	Total
Block	Mean Plant Density	10.54	41.97	5.56	4.20	22.87	5.70	
1		521	635	513	495	563	490	
2		573	635	446	409	746	591	
3		491	682	553	492	581	449	
4		533	603	475	388	649	530	
Total								13.043

This gives an overall average production of wilted green matter of 53,476.80 lb. per acre.

From the visual inspection of the stems at the time of harvest, it would appear that the plots of greater plant density produced the better fibre yield. With these the stems are straighter and finer and with a much lesser degree of branching. At the harvest all plots were showing slight to moderate lodging, with the lesser densities less affected than the others.

Thirty pounds of stalks of each plot were selected at random and subjected to tank retting individually in drums. The yield of pure fibre obtained is as follows, and is expressed in ounces per plot sample. Sampling is not considered quite satisfactory but the entire produce from the plots could not be handled by the station's facilities.

TABLE 8

Yield of Fibre per 30lb. sample—

TREATMENT

Block	G	E	F	J	H	I
1	24	31	26	17	27	29
2	16	54	30	25	22	22
3	24	33	12	20	33	18
4	25	34	11	21	29	30

Retting was resorted to as no decorticator is present on this Station, but this method of fibre preparation was found to be far from satisfactory as the fibre produced, though apparently of good quality, was somewhat discoloured. A better sample was produced when only the stalk ribbons were retted, and an extremely good and very clean sample was produced by hand decortication. Retting in ground water was not found as satisfactory as tank retting, and dew retting was completely unsuitable. A point worth noting in tank retting is that the water should be changed at least twice during the process. Tank retting in this case required 29 days for completion, but a week less would be sufficient for plots of the closer spacing.

In order to compare the percentage recovery of fibre from the various plots the following table was prepared (Table 9). Figures are in percentages.

TABLE 9

Percentages Fibre Recovery—

TREATMENT.

		G	E	F	J	H	I		
	Inter-row spacing	14″	7″	21″	28″	14″	21″		
	Mean Intra-row spacing	10.31″	4.65″	11.76″	12.19″	4.26″	11.67″	Total	Mean
Block	Mean Plant Density	10.54	41.97	5.56	4.20	22.87	5.70		
1		5.00	6.46	5.42	3.54	5.63	6.04	32.09	
2		3.33	11.26	6.25	5.21	4.58	4.58	35.21	
3		5.00	6.88	2.50	4.17	6.88	3.75	29.18	
4		5.21	7.80	2.29	4.37	6.04	6.25	31.24	
Total		18.54	31.68	16.46	17.29	23.13	20.63	127.72	
Mean		4.635	7.92	4.115	4.323	5.783	5.155		5.32

The overall average recovery of fibre from whole wilted plants =5.32 per cent.

The following is the summary of the statistical analysis of the above.

TABLE 10

ANALYSIS OF VARIANCE.

Factor	Sum of Squares	Degrees of Freedom	Variance	F.
Treatments	39.48	5	7.896	3.35
Blocks	2.91	3	0.97	....
Error	35.31	15	2.354	....
Total	77.70	23	...	...

Therefore there is a significant difference in the percentage recovery of fibre when the various spacing treatments given are compared. The variation between the block is so minute that it can be completely ignored, which proves the effectiveness of the method of tank retting.

The critical difference in the percentage recovery between the various treatments is evaluated to be 9.25.

Thus it can be seen from the above that in the factor of percentage fibre recovery from retting, plots of an average density of 41.97 give a far superior yield to the others, whose differences amongst themselves do not reach significance.

From the figures listed on Table 1, it is obvious that percentage fibre recovery increases slightly with increasing plant density within the limits of this experiment, and under these experimental conditions of relatively poor plant stand and high insect attack. The high order correlation co-efficient is 0.8143.

The fibre yield for the plots was calculated and the figures presented in Table 11 for analysis.

TABLE 11

YIELD FIBRE.

TREATMENT.

		G	E	F	J	H	I		
	Inter-row spacing	14″	7″	21″	28″	14″	21″		
	Mean Intra-row spacing	10.31″	4.65″	11.76″	12.19″	4.26″	11.67″	Total	Mean
Block	Mean Plant Density	10.54	41.97	5.56	4.20	22.87	5.70		
1		0.93	1.46	0.99	0.62	1.13	1.06	6.19	
2		0.68	2.53	1.59	0.76	1.22	0.97	7.75	
3		0.99	1.68	0.49	0.73	1.43	0.60	5.75	
4		3.48	7.20	0.04	0.61	1.40	1.18	25.50	
Total		0.87	1.80	3.11	2.73	5.18	3.81	5.81	
Mean		1.53	0.88	0.7875	0.68	1.295	0.9525		1.0625

The following Table 12 is the summary of the statistical analysis of the above.

TABLE 12

ANALYSIS OF VARIANCE.

Factor	Sum of Squares	Degrees of Freedom	Variance	F.
Treatment	3.50	5	0.70	4.9
Block	0.44	3	0.137	....
Error	2.15	15	0.143	....
Total	6.09	23	...	...

Thus there is a highly significant difference in the effect of the various treatments on yield of fibre, and the critical difference between the various treatments is 2.28 with the densely spaced group of plots significantly out-yielding all the others with the exception of the group immediately below it.

D. FIBRE YIELD IN RELATION TO PLANT DENSITY.

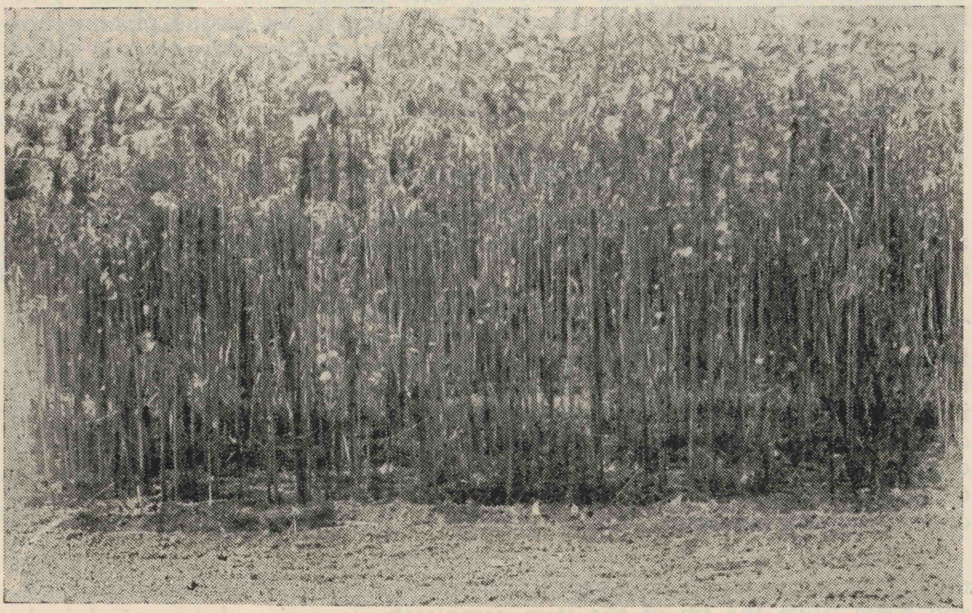
From the information listed on Table 1 it was calculated that fibre yield and plant density have a high order positive correlation of 0.842.

The chief notable drawback of this experiment was that the density range did not reach a sufficient magnitude.

The average yield of fibre per acre was only 1.06 tons, and the maximum yield recorded was 2.53 tons. This compares with the world average.

E. HEIGHT OF THE CROP IN RELATIONSHIP TO THE PLANT DENSITY.

From the figures given in Table 1 for the November planting, it is quite apparent that increased plant height results from increased plant density in accordance with the theory. In the first planting the 7 inch row spacings gave



FIBRE CROP OF KENAF READY TO HARVEST AT LALOKI NEAR PORT MORESBY.

the longest length of stem, followed by the 14 inch row spacings and the denser of the 21 inch spacings. The less dense 21 inch and 28 inch gave the least. Even so, the plant height in all cases was somewhat disappointing, and the tallest block gave only a final 93 inches.

With the second planting the differences in plant height were not apparent. This may have been due to the time of planting, but the greater density and uniformity of the plots is probably a contributing factor. Here the tallest plot gave only an average height of 63 inches.

F. NATURAL BRANCHING IN RELATION TO PLANT DENSITY.

From the figures in Table 1, the two factors of percentage natural branching and plant density were found to have a correlation co-efficient of 0.7571. This correlation is not as high as should be expected and which past work in other countries with similar crops would indicate. It is considered that factors other than that of plant density are also influencing the degree of natural branching in these plots. One such would be the degree of insect attack, especially that of the tip borer, which, by stunting temporarily some of the plants in the block, would tend to increase branching in the unattacked adjoining plants.

The figures in Table 1 were taken on the 10th January, 1952, when the plants were 47 days of age. A further count was made on the 18th March, 1952, but the figures for this are practically meaningless as much of the evidence of borer attack had disappeared, the plant tissues having healed. Thus for these figures it cannot be stated with any certainty whether the branching occurred naturally or was caused by borer attack. The figures for the adjusted percentage of natural branching in Table 1 were obtained by calculating the proportion of plants which would have branched naturally, but which were first attacked by borer, and adding these to the direct count of those plants which did branch naturally.

A similar count was also made for the plots in the second planting and the figures are given in Table 2. However, these plots were very uniform and both borer attack and natural plant branching were negligible in comparison. Also because of the much increased densities of the plots in the second planting, the two groups of figures cannot be directly compared to evaluate differences in regard to this aspect.

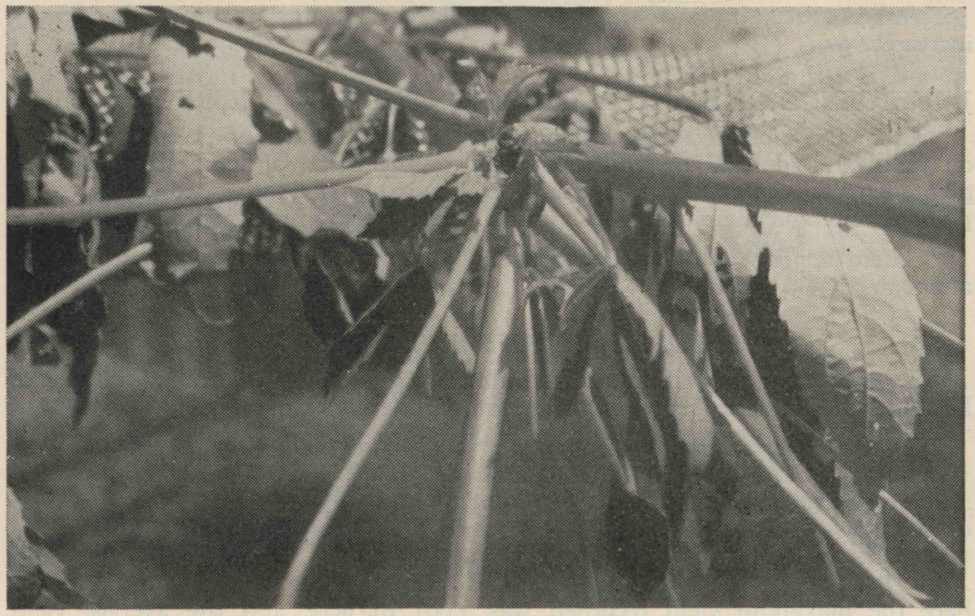
There was no evidence of any bifurcation in any plot.

G. INSECT DAMAGE.

A total of 17 insect species were observed attacking these Kenaf crops and it is obvious that the plant is most attractive particularly to HEMIPTERA and COLEOPTERA.

The insects comprised species of LEPIDOPTERA, COLEOPTERA, HEMIPTERA and ORTHOPODA. With the exception of two, they were foliage feeders, but, although foliage attack was very noticeable, the plants did not seem to suffer to any great extent. There were two species of considerable economic importance, the first being the cotton staining bug. This insect seems to cause considerable damage to the seeds, as it punctures through the young developing capsule into the ovule and its attacks are followed by secondary fungal development on the capsule. Much of the lack of seed yield could be the result of such depredations, and a trial to see whether this is so should be carried out.

The other serious insect pest, and which has been given great attention in these trials is the *Earias* tip borer. It attacked the plants in all stages of growth and bores down the tip of the stem completely destroying the terminal buds. This causes the plants to branch profusely, seriously diminishing the plant height



STANDING KENAF PLANT SHOWING DAMAGE BY BORER. (Note multiple branching.)

and the yield and the quality of fibre. Damage was particularly profound when the plants were attacked while still young. Depredations were very severe for the plots of the first planting but were insignificant on those of the second planting where the pest was of no longer of economic importance. However, as the second planting date has obviously an unsuitable photoperiod for the crop, and as the plots of the attacked planting far outyielded those of the other in both seed and fibre production, there can be no benefit in arranging the date of sowing to avoid attack by this pest.

The decline in attack could be attributed to parasites, which were probably helped by the drier weather. A chalcid wasp was bred out from attacked caterpillars.

H. INFLUENCE OF PLANT DENSITY ON BORER DAMAGE.

From the figures listed in Table 1, it can be calculated, that the factors of plant density and percentage plant attack by borers are correlated with a positive co-efficient of 0.7444.

The regression of the percentage borer attack on plant density is analysed in Table 13.

TABLE 13.

Factor	Sum of Squares	Degrees of Freedom.	Variance	F.
Regression	1063	1	1063	27.32
Error	856	22	38.9	....
Total	1919	23	....	....

Thus it can be readily seen that regression is highly significant, and that the percentage attack by borer in the plot falls considerably as the plant density increases.

J. INFLUENCE OF BORER DAMAGE ON YIELDS OF FIBRE AND SEED.

From the tabulated figures it can be seen that by far the greatest influence on yield of fibre from these Kenaf stands of the first planting is the factor of plant density. In its turn, the borer damage is also influenced considerably by plant density and there is obviously a multiple correlation between the three.

There appears to be no relationship whatsoever between percentage borer attack and yield of seed.

SUMMARY AND DISCUSSION.

1. An account is presented of a cultural trial with Kenaf carried out at the Lowlands Agricultural Experiment Station, Epo, Papua, in the 1951-1952 season.

2. The reported yields of fibre per acre are 1,000 to 3,000 lb. in Cuba (Crane[2]), 1,561 to 6,245 in India (Michotte), 3,300 to 6,600 in India (David[7]), 3.123 in Egypt, 1,296 in Rhodesia (Walters) and 3,103 lb./acre (Ergle[8]). The experiments of Crane and others (6) in Cuba gave a maximum yield of 5,569 lb./acre, whereas those of Walker and Sierra (11) gave a maximum of 3,603 and 3,296 lb./acre in 1946 and 1947 respectively. In the experiment presented here the maximum yield recorded was 5,667 lb./acre, and the average yield from the four plots with plant densities of between 40 and 50 plants/square yard was 4,032 lb. fibre per acre. Thus the yield of fibre compares very favourably to those of the recognized Kenaf producing countries. This is a somewhat remarkable conclusion when the factors of the unfavourable season for the first half of the crop growth, the great insect damage, the apparent lack of plant height, and the deficiency of density of the plants per square yard are considered. Although the results presented here are only those of a single season's investigations, it would seem that in spite of the obvious deterents to Kenaf growth which prevailed, the crop can be grown for fibre in this locality with yields highly favourable in comparison with those obtained elsewhere.

3. In regard to the influence of plant density on yield of fibre, the highest yield of fibre per acre was obtained from the four plots with an average plant density of 41.97 per square yard and this was the highest plant density of any group of plots which could be considered in this section of the experiment. On analysis the differences in yield of fibre from plot groups with a mean average density of 41.97, 22.87, 10.54, 5.70, 5.56 and 4.20, were highly significant, with the first far above the others, and the second only significant in comparison to the last. The critical difference was of the order of 0.57 tons/acre. A correlation of 0.842 was obtained between the factors of plant density and fibre yield. This experiment did not carry the plant densities to a level as high as their critical effect on fibre yield, but this is due to circumstances which have been previously enumerated.

4. A very interesting indication in this experiment was that the differences in the percentage fibre recovery of the plots were significant when the latter were grouped into their respective densities. The 41.97 density group gave a far higher percentage recovery (7.92 per cent.) than any of the others. The average percentage recovery was 5.32 per cent. from all plots. This former compares with the 5.5 per cent. recovery reported by Crane and Acuna (3) when it is considered that here the weight was taken with the plants in a wilted condition, whereas in the Cuba trials the plants were full and sappy and thus would not give as high a result. It is a well known fact that the percentage recovery varies with the age of the plant and Horst found that recovery was

1.66 and 2 per cent. at 97 days of age, and recovery then increased until it was 6.44 per cent. at maturity. Crane et al (6) found that recovery varied from 2 per cent at 40 days to 7 per cent. at maturity, but in this trial, the percentage recovery significantly increases with plant density, and has a positive correlation of the order of 0.8143. However, here there is a secondary factor of insect damage, which may have influenced the plots considerably in this regard as the plots of the higher plant densities were relatively less affected than those of the lower.

5. Although the second planting was not harvested for fibre, and although the plant densities obtained were much greater, there can be no doubt that the first planting would give a much higher fibre yield. It is considered that the photoperiod plays a major role and that a February planting is far too late for Kenaf in this area.

6. Both dew and tank retting were tried. Dew retting proved absolutely futile although what would appear to be favourable climatic conditions existed at the time. Tank retting proved highly effective, but the fibre produced was rather discoloured and possibly constant changing of water would tend to improve the produce. Retting in ground-water (up to 8 inches of muddy water lying in depressions) was not satisfactory. No decorticating machine is present in the area but hand decortication of a small sample gave excellent and clean fibre. Ribbon retting (outside strips of bark removed from the stems) was faster and superior to tank retting of the whole of the stem. Burkett et al (1) report that good quality produce can be obtained by tank retting, and Watkins and Allwood (13) report that tank retting gives good results when carried out at 34 degrees centigrade in a medium of pH between 6 and 8. It is concluded that retting should be a factor marked down for further investigation in this area.

7. Fibre quality could not be tested. However, during the rice harvest the station converted Kenaf by hand, and manufactured binder twine which proved highly satisfactory.

8. Plant density affects the time to blooming of the plants. It was found that the first flowers were produced in the first planting when the crop was 89 days old, but these flowers only appeared on the outside rows of the plot. The plots with densities of over 200 plants/square yard flowered much later than those of the lighter densities.

9. Photoperiod affected the time to maturity. In the November sowings the plots required 200 days to mature all capsules, and in the February sowings required only 152 days.

10. Total seed yield was very poor indeed, the average being only 83.6 lb./acre. The November plantings gave seed yields double those of the February plots. As harvesting the same crop of both seed and fibre has been found not to be feasible in both Cuba and El Salvadore (Crane and Acuna 4) it is possible that seed may not be produced in sufficiency and with economy to meet local demands for crops in this area, and that seed will probably have to be imported continually should Kenaf wish to be grown. This has been found to be the position also in other Kenaf countries and Narusevic (9) reports that Russian Kenaf seed is produced in Uzbekestan and the fibre crops in the North Caucusus.

11. Seed viability also was found to be extremely low. Immediately after the harvest the germination was only of the order of 2 per cent. Over a five month period viability gradually increased to 12 per cent.

12. The differences in the yield of seed just failed to reach the significant level in regard to plant density in the first planting. In the second planting there were no differences. Crane and Acuna (5) conclude that for Cuba spacing significantly effects yield of seed.

In this regard also the literature is at great variance. Dekker in Java reports that the best spacing for seed yield is 30 inches to 40 inches, Oliviera in Brazil considers 12 inches x 12 inches superior and Chousay in El Salvadore considers that 32 inches x 10 inches is the most satisfactory. On the other hand David in the Philippines considers that plant densities of between 15 and 50 per square metre are similar and Walker and Sierra state that a sowing rate of 20 lb./acre is the most satisfactory. For this area this factor as yet remains unknown.

13. Although in the February planting the plots are uniform in height, in the November planting the plots of the higher plant densities are far superior in height to the others. This has been observed elsewhere with Kenaf, by Crane and Acuna (4) and David (7) in Cuba and the Philippines respectively.

14. In the February planting the plots were more even and there was no effect of plant densities on plant branching. This is possibly due to the much greater plant densities obtained in these plots. In the November sowings branching decreased with plant density, giving a negative correlation of 0.8571. This is not as high as might be expected and possibly the factor of insect attack also plays a major role in this effect. Crane and Acuna (5) found, on the contrary, that spacing did not affect plant branching but the results presented here are supported by the findings of David (7).

15. Seventeen insect species were observed attacking these Kenaf crops and were sent to the Entomologist at Keravat for identification. Of these, only two are considered serious. The first of these is the Cotton stainer which seems to adversely affect seed formation and viability, and the second is the tip borer (*Earies sp.*) whose attack was investigated in these trials. This insect destroys the terminal bud and bores a short distance down the stem, forcing the plant to branch. If attacked very young the plant can be killed completely. The effect on the yield and quality of fibre would be considerable. The caterpillars are parasitized to a small extent.

It was found that an increase in plant density brought about a considerable decrease in percentage of plants attacked, and these factors have a negative correlation of 0.7444. The regression of attack on density is significant.

The attack in the second planting was very slight and unimportant, but the photoperiod is such that Kenaf must be grown when the attack is at its highest. It is thought that general sanitation measures should lessen the attack considerably. Insecticides were not tried as they were not available.

Literature Cited.

1. Burkett, A. L., et al : Effects of age of plant and retting procedures on kenaf (*Hisbiscus cannabinus L*) fibre. Agron J. 41: 255-60. 1949.
2. Crane, J. C. : Kenaf. Fibre plant rival of jute. Econ. Bot. 1:334-50. 1947.
3. Crane, J. C. & Acuna, J. B. : Effect of planting rate on fibre yield of *Urena lobata* as compared with *Hibiscus cannabinus*. J. Amer. Soc. Agron. 37:254-261. 1945.
4. Crane, J. C., & Acuna, J. B. : Growth and development of kenaf *Hibiscus cannabinus*, with special reference to fibre content of the stems. J. Amer. Soc. Agron. 37:352-360. 1945.
5. Crane, J. C., & Acuna, J. B. : Effect of plant spacing and time of planting on seed yield of kenaf, *Hibiscus cannabinus*. J. Amer. Soc. Agron. 37:969-978. 1945.
6. Crane, J. C., et al : Effect of plant spacing and time of planting on fibre yield of kenaf, *Hibiscus cannabinus*. J. Amer. Soc. Agron. 38:46-60. 1946.

7. David, P. A. : Kenaf, *Hibiscus cannabinus* L. Culture in the College of Agriculture, Los Banos, Philippines. Agr. 32:21-30. 1948.

8. Ergle, D. H., et al : Malvaceous bast fibre studies. J. Amer. Soc. Agron. 37:113-127. 1945.

9. Narusevic, P. M. : Production of seed of kenaf (*Hibiscus cannabinus*) in regions where it is grown as a fibre crop. Selek Semenovsk. 19:No.5:58-9 (Abst. 1247 FCA 5:4). 1952.

10. Nevennyh, V. A. : Effect of short day on development and growth of *Hibiscus cannabinus*. Doklady Akad. Nauk. USSR. 59:371-4. Abst. 311 FCA 2:1). 1948.

11. Walker, J. R., & Sierra, M. : Some cultural experiments with kenaf (*Hibiscus cannabinus*). U.S.D.A. Circ. No. 854, pp. 24. 1950.

12. Watkins, J. M. : Growth and fibre production of kenaf as affected by plant spacings in El Salvadore. J. Amer. Soc. Agron. 38:978-83. 1946.

13. Watkins, J. M., & Allwood, E. : Retting of kenaf : *Hibiscus Cannabinus*. J. Amer. Soc. Agron. 40:997-1004. 1948.