DEPARTMENT OF AGRICULTURE,
FIJI.

Bulletin No. 6.

NOTES ON A LEMON-GRASS FROM FIJI.

BY

CHARLES H. KNOWLES, B.Sc. (LOND.),

SUPERINTENDENT OF AGRICULTURE.

BY AUTHORITY: S. BACH, GOVERNMENT PRINTER, SUVA.—1913.

NOTES ON A LEMON-GRASS FROM FIJI

(*Cymbopogon coloratus*).

By CHARLES H. KNOWLES, B.Sc. (Lond.), Superintendent of Agriculture.

THE following notes refer to a lemon-grass, the seeds of which were received from India and planted at the Nasinu Experiment Station in 1907.

The parts of the plant above the ground, but principally the leaves, contain a lemon-scented essential oil, which may be obtained by distilling the plant in water.

When samples of oil were sent to London for valuation in 1909 the report from the Imperial Institute stated that the character of the oil was similar to that of a mixture of citronella and lemon-grass oils and asked that botanical specimens might be sent for identification.

Two lots of specimens were sent, from which the plant was identified at Kew as *Cymbopogon coloratus, Stapf.*, a species which had not been hitherto used commercially for the production of volatile oil. This fact explained the abnormal character of the so-called "lemon-grass oil" which had been obtained from the grass.

The oil was reported on in 1910 as being inferior to lemon-grass oil for perfuming soap. A little while later, after further inquiries had been made regarding its use, it was reported that it was possible its value might be greater than at first thought as it had the valuable property, from a soap-making point of view, of retaining its characteristic odour after the soap has been kept for a considerable time, which is somewhat unusual for an essential oil.

A sample of about 40 lb. was sent to the Imperial Institute for further examination and sale in 1912, and the following is extracted from the report of the Director :—

"*Colour.*—A deep yellow, fairly mobile oil with a strong lemon-like odour.

"Specific gravity at 15°/15° C. 0·912. Optical rotation in 100 mm. tube at 24° C., −9° 24′.

"*Solubility.*—Soluble in 0·6 volumes or more of 80 per cent. alcohol but not soluble in 10 volumes of 70 per cent. alcohol. Aldehydes (by sodium sulphite method), 34 per cent.; total acetylisable constituents, 70·0 per cent.; including (1) geraniol, determined by phthalic anhydride, 11·5 per cent.; (2) other alcohols or aldehydes (difference), 58·5 per cent.

"*Remarks.*—The oil differs both from citronella and lemon-grass oils, though resembling each in certain respects. It could not therefore be sold as either a lemon-grass or a citronella oil and it was necessary to find a market as a new product. It was sold for 2d. per ounce in London in January, 1913. This price for the small consignment (40 lb.) was above the current value for citronella and below that for lemon-grass oil.

"It is possible that a wider market may be found for the oil when its composition is completely determined. Part of the consignment has been reserved at the Imperial Institute for the purpose, and considerable progress has been made with the work.

"Two firms, who were approached on the subject of purchasing the oil, stated that they could not use a new oil unless they could be assured of a regular supply. Information should therefore be furnished to the Imperial Institute as to whether the price obtained in the present instance will be remunerative in Fiji and what quantity of oil is likely to be available annually for the English market."

The following particulars are obtained from the plots established at Nasinu Station :

Soil.—The grass is growing well on sloping ground, the soil of which is brownish-red, not very good in quality.

Preparation of land.—The ground was first ploughed and harrowed, and young plants from a seed-bed set out at distances of 3 feet.

Cultivation.—The space between the young plants was kept clean by weeding and the plants soon grew and covered the ground.

Planting.—Plants may be set out any time during wet weather, but from September to December is best.

Under normal conditions the grass flowers about April or May, when about 4 feet high. After the grass has been cut it flowers irregularly during the year.

Time to cut.—The best time to cut appears to be when the grass is from 3 to 4 feet high but before it is heavily in flower. Subsequent cuttings may be made whenever the grass is over 3 feet high.

Number of cuttings per annum.—Two cuttings may be depended on, while three may be made unless dry weather sets in for some time.

Amount of oil in the grass.—To determine the oil-content at various ages of grass, a plot was divided into four parts, A, B, C, and D, and the whole of the grass in them was cut down. Part A was cut, and the grass distilled in water, when it was about 1 foot high. B was cut at about 2 feet, C at about 3 feet, and D when 4 feet high and just commencing to flower ; each time a plot was cut, the previously cut plots were again cut. The results for two experiments in different years were as follows (oil in pounds per acre and percentage in grass) :—

1911.

Part.	Date.	A.		B.		C.		D.	
		lb.	%	lb.	%	lb.	%	lb.	%
A, cut at 1 foot ...	7 July	3·8	·38	....	..	....	..	....	..
B, cut at 2 feet ..	7 September	2·6	·46	13·25	·42	....	..	....	..
C, cut at 3 feet....	23 October ...	8·0	·38	8·0	·38	44·0	·47	....	..
D, cut at 4 feet ...	17 November .	2·5	·48	4·36	·54	·3·7	·51	54·5	·40
	Totals	16·9	..	25·61	..	47·7	..	54·5	..

1912.

Part.	Date.	A.		B.		C.		D.	
		lb.	%	lb.	%	lb.	%	lb.	%
A, cut at 1 foot ...	16 April	2·9	·36	....	..	....	..	....	..
B, cut at 2 feet ..	20 May	5·5	·39	10·16	·30	....	..	....	..
C, cut at 3 feet....	26 June	2·82	·65	3·87	·80	24·10	·30	....	..
D, cut at 4 feet ...	13 July	5·0	·66	5·8	·65	5·7	·50	48·4	·47
	Totals	16·22	..	19·83	..	30·3	..	48·4	..

It will be seen that the young grass is richer in oil than the older grass, but the total yield per acre obtained in the same time is less ; thus plot A, which was cut four times, only gave one-third of the quantity of the oil obtained during the same time from the one cutting of D.

Oil in leaves and stem.—Grass cut when flowering was separated into leaves and stems and distilled separately while a similar lot was distilled whole as a control :—

One hundred and thirty lb. leaf gave ·396 lb. oil (·30 per cent.) ; 69 lb. stem gave ·040 lb. oil (·06 per cent.) ; (total oil, ·436 lb.) ; average, ·22 per cent. ; 200 lb. leaf and stems gave ·455 lb. of oil (·23 per cent.).

If allowed to grow till the grass is flowering freely there would therefore be a loss of labour, &c., in having to cut, carry in, and distill the stems which contain very little oil. It is not practical to separate them. A further experiment was made on similar grass (heavily in flower) cutting it into three parts; the flowering tops were cut off first and the stalks were cut at about 2 feet leaving the middle portion containing mostly leaves. The results were as follows:—Lower part, 70 lb.; weight of oil, ·2057 lb. (·30 per cent.). Middle part, 32 lb.; weight of oil, ·1298 lb. (·41 per cent.). Tops, 12 lb.; weight of oil, ·0198 lb. (·16 per cent.) Total, 114 lb.; weight of oil, ·3553 lb.; average, ·31 per cent. A similar weight of undivided grass gave ·3454 lb. (·30 per cent.). It is not advisable to attempt to separate out useless portions in this way, and the best results are likely to be obtained by distilling as soon as the grass is about $3\frac{1}{2}$ to 4 feet high.

Average oil-content of leaves.—The total distillation is as follows:—1911, 7,943 lb., giving 28·63 lb. oil (·36 per cent.); 1912, 11,279 lb, giving 39·95 lb. oil (·32 per cent.).

Effect of moisture on percentage of oil in leaves.—A cutting made during heavy rain gave only ·25 per cent. of oil. This fall is of course due to the water weighed with the leaves. It would be perhaps difficult to confine distillation on a large scale to fine weather. The figures in the report were obtained by reaping the grass in fine weather unless the contrary is specially mentioned.

Yield per acre.—The table given above indicates the amount of oil which may be obtained per acre per cutting. The plots, however, are rather small for the purpose of this calculation, but a record was kept of a number of stools cut during the general distilling. One thousand one hundred and seventeen stools gave 10·01 lb. of oil, or at the rate of 43·4 lb. per acre per cutting—a figure which I think may be accepted.

Distilling.—The still in use at Nasinu is a simple one of copper, holding 90 gallons. An inner cage is provided into which the grass (from 168 to 200 lb.) is packed. The cage is then lowered into the boiler which is from a quarter to half full of water. On boiling the water, oil comes over with the steam and is condensed with the latter by passing through a coil surrounded by cold water. The mixture of oil and water is caught in vessels provided with an outlet consisting of a tube entering near the bottom of the vessel, running upwards and ending an inch or so below the rim. In this way the vessel remains full of liquid to the level of the outlet of the tube and as more enters at the top an equal quantity runs off from the bottom.

The oil is lighter than water and floats on the surface of the water in the collecting vessel. Thus more or less pure water only runs off below. The smaller drops of oil mixed with water will be unable to rise to the surface in the limited time of the distillation, and some oil escapes from the first vessel with the water. A second or even third vessel may be used, but the quantity of oil which so escapes is not great and provided this liquid as collected is returned to the boiler from time to time, the oil is not actually lost.

Distillations were made with charges of 200 lb. of grass in which the distillate was collected separately each hour, and the oil so obtained carefully weighed. Four distillations were made in this way and, except in one case, the amounts of oil collected after six hours were too small to be weighed properly; six hours is therefore taken as the time necessary to exhaust a charge of grass with the 90-gallon still used.

As the figures in one experiment differed so much from those for the other three, the latter only are used to give averages which are as follows:—

Hour.	*Pounds of oil obtained.*	*Percentage of total.*	*Total for period.*
First	·3256	51·1	·3256
Second	·1481	23·2	·4737
Third	·0733	11·6	·5470
Fourth	·0433	6·8	·5903
Fifth	·0315	4·9	·6218
Sixth	·0154	2·4	·6372
Total .	·6372	100·0	..

It will be seen that the oil coming over during the sixth hour is quite small. After that, the quantity obtained in one hour was too small to collect and weigh satisfactorily by itself. As the amount of oil coming over in any given time gradually decreases, there will be some point after which the oil collected will not pay for the cost of distillation. This is the point at which distillation should be stopped. In the 1913 experiments, 1,117 stools gave 2,988 lb. of grass from which 10·01 lb. of oil were obtained, or at the rate of 43·4 lb. of oil per acre.

Now, if we distill each charge for 6 hours we get the full 43·4 lb. out of the grass from one acre. If we distill for 5 hours we only obtain 97·6 per cent. of this quantity. In this way we can calculate how much oil per acre per cutting will be obtained by carrying on distillation for any length of time from 1 to 6 hours, and we know what oil will be lost.

To arrive at the time that would be taken in distilling the grass, and therefore to obtain the cost of this work, it is assumed that continuous distillation could be carried out. In fact, to avoid loss of fuel it would be necessary to work in this way on a large scale. One half hour is allowed to remove the exhausted charge, introduce the new one and heat up. A day of 24 hours is divided into three shifts and each shift would require one unit of labour for working the still and a quarter unit for collecting firewood, provided it was conveniently near.

A more economical arrangement would be to have two or three boilers so arranged that one can be emptied of the spent charge and a fresh charge placed in it while the others are in operation.

We know that by distilling for a certain number of hours we get a fixed quantity of oil, so we can easily calculate the number of hours of distilling that would be needed to extract the oil from the grass of one acre, for each length of time per charge from one to six hours. Then, allowing that $3\frac{3}{4}$ units will be required each 24 hours at 1s. 4d. per unit we arrive at the cost of distilling. The figures may conveniently be arranged in a table as below :—

Length of time of distilling hours.	Amount of oil obtained per acre.	No. of hours required to distill.	Cost to distill.	Value of oil at 2d. per oz.	Value of oil lost.	Nett gain (value of oil less cost and oil lost.)
	lb.		£ s. d.	£ s. d.	£ s. d.	£ s. d.
1 hour	22·2	102	1 1 3	2 19 2	2 16 7	....
2 hours	32·3	170	1 15 5	4 6 2	1 9 7	1 1 2
3 hours	37·3	239	2 9 9	4 19 6	0 16 3	1 13 6
4 hours	40·2	307	3 4 0	5 7 2	0 8 7	1 14 7
5 hours	42·4	375	3 18 1	5 13 1	0 2 8	1 12 4
6 hours	43·4	443	4 12 4	5 15 9	....	1 3 5

The last column indicates that beyond 4 hours the value of the oil obtained is less than the extra cost of distilling and therefore it is suggested that under the conditions holding for these distillations the operation should be stopped between the fourth and fifth hours.

It must be remembered that with a large still, or a battery of stills, the increase in labour would be less in proportion ; the same labour would be sufficient for a still many times greater than the one in use at Nasinu. This would give a larger quantity of oil in the same time and the cost would be considerably reduced. It would be necessary to ascertain the length of time required to exhaust a charge and to find by proceeding as described how much oil is obtained per hour, from which data a table could be prepared as above showing the most economical point at which to stop distillation.

The actual cash returns per acre will vary considerably under different conditions, but it is thought that with a larger and more conveniently-arranged apparatus than is in use at Nasinu, the difference between the value of the oil obtained and the cost of distilling it, should be at least £2 per acre per cutting.

21st May, 1913.

C. H. KNOWLES.