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SAFFLOWER OIL

BY

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Imperial Economic Botanist,

AND

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(*Received for publication on 14th March 1921.*)

I. Introduction.

SAFFLOWER (*Carthamus tinctorius* L.) is widely cultivated in India both as an oil seed and to a much less extent for the reddish dye in the flowers (carthamin). Open sandy and rather dry soils best suit the crop, which is generally sown mixed with gram, barley or wheat. On this account, the area under safflower is not recorded separately in the statistics of Indian crops. Mann and Kanitkar[1], in a recent paper, state that the crop is extensively grown in the driest areas of the Deccan for its oil seed. In this tract, the oil is one of the most valued of edible oils and the oil cake, when prepared after thorough decortication, is one of the most valuable and most used cattle foods and one of the principal manures for sugar-cane and other crops in Western India. A large portion of the clarified butter (*ghi*) used in many parts of the country is adulterated with safflower (*kusum*) oil.

Since 1908, safflower has received some attention at Pusa and a number of elementary species of this crop has been isolated and studied. The original seed, which in some cases contained numerous heterozygotes, was obtained from Bombay, Bihar, Sind and the United Provinces. Subsequently, the elementary species isolated from the crop as grown near Dacca in Bengal have been studied. Some of the results[2] obtained were published in 1915. These dealt mainly with flowering, pollination, natural cross-fertilization, the systematic botany of twenty-four elementary species and with an examination of the dye yielding capacity of the types. Natural cross-fertilization was found to be particularly common in safflower as grown in Bihar where this crop is largely composed

[1] Safflower as a drying oil, *Jour. of the Soc. of Chem. Ind.*, XXXVIII, 1919, 36 T.

[2] Studies in Indian Oil Seeds, No. 1. Safflower and Mustard. *Mem. Dept. of Agr. in India* (*Botanical Series*), vol. VII, 1915, p. 237.

of heterozygotes. In Bombay and the United Provinces, on the other hand, safflower, as grown by the people, is much more uniform and contains fewer heterozygotes. Cross-fertilization readily takes place at Pusa to the extent of about sixteen per cent. when the types are grown next to next, so that special precautions are necessary in keeping the types pure and in the conduct of variety trials. Setting takes place readily under large muslin nets but is not satisfactory under parchment bags. No evidence of loss of vigour from continuous self-fertilization for eleven years has been observed. The growth continues to be robust, the plants are doing well and no difficulties are met with in germinating the seeds. So far, natural crossing does not appear to be essential in maintaining the vigour of this species.

The elementary species of Indian safflower differ very greatly as regards general habit, leaves, bracts and flowers as will be evident from the following classification of twenty-four types described in a former paper.

Classification of the Types.

I. Outer bracts lanceolate, distinctly spinose.

1. Bracts smooth, green.

A. Florets white.

Type 1. Plants tall, erect; leaves dark green, incised. Intermediate as regards time of flowering, very late in ripening.

B. Florets yellow, not turning red on fading.

Type 2. Plants intermediate in height, spreading; leaves light green, incised, bracts long. Intermediate as regards time of flowering.

Type 3. Plants intermediate in height, spreading; leaves dark green, serrate. Very early.

Type 4. Plants short, spreading; leaves very light green, margin dentate; bracts short and narrow. Very early.

C. Florets yellow, turning to red on fading.

(*a*) Flower buds yellow with a red dot on the apex.

Type 5. Plants intermediate in height, somewhat erect; leaves very dark green, dentate. Early.

(*b*) Flower buds yellow with no red dot.

Type 6. Plants intermediate in height, spreading; leaves somewhat light green, serrate. Very early.

Type 7. Very similar to type 6, but the plants are somewhat taller and later and the leaves lighter in colour.

II. Outer bracts ovate to rounded, moderately spinose to spineless.

1. Bracts hairy, whitish.

A. Florets yellow, not turning to red on fading.

(*a*) Flower buds pale yellow.

Type 8. Plants intermediate in height, spreading; leaves dark green, serrate. Early.

(*b*) Flower buds deep yellow.

Type 9. Plants tall, spreading; leaves dark green, almost spineless, serrate. Early.

B. Florets yellow, turning to red on fading.

(*a*) Flower buds pale yellow.

Type 10. Plants tall, very erect with long almost parallel branches; leaves long, dark green, almost spineless, serrate. Late.

Type 11. Plants tall, very erect, branches shorter than in type 10; leaves dark green, spines few, serrate. Early.

Type 12. Plants rather tall, somewhat erect; leaves dark green but lighter than in type 11, serrate; early (later than type 11).

Type 13. Plants tall, erect; leaves long, light green, spines few, incised. Late.

(*b*) Flower buds deep yellow with a trace of red near the apex.

Type 14. Plants tall, erect; leaves long, dark green, spines few, incised. Intermediate in time of maturity.

(*c*) Flower buds deep yellow, reddish near the base.

Type 15. Plants short, spreading; leaves light green, spinose, serrate; bracts spiny. Very early.

Type 16. Plants intermediate in height; leaves light green, spines few. Intermediate in time of maturity.

(*d*) Flower buds deep red with a yellow apical point.

Type 17. Plants tall, erect with long branches; leaves dark green, nearly spineless, incised. Late.

2. Bracts almost smooth, green; florets yellow turning to red on fading.

A. Flower buds deep yellow.

Type 18. Plants tall, branching above the ground, erect; leaves long, somewhat light green, nearly spineless, deeply incised. Late.

Type 19. Plants tall, erect, branching from the ground; leaves long, dark green, nearly spineless, incised. Very late.

Type 20. Plants short, somewhat spreading, very spinose; leaves small, very light green, serrate. Very early.

B. Flower buds deep yellow with a reddish apex.

Type 21. Plants intermediate in height, somewhat spreading; leaves somewhat light green, incised. Late.

Type 22. Plants tall, somewhat erect; leaves dark green, incised. Early.

C. Flower buds deep yellow with a reddish base.

Type 23. Plants short, spreading; leaves light green, serrate. Intermediate as regards time of maturity.

D. Flower buds deep red with a yellow apical point.

Type 24. Plants tall, erect; leaves long, somewhat light green, incisions few. Late.

The wide range in habit, branching and in time of flowering, exhibited by the elementary species of safflower, is so great that it appears likely that, for any particular set of soil conditions, the yield will depend largely on the efficiency of the type. Those which branch and stand well, such as Nos. 5, 6, 7, 14, 15, 16 and 19, are likely to yield better than the tall types with crowded branches. The time of flowering and the period when ripening takes place are also likely to be important. Once the most efficient type is found and a stock of pure seed has been obtained, the establishment of the improved kind is largely a matter of organization. The country crop must be replaced entirely and the work must be carried out on a systematic plan starting from a given centre. If this is not accomplished, natural crossing will take place and little or no permanent benefit will result from distributing improved seed.

The elementary species of safflower, when grown at Pusa, differ both in the percentage of oil in the seed and to a much greater extent in the content of carthamin.

TABLE I.

Oil content of the types of Indian safflower.

Type	Date of appearance of first flower	Weight in grammes of 100 seeds	Percentage of oil	Colour of faded florets
1	2nd March 1914	6·1	13·86	Colourless.
2	25th February 1914	4·4	26·86	Light brown.
3	16th Do. Do.	5·6	24·12	Brown.
4	14th Do. Do.	3·9	25·60	Do.
5	23rd Do. Do.	4·5	27·26	Red.
6	23rd Do. Do.	5·1	26·77	Reddish yellow.
7	20th Do. Do.	5·0	30·19	Do.
8	23rd Do. Do.	4·2	24·00	Light brown.
9	23rd Do. Do.	4·8	27·99	Brown.
10	3rd March 1914	4·2	25·54	Red.
11	23rd February 1914	3·2	28·19	Do.
12	20th Do. Do.	5·1	27·18	Do.
13	2nd March 1914	4·0	24·43	Do.
14	25th February 1914	3·8	27·19	Do.
15	20th Do. Do.	3·1	26·42	Do.
16	27th Do. Do.	3·9	25·72	Do.
17	9th March 1914	3·9	28·64	Deep red.
18	2nd Do. Do.	4·2	24·99	Red.
19	10th Do. Do.	2·8	28·95	Do.
20	23rd February 1914	4·3	26·53	Do.
21	23rd Do Do.	2·9	25·46	Do.
22	20th Do. Do.	5·3	20·77	Do.
23	25th Do. Do.	3·4	26·35	Deep red.
24	4th March 1914	3·1	26·82	Do.

Dr. Marsden, who examined the comparative strengths of some of these types of safflower, placed them in the following order—Type No.

24, 17, 20, 16, 23, 10, 12, 5 and considered that type 24 was about eight times as rich in dyestuff as type 5. Types 1, 8 and 9 contained no red dye. The range in oil content is not so great as that of carthamin but the analyses quoted above indicate that the types do differ appreciably in the percentage of oil in the seeds.

There are a number of references to safflower oil in the literature. The earlier results are summed up by Lewkowitsch in the second volume (p. 85) of the fourth edition of *Chemical Technology and Analysis of oil, fats and waxes*, and are also referred to by Watt in *The Commercial Products of India* (p. 281). Lewkowitsch considered that safflower oil might become important in industries, that it has good drying properties and should form a substitute for linseed oil in many instances and find extended use in the manufacture of soft soap. He refers to the disadvantage of the high percentage of husk in the seed, to the resulting high proportion of woody fibre (40·75 per cent.) in the pressed cake and to the necessity of first decorticating the seeds.

In 1916, it was decided to undertake the testing of safflower seed in Great Britain under commercial conditions. The investigation was placed in the hands of Mr. J. Stewart Remington and a ton of safflower seed, grown partly at Pusa and partly in the neighbourhood of Behea near Patna, was despatched to England through Messrs. Ralli Bros., Calcutta. The seed arrived safely at Liverpool but the work of testing it was greatly delayed by the war. Much time was lost on account of the difficulty in obtaining the benzene needed for the extraction. As the war progressed, the staff of the Aynsome laboratory became more and more taken up with military duties and the tests could not be finished till after the armistice. The work, however, was finally completed and the report is printed in Chapter II of this bulletin.

While this investigation was in progress, the subject was independently examined at Poona by Mann and Kanitkar (J. S. C. I., XXXVIII, 1919, 36 T). These investigators analysed a number of samples of safflower seed with the following average result. Husk 50·8 per cent.; kernel, 49·2 per cent.; oil in the whole seed (average of 55 samples) 31·6 per cent., maximum 36·9 per cent., minimum 25·4 per cent. The various constants of safflower oil were determined and particular attention was paid to its characters after heating under well defined conditions. Samples of the fresh oil were heated first with oxygen and then with carbon dioxide to 100° C, 186° C and 300° C for various periods and the characters of the products determined in each case. The results showed that it is only at 300° C in oxygen that the well known characteristic results of heating safflower oil became evident. For the first two hours, the amount of change is small but it then increases very rapidly till

the oil becomes a semi-solid mass—the *roghan* of the Indian bazaars. The authors also examined the drying properties of the oil after heating and when mixed with manganese borate. By heating to 186° C in oxygen, a very marked reduction in the length of time required for drying was obtained.

II. The Commercial Possibilities of Safflower Seed.

The results of the technical investigation of the ton of safflower seed sent from India in 1917 are given in a report by Mr. J. Stewart Remington, dated July 16th, 1920. This is reproduced in full below :—

Report on Safflower Seed.

"Safflower (*Carthamus tinctorius* L.) is a dye-yielding plant, but is especially useful on account of its seeds. According to Mollison[1], safflower is the most important oil-seed crop in the Bombay Presidency. The chief centres of cultivation are the black soil areas of Ahmednagar, Poona, Satara, Bijapur, Dharwar and Belgaum where it is frequently grown with other crops such as wheat. There are two indigenous methods of oil production, one in which the seeds are simply subjected to cold-dry pressure either before or after they have been husked, the yield of oil ranging from 20 to 30 per cent. and a second method of hot dry extraction or downward distillation in two pots, one placed above the other, having a perforated plate between, the fuel being piled round the upper pot. Under this latter system, the seeds are partly roasted, the oil draining down to the lower vessel. The sweet oil of Bombay is an oil made by mixing safflower, earth-nut and *til* seeds together and expressing the oil from the mixture.

Some time ago, a sample shipment of one ton of safflower seed was received from the Imperial Research Institute at Pusa, with the object of having the seeds submitted to a thorough technical investigation at the Aynsome laboratories. The seeds on arrival were treated in a modern benzene extractor, designed by Messrs. G. Scott and Son Limited of Kingsway, London, several experiments being carried out. Of the following tests, No. 3 represents the commercial method which would be adopted if called upon to submit a proposition, the other experiments being simply given as an indication of what has been done.

Test No. 1. (July 9th, 1918.) The crushed seed (1 cwt. 2 qr. 15 lb.) was put into an extractor and benzol was vaporised, the vapour passing

[1] *A text book of Indian Agriculture*, vol. III, 1901, p. 98.

downwards through the meal. The extraction was continued for 5 hours. Dry steam was then admitted and passed downwards through the meal for 1 hour, at which time the meal was free from benzol. The solvent, oil and water were heated with as team coil until free from solvent. This took 7 hours. No open steam was admitted to the mixture, hence the length of time taken. The weight of oil obtained was 33 lb. The percentage of oil remaining in the seed was 3·12 per cent. and the moisture content in the residue (meal) was 8·42 per cent.

Test No. 2. 3 cwt. 12 lb. of the crushed seed was put into the extractor which was then full. Owing to charging delays, the first was left in with the meal over night.

The full data.

First wash (over night)	12 hours.
Recovering solvent from oil	30 minutes.

Second wash.

Admitting solvent	30 minutes.
Running out solvent and oil	30 ,,
Vaporising meal (until extractor hot)	1 hour.
Steaming off meal	1 hour.
Solvent from oil	1 hour 15 minutes

Yield 13·22 per cent. oil.
Meal still contained 9·7 per cent. oil.
80 gallons of solvent were used for the first wash.
60 gallons of solvent were used for the second wash.

Test No. 3. (July 18th, 1918.) 2 cwt. 1 qr. 25 lb. of the crushed seed was put into the extractor and the meal was vaporised until the seed and the whole plant was hot after which all washes would be warm.

Vaporising	1 hour.
Run in first wash	30 minutes.
Running out last wash	30 ,,
Recovering solvent from oil	30 ,,
Second wash	30 ,,
Vaporising meal	30 ,,
Steaming off meal	30 ,,
Steaming off oil	45 ,,
Yield 20·577 per cent.	1 hour.

Oil still in meal 2·21 per cent.
60 gallons of solvent used in the first wash.
50 gallons of solvent used in the second wash.
A very good result.

Test No. 4. (January 10th, 1919.) 1 cwt. 3 qr. 0 lb. of crushed seeds were filled into the extractor. Owing to a leakage since the previous

test made on July 18th, 1918, there was a shortage of solvent in consequence of which only 20 gallons were available. This has shown its effect in the yield of oil. The extraction, however, gives a further indication of treatment.

Charging extractor	15 minutes.
Vaporising started on meal and continued until all hot	1 hour
First wash run in	15 minutes.
First wash run out	15 ,,
Second wash run in	15 ,,
Second wash run out	10 ,,
Third wash run in	15 ,,
Third wash run out	15 ,,
Vaporising meal	30 ,,
Steaming off meal until solvent free	35 ,,
Stoaming off oil until solvent free	25 ,,
Discharging extractor	25 ,,

Yield 22 lb. oil.
Meal still contained 6·6 per cent. oil.
1st wash took 20 gallons of solvent.
2nd ,, ,, 15 ,, ,, ,,
3rd ,, ,, 12 ,, ,, ,,

Test No. 5. (13th January 1919.) 1 cwt. 3 qr. 6 lb. of the crushed seeds were placed in the extractor.

Charging extractor	15 minutes.
Vaporising meal until quite hot	1 hour 5 minutes.
First wash run in	15 minutes.
First wash run out	15 ,,
Second wash run in	10 ,,
Second wash run out	10 ,,
Third wash run in	10 ,,
Third wash run out	5 ,,
Vaporising meal until hot	30 ,,
Steaming off meal until solvent free	30 ,,
Steaming off oil until solvent free	30 ,,
Discharging meal	25 ,,

Yield 18·5 lb. oil.
Oil left in meal 14·0 per cent.

From the foregoing tests, it will be seen that No. 3 is the best, and the one which would be adopted commercially in treating safflower seed. The other tests were carried out to show what would be likely to take place under altered conditions of working and what yields would be obtained. The further examination and experiments carried out were performed on the oil from the No. 3 test.

The oil obtained from the third test extraction gave the following constants :—

Specific gravity at 15°·5 C.	0·9258
Acid value	9·78
Acidity (calculated as oleic)	4·91 per cent.
Saponification value	197·31
Ester value	187·53
Hehner value	95·74
Viscosity (Redwood) at 70° F	245·8
Relative viscosity (water = 1)	8·4
Butyro-refractometer at 15°·5 C	78
„ „ at 40° C	64
Refractive index at 15°·5 C	1·4771
„ „ at 40°·0 C	1·4685
Unsaponifiable matter	1·25 per cent.
Glycerol	4·26 „

The fatty acids gave :—

Butyro-refractometer at 15°·5 C	65
„ „ at 40°·0 C	50
Refractive index at 15°·5 C	1·4691
„ „ at 40°·0 C	1·4593

According to Mann and Kanitkar (*J. S. C. I.*, Feb. 1918) a bazaar sample of safflower seed gave :—

Specific gravity at 26° C	0·914
Saponification value	177
Acid value	2·6
Iodine value	116
Hehner value	94·8

A laboratory pressed sample by the same authors gave :—

Specific gravity at 26° C	0·914
Saponification value	202
Acid value	0·6
Iodine value	122

On examining the safflower seeds, it was found that these consisted of husk 50·4 per cent., kernel 49·6 per cent. Mann and Kanitkar found on the examination of a number of samples husk 50·8 per cent, kernel 49·2 per cent., and further found that the percentage of oil in the whole seed (the average of 55 samples) was 31·6 per cent., maximum 36·9 per cent., minimum 25·4 per cent. Safflower oil has been stated to have possibilities as a drying oil and it has been used in this way in India for many years. It is boiled by heating in earthenware vessels for about two hours, during which period a large amount of acrolein (acrylic aldehyde) is given off, and it is then run into vessels partly filled with water. In these vessels, the oil quickly solidifies to a gelatinous mass, which is sold as " roghan " or Afridi wax, and is used in the preparation of Afridi wax cloth. According to Lewkowitsch, this gelatinous condition is less a product of drying in the ordinary sense than one of polymerisation, but he brings forward no evidence on this point to support the statement. In consequence, further investigations on this matter are being undertaken.

In studying safflower oil from the drying point of view, it was thought desirable to carry out a series of tests with various commercial dryers as follows :—

Drier used	Oil film sticky after	Oil film dry after
Manganese resinate 2 per cent.	45 hours	93 hours
Manganese linoleate 2 per cent.	Less sticky than No. 1 after 45 hours	90 „
Lead resinate 2 per cent.	102 hours	—
Lead linoleate 2 per cent.	44 „	93 „
Cobalt resinate 1 per cent.	—	21 „
Cobalt linoleate 1 per cent.	45 „	93 „
Cobalt acetate 1 per cent.	15 „	28 „

From the results it will be seen that cobalt resinate should furnish an excellent dryer for safflower oil. If properly incorporated, it does not cause the oil to become too dark in colour. As will be seen, lead resinate gave the slowest results, whilst cobalt acetate was second best, then manganese linoleate. It would be desirable to have further work done as regards the action of dryers, especially as regards combinations of cobalt and manganese and this is now being done to be reported later.

A drying oil, rather dark in colour, was made on the following lines :—

Safflower oil	33 lb.
Cobalt resinate	1 lb.

The above was heated in an experimental oil boiling tank for 5 hours at 300° F and blown with air for two hours. This sample dried on glass to a hard film in 18 hours.

Pale bronze green paint was made using the above prepared oil which commercially would be as follows :—

Pale Brunswick green	1 cwt. 2 qr. 0 lb.
Patent paint dryers	1 qr. 9 lb.
Raw umber	10 lb.
Dark bronze green	8 lb.
Turpentine	1½ lb.
Sub Turps. (White Spirit)	2 lb.
Boiled safflower oil	1 qr. 2 lb.

This paint dried with a nice glossy coat in 20 hours. It is at present undergoing a weather test on a panel 14″×8″ in duplicate against two panels covered with the same paint, but with linseed oil used in place of the safflower oil. At the time of making this report, the linseed panels show signs of blistering (6 months' exposure) the safflower oil panels are still bright and intact.

In the case of varnishes, it was found that the oil has certain important advantages over linseed oil inasmuch as it does not "break" or throw any foots even when heated to 600° F (315°·5 C). It, however, darkens in colour on heating for some time at a high temperature but the varnish made from it is quite satisfactory, is easy flowing and bright. If heated and blown under special conditions, it would make a very satisfactory "stand oil" for enamel manufacturers and could be used in the linoleum trade with advantage either wholly or as an adulterant for thickened linseed oil.

One of the most important uses for safflower oil would be in the manufacture of soap. Experiments were tried by making soap in the ordinary way in a soap pan, by saponification with alkali (soda), salting out, pressing and standing in a cooker for 20 days, then using the safflower meal from the extraction of the seed, ground to a fine powder, as a filler. Soap was also prepared by making the fatty acids in an autoclave with the addition of a small quantity of zinc oxide (2 per cent.) and then treating the fatty acids with alkali by a semi-cold process and again using the meal as a filler. In both cases good soaps were obtained. A soap made on either of these lines should be a distinct advantage in India as it could be guaranteed to contain no animal fat whatever.

Safflower oil lends itself very well to the process of bleaching, especially by an oxidizing agent. By a special cold process devised here, a sample of oil was produced of a pale straw colour which would be very useful for certain special preparations in the paint trade, such as enamels and for artists' colours, and this process was found greatly to improve the drying properties of the oil. If the oil is required for edible purposes, then bleaching should not be carried out by chemical

means as it is very difficult in commercial practice to free the oil from every trace of the chemicals used. In such cases, resort should be made to the proper use of Fuller's earth and animal charcoal. For the above purpose, the oil would have to be practically neutral and should contain no free fatty acid. With an oil of low acidity, it could be neutralised by proper treatment with alkali and subsequently washed with water to free it from the chemical or the acidity could be removed by successive washings with industrial methylated spirit, which, if used in sufficient proportion to the oil, will separate out with ease when it can be run off and the spirit recovered by distillation, the extracted fatty acids being collected and disposed of for soap making purposes. The washing of the oil with spirit should not be carried out longer than is necessary to remove the acid, as some oil (about 4 per cent.) is also washed out. The washed and neutral oil must then be warmed up to free it from small quantities of methylated spirit and is then treated with Fuller's earth and charcoal to obtain the bleached and neutral oil for edible purposes for which it would be very suitable. Working on the above lines, a very nice sample of a pale yellow salad oil was produced on a laboratory scale.

In the paper previously quoted by Mann and Kanitkar, it is pointed out that the percentage of husk to kernel is very high, and that no use has been found for it, that it is brittle and useless as a food, as when used for cattle it has an irritant tendency. It contains little nitrogen, hence reducing the manurial value of the meal. The meal from No. 3 extraction was analysed with the following results :—

Moisture	7·50
Oil	2·21
Albuminoids	15·96
Carbohydrates	35·48
Crude fibre	32·88
Mineral ash	5·97
	100·00

It will be seen that the above meal is useless as a feeding material on account of the high amount of crude fibre. The best use technically it could be put to in India would be as a filler for soap, or as a slow acting manure for agricultural purposes. In this connection, it could be used in a similar manner to rape dust or castor oil meal on light soils.

From the foregoing details it will be seen that safflower seed oil should become a very valuable economic product if it can only be brought over and utilized on the Home markets. It should be an

excellent oil, if properly manipulated, for the colour, paint and varnish industries, also for soap and linoleum manufacture, as well as for edible and culinary purposes, in the latter cases if proper means are devised as regards refining and bleaching. The investigations so far undertaken on safflower seed and safflower seed oil by no means exhaust the subject. As regards the seeds, further investigations are desirable, and are being continued at these laboratories, on the proteins of safflower seed, and will be referred to later. A further investigation is also desirable as regards the changes taking place in the oil under ozonization which can be advantageously carried out at the laboratories as well as more extended tests than have at present been possible on the weathering of paints and varnishes made with this oil, in conjunction with various combinations of dryers, especially as regards varnishes and the quick maturing of the same. These it is hoped will form the subject of future papers on this interesting Indian product. The writer will be pleased to answer any questions from those interested in the commercial possibilities of this product."

J. STEWART REMINGTON.

AYNSOME TECHNICAL LABORATORIES,
GRANGE-OVER-SANDS,
LANCASHIRE.

The results of this investigation are so encouraging that it is hoped that the industries concerned will pay particular attention to this oil seed. In order to facilitate further large scale trials by the trade, Messrs. Ralli Brothers, Bombay, are prepared to collect and ship consignments of this seed to Great Britain. Should a large demand for export arise, the Agricultural Department of Bombay have agreed to encourage and develop the cultivation of improved varieties of this crop in suitable localities in the Deccan.

PUSA,
March 12th, 1921.

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