TRIALS WITH SOYBEAN IN CEYLON

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MUCH has been written in recent years on the virtues of the soybean, and it is not the object of this article to add to the catalogue of the uses to which it may be put. An article contributed to the local press (11) gave selections from this catalogue, and it is our intention to publish details of the ways in which the soybean can be used, as a part of the departmental propaganda programme. It will suffice here to state that the seed contains the vitamins A, B and D that are present in milk, that the sprouted seedling also contains vitamin C, that the seed is rich in calcium, sodium, manganese and phosphorus, and that its reserve food is in the form of protein, of which it contains 40 per cent., and oil (17 per cent.) whereas other pulses have very little of these substances, and store most of their reserves as starch or sugar. It can therefore be used in place of meat and it is of particular value to sufferers from diabetes.

The object of this article is to describe those experiments that have been carried out in order to determine the conditions under which the soybean is best grown in Ceylon. The greater part of the voluminous literature deals with its cultivation in temperate and sub-tropical climates, and, while the technique there used is invaluable as a basis on which to work, it is inevitable that modifications should be necessary under tropical conditions. It has also been necessary to choose between the enormous number of varieties that have been used or evolved in every country in which the cultivation of soybean has become established. Our trials are still in progress, but we have collected sufficient information to be able to make general recommendations, and it is hoped to deal with matters of detail in a subsequent article.

We have tried thirty-two varieties, varying considerably in size and colour. The largest has an average weight of 30 grammes per 100 seeds (or say 1,500 seeds to the pound) and the smallest weigh only 5 grammes per 100 seeds (9,000 seeds per pound). The colours include yellow, green, brown and black, and the seeds vary in shape from flattened to almost spherical,

and in hardness, the small seeds being generally harder than the large ones. It has been found convenient to divide the varieties into two main classes according to seed size, because other characters appear to be correlated with it. Generally speaking, the large-seeded varieties mature in 3–3½ months, the vegetative growth is poor so that they must be planted close together, the yield is not good, but the seeds are comparatively soft and easily cooked; whereas the smaller-seeded varieties require 4–5½ months to mature, they can be planted fairly widely and will give a good volume of green material and also a good crop of seed, but the seeds are hard. One or two varieties with very small seeds are climbers and have a very long vegetative period and are suitable only as green manure or fodder plants.

The first trials were made with samples of seed and were perforce carried out in very small plots, so that statistical comparison of results was not possible. The primary object of the trials was acclimatization and multiplication of seed, but opportunity was taken to make general observations on factors that were likely to be of importance, to serve as a guide for more precise trials to be carried out at a later date. For example, the effect of lime was observed by treating alternate rows of plants and measuring the effect of the treatment on their subsequent growth. The method of observation was first to measure the height of the plants and to calculate a mean for each row which would serve as an index of plant size. Then the lime was applied (at the rate of 1 ton per acre) and similar measurements were made subsequently at fortnightly intervals. These measurements were converted into percentages of the first record for each row, so that the relative rates of growth were being compared and not the actual heights of the plants. The results of the trial are found in Table I. where it is seen that, of seven varieties measured, five showed a greater rate of growth as a result of the application of lime. A sixth (Hahto) should really show the same result; but at the beginning of the trial, one of the rows of this plot (subsequently to be limed) was badly damaged by hare, which bit off the tops of the seedlings, and this row never recovered from this check on the growth of the plants; if its records be omitted, the rest of the plot shows an advantage in favour of the limed rows. The conditions of the experiment did not permit of comparisons being made of the yield of seed. The effect of the lime was visible, a few days after its application, by an appreciable darkening of the colour of the foliage of the treated plants. Experience is general that lime stimulates the growth of leguminous plants.

The effect of spacing was first investigated with one of the small-seeded varieties, Poona Yellow, in a randomized block experiment. Three spacings were used—2 feet by 3 inches,

2 feet by 6 inches, and 2 feet by 12 inches,—and there were twelve replications of each set of treatments. The trial area was limed at the rate of one ton per acre, $2\frac{1}{2}$ weeks before sowing; a plot contained 3 rows each 3 feet long, and there were no gaps between plots. A month after sowing, the whole area was treated with nitrate of soda at the rate of one cwt. per acre. At harvest, a length of 2 feet was harvested from the middle row of each plot. The results are shown in Table II.; differences are significant, and the trial shows that the narrowest spacing (2 feet × 3 inches) is better than either of the others. The yield per plant is greatest at the widest spacing, but the increase is not sufficient to compensate for the smaller number of plants, and the conclusion is formed that planting in drills is to be preferred to " square " planting.

It will be noted that no mention has yet been made of inoculation of seed prior to sowing; in neither the trials carried out nor the multiplication areas planted was the seed inoculated, and yet a yield equivalent to half a ton of seed per acre had been obtained with one small-seeded variety. The pathological division of the Agricultural Department has published two articles in this journal (12, 13) which suggested that plant growth was improved as a result of inoculation of seed prior to sowing, and that the green matter of these plants may contain a greater percentage of nitrogen, but it was not able to demonstrate that seed inoculation produced any increase in yield.

The question is of considerable importance to Ceylon, apart altogether from its scientific interest. The cultivator who grows soybean as part of a permanent rotation has no cause for worry, because he has only to sow inoculated seed once and his land will become inoculated with the necessary bacteria by the decay of nodules, thus rendering further inoculation of seed unnecessary. The chena cultivator is in a very different position; he will grow soybeans on one area one year and on a different area the following year, and it becomes very important to him to know whether or not inoculation is necessary; should it be so, he must either renew his seed for sowing each year or he must carry soil from one chena to the next; failure to do one of these things would mean the failure of his crop, and of the soybean as a potential chena crop.

The trials next to be described were meant to provide more evidence on points already investigated, such as spacing and liming, and also to decide whether or not seed inoculation was necessary, or whether possibly the benefit conferred on the plant by the extra nitrogen manufactured by the bacteria could be conferred as easily by the addition of some form of combined nitrogen to the soil. There is a considerable literature on the subject of root nodules and the bacteria which produce

them, and the general opinion is that nitrifying bacteria and added nitrogen (particularly in the form of nitrates) are antagonistic in their action, because the addition of nitrate nitrogen to the soil results in a decrease of the number, size and efficiency of nodules on the roots of leguminous plants. Points of detail vary; Orcutt and Wilson (2) state that the addition of nitrate in quantities of 200 lb. per acre has a depressing effect on nodule formation, whereas quantities of 50–100 lb. per acre are associated with increased nodulation. Umbreit and Fred (5) on the other hand, state that even the latter quantities tend to prevent the formation of nodules but they suggest that the plant derives more benefit either from the nitrogen fixed by the nodules or from that added as nitrate, according to the conditions under which it is growing. Where the carbohydrate-nitrogen ratio in the plant is balanced, as it is under normal conditions, better results are obtained by inoculation; but where abnormal conditions such as drought or shortness of the growing season upset the carbohydrate-nitrogen balance, then it is preferable to add combined nitrogen to the soil.

The results of the interactions of nitrogen compounds and nodule-forming bacteria affect us only in their effect on agricultural practice in Ceylon, and since there appear to be conditions where inoculation of seed is not necessary, we are trying to determine whether those conditions exist in Ceylon, and if so, where.

Two trials of similar design were laid down at Jaffna and Anuradhapura in the *maha* 1938–39 season. They were of a somewhat complicated (factorial) design which allows the comparison of a large number of effects without excessive replication of treatments, by using combinations of treatments arranged according to a definite system. For example, the trials to be described each had only 32 plots, yet they compared the effects of five different treatments and also of any interactions between any numbers of treatments. The effects that were to be compared are tabulated below :—

		Jaffna	Anuradhapura
1.	Variety :	Chame *vs.* Yellow I	Poona Yellow *vs.* Small seeded
2.	Spacing :	1′ × 1′ *vs.* 1′ × 6″	2′ × 6″ *vs.* 2′ × 3″.
3.	Inoculation :	Seeds inoculated prior to sowing *vs.* not inoculated.	
4.	Manuring :	Plots treated with nitrate of soda at the rate of 1 cwt. per acre *vs.* not treated.	
5.	Liming :	Plots treated with lime at the rate of 1 ton per acre *vs.* not treated.	

The varieties used in the Jaffna trial belong to the large-seeded class and were, therefore, planted more closely than the small-seeded ones grown at Anuradhapura. The trial at Jaffna was irrigated; that at Anuradhapura was not. The nitrate of soda was added in two doses; half, two weeks after sowing,

and the remainder two weeks later. The lime was added in one dose, two weeks before sowing. Two seeds were planted per hole. Each trial was of the 2^5 factorial design described by Yates (10) and was made up of thirty-two plots, representing all possible combinations between the five pairs of factors. The plots were randomized in four blocks, and certain high order interactions were confounded with block differences. The arrangement of the trials and the results are shown in Tables III, IV and V. At Anuradhapura the differences between the treatments did not reach the level required by the statistician and we are unable to say with confidence that the differences are not due to chance. At Jaffna the required level of significance was reached, and seven factors produced differences sufficiently large to be relied on. These differences are indicated by asterisks in Table IV and must be examined in greater detail (see also Table VI.).

1. *Spacing.*—The narrower spacing ($1' \times 6''$) gave a marked increase in yield over the wider spacing ($1' \times 1'$). The magnitude of this difference cannot be accepted without confirmation because there were sufficient gaps in the rows to cast some doubt on the actual spacing in the plots; but because the percentage of survivors in the two treatments differed by only 0·05 per cent. (being 77·56 per cent. at the wider spacing and 77·61 per cent. at the narrower) and because, in spite of gaps, the narrower spacing still gave the bigger yield, it is accepted that the narrower spacing is definitely to be preferred.

2. *Inoculation.*—The advantage of inoculation is very clearly indicated in this experiment; the result is of interest for two reasons—first, because it is the only trial in Ceylon in which a significant increase in yield has been obtained as a result of the inoculation of seed, and second, because it disagrees with the suggestion made by Park and Fernando (13) that the early-maturing varieties do not respond to inoculation; nevertheless, the size of the difference obtained in this trial entitles it to some consideration.

3. *Manuring.*—The effect of manuring is markedly less than that of seed inoculation, but it is still significant. It is possible that the magnitude of the effect could be altered by varying the amount of manure applied.

4. *Interaction between variety and spacing.*—An analysis of this effect (Table VI) indicates that the performance of the variety Yellow I was better than that of Chame at the narrower spacing, but that there was no difference between them at the wider one. If the narrow spacing is to be preferred then Yellow I is the better variety to use.

5. *Interaction between spacing and inoculation (Table VI.)*—The effect of inoculation is more marked at the narrower spacing.

6. *Interaction between variety and manuring.*—The variety Yellow I has responded to manuring hardly at all, but there has been a marked response from Chame.

7. *Interaction between inoculation and manuring.*—The effect of the addition of nitrate of soda is noticeable only in the absence of inoculation; the effect of inoculation is significant whether or not the plots are manured, but it is more marked in those plots that have not been manured. It is concluded that the effects of manuring with nitrate and of inoculation of seed are antagonistic, but that the effect of inoculation is the stronger, at least with the particular dose of nitrate applied in this experiment; where inoculation is not feasible, however, nitrate of soda may be added with good effect.

The general recommendations to be drawn from this trial are that the variety Yellow I may be recommended to be inoculated prior to sowing, and should be spaced not wider than $1' \times 6''$.

The absence of any definite effect of lime may perhaps be due to the fact that the soils of the Jaffna peninsula are, in general, calcareous and that the addition of one ton of lime per acre made no appreciable difference to the available lime content.

More trials of the kind described in the preceding paragraphs are being carried out, which it is hoped will confirm the general conclusions already formed and will also give more information on points of detail.

It has already been stated that nodule development and its reaction to treatment of different kinds, are of interest to us only in so far as they may affect agricultural practice. At the same time, we have examined samples of plants growing under the conditions of the Jaffna and Anuradhapura trials in order to observe any correlation between nodule development and yield of seed.

It is known that the nodule-forming bacteria can be divided into strains any one of which will produce effective nodulation on a limited number of host plants. Thus one strain is effective only on peas, vetches and lentils; another on *Vigna*, *Arachis*, *Lespedeza* and *Phaseolus*; while the soybean strain is said not to affect any other plant. Ruf and Sarles (9) examined soybean plants that had been inoculated with effective and ineffective strains of bacteria, and found that an effective strain produced fewer but larger nodules concentrated round the base of the tap root, whereas an ineffective strain produced more and smaller nodules scattered over the entire root system. In our experiments we used only one strain of bacterium, which had previously been determined to be effective, but we also used other treatments which we considered might be equivalent to inoculation

with an ineffective strain ; we therefore adopted Ruf and Sarles' criterion of effectiveness and classified accordingly the plants growing under our different treatments. Plate I. shows the scheme of classification devised by Ruf and Sarles ; according to them, an effective strain of bacterium (*i.e.* good inoculation) would produce few large nodules, situated mostly in area A1, with a few in B1 and A2. Our classification was perhaps more strict, because we were comparing treatments that might be expected to produce greater differences than those of Ruf and Sarles' experiments. We examined 20 plants of each treatment, counting and weighing the nodules, and classifying their distribution on the plant. The results appear in Table VII, and, since only main effects are required, have been averaged in the lower half of the table ; the averages are not only more easily interpreted, but are also of greater accuracy, because they are means of eighty readings.

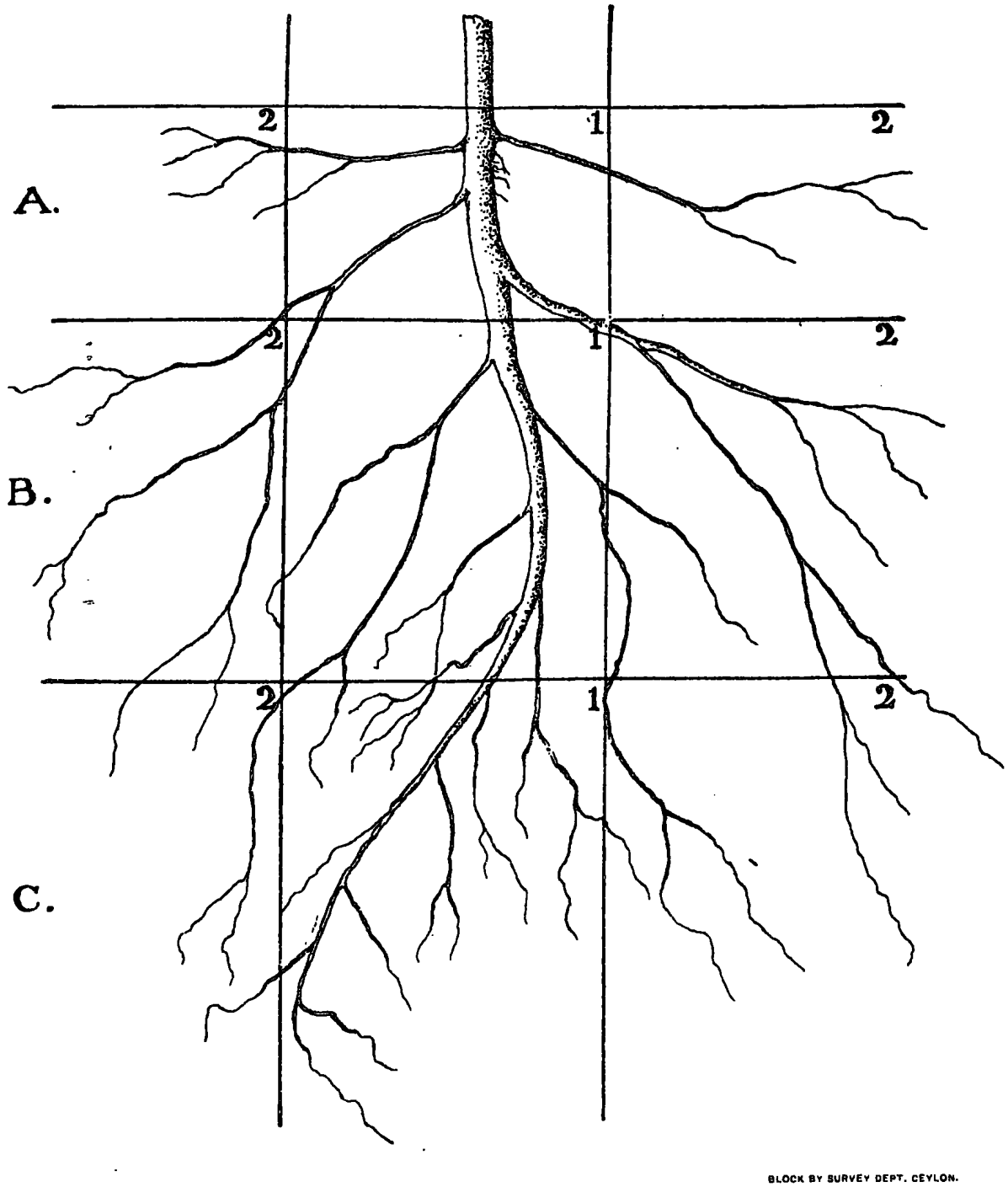
The results show a general agreement with those of other workers. The inoculated plants show a better distribution of nodules according to Ruf and Sarles' classification than do the uninoculated ones ; if we take the areas A1 + B1 + A2 as areas indicating efficient inoculation, we find that they represent 61·5 per cent. of the total in the inoculated series, but only 48 per cent. in the uninoculated series. The nodules are fewer in the inoculated series (agrees with Ruf and Sarles) but they are not larger. The effect of manuring agrees with the finding that the addition of combined nitrogen depresses nodulation. The unmanured series have the better nodule distribution (A1 + B1 + A2 = 60 per cent. for unmanured treatments and 49·5 per cent. for manured treatments), and they have fewer and bigger nodules. The effect on nodulation of the addition of lime is much less marked. There is no difference between distribution (A1 + B1 + A2 is 54·25 per cent. for the limed series and 55·25 per cent. for the unlimed series) and only a small difference in weight and number of nodules, but both differences are in favour of liming.

SUMMARY.

The results of preliminary investigations into the technique of soybean cultivation in Ceylon suggest—

(1) that the beans should be drilled at distances which will vary with the size of seed sown.

(2) that inoculation of seed prior to sowing is beneficial but not essential.



BLOCK BY SURVEY DEPT. CEYLON.

PLATE I.—DIAGRAMMATIC REPRESENTATION OF THE ROOT SYSTEM OF THE SOYBEAN. DIVIDED INTO AREAS ACCORDING TO THE METHOD USED BY RUF AND SARLES.

(3) that where inoculation is impracticable, a smaller increase in yield may be obtained by manuring with nitrate of soda.

(4) that lime is beneficial.

I have pleasure in recording my indebtedness to Mr. W. N. Fernando of this division for general supervision of these trials, and to the Agricultural Officer, Northern, and his Farm Managers at Anuradhapura (Mr. E. S. Jayasundera) and Jaffna (Mr. K. Balasingham) for their co-operation in the trials at those stations.

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TABLE I.

Effect of lime on development of soybean plants

Short-aged varieties.

	Easycook.			Rokusan.			Chame.			Hahto.		
	1	2	3	1	2	3	1	2	3	1	2	3
Average of limed rows	6·39..	9·93..	11·12..	13·15..	20·61..	21·95..	13·52..	26·00..	27·75..	12·82..	17·08..	18·42
	100..	**155..**	**174..**	**100..**	**157..**	**167..**	**100..**	**192..**	**205..**	**100..**	**133..**	**144**
Average of whole plot	6·64..	9·87..	11·06..	13·33..	20·05..	21·48..	13·91..	25·80..	27·57..	13·37..	18·18..	19·62
	100..	**149..**	**167..**	**100..**	**150..**	**161..**	**100..**	**185..**	**198..**	**100..**	**136..**	**147**
Average of unlimed rows	7·00..	9·80..	10·98..	13·50..	19·57..	21·07..	14·47..	25·46..	27·27..	14·12..	19·68..	21·25
	100..	**140..**	**157..**	**100..**	**145..**	**156..**	**100..**	**176..**	**188..**	**100..**	**139..**	**150**

Long-aged varieties.

	Brown.					Yellow.					Black.				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Average of limed rows ..	12·86..	33·86..	77·89..	86·07..	93·21..	8·41..	15·64..	24·15..	33·53..	37·07..	9·54..	26·59..	46·04..	63·50..	69·00
	100..	**263..**	**606..**	**669..**	**725..**	**100..**	**186..**	**287..**	**399..**	**441..**	**100..**	**279..**	**483..**	**666..**	**723**
Average of whole plot ..	12·81..	31·86..	71·97..	81·95..	88·19..	8·37..	15·24..	23·17..	32·93..	37·41..	9·61..	26·62..	43·82..	60·26..	66·65
	100..	**249..**	**562..**	**640..**	**688..**	**100..**	**182..**	**276..**	**393..**	**447..**	**100..**	**277..**	**456..**	**627..**	**693**
Average of unlimed rows ..	12·62..	27·86..	61·00..	73·71..	76·71..	8·29..	14·43..	21·19..	31·57..	38·14..	9·75..	26·71..	39·94..	54·19..	62·25
	100..	**221..**	**483..**	**584..**	**608..**	**100..**	**174..**	**256..**	**381..**	**460..**	**100..**	**274..**	**410..**	**556..**	**638**

The figures in ordinary type represent the average height of the plants in these rows, in centimeters. Each figure in heavy type represents the height recorded in the line above, expressed as a percentage of the height in the first column of each table, and thus expresses the average rate of growth. The first measurement (column 1 in each case) was made before the lime was applied ; the other measurements were made at regular intervals after the application of lime.

TABLE II.

Spacing trial with soybeans—Yields of seed. Season *yala* 1939

Yield in ounces.

Spacing.	Replications.												
	1	2	3	4	5	6	7	8	9	10	11	12	Total.
2′ × 3″	1·25	2·00	1·50	3·75	2·25	2·25	2.50	3·00	3·00	5·00	2·25	1·50	30·25
2′ × 6″	1·00	1·00	1·00	3·00	2·75	1·75	2.75	2·00	1·75	1·00	2·00	1·00	21·00
2′ × 12″	1·25	1·25	1·00	3·00	3·00	1·50	0.75	1·25	1·25	1·50	0·50	1·25	17·50

The odds are 100 to 1 that the differences are significant, and that the 2′ × 3″ spacing has given a significantly bigger yield than that at 2′ × 12″. The odds are 20 to 1 that the yield at 2′ × 3″ is significantly better than that at 2′ × 6″. The difference between the yields at 2′ × 6″ and 2′ × 12″ is not significant.

TABLE III.

Design of trials at Anuradhapura and Jaffna and yield of each plot in lb.

Anuradhapura.

ay-im 4·34	bylim 4·61	bxli- 5·58	bx- -m 4·42	ayl- - 4·27	ax-i- 5·03	by- - - 6·20	axl-m 5·16	Block 1. . .
axl- - 4·03	bx - - - 4·70	ax-im 4·09	bxlim 3·64	ay-i- , 3·86	ayl-m 5·00	by - -m 3·98	byli- 4·25	Block II. . .
ayli- 3·69	bxl- - 4·73	ay- -m 4·70	by- i- 5·27	byl-m 5·20	axlim 4·77	ax- - - 5·19	bx-im 5·87	Block III.
axli- 5·87	bx-i- 6·03	ax--m 5·02	byl- - 4·27	by-im 5·31	bxl-m 5·31	aylim 4·03	ay - - - 3·05	Block IV. . .

a : small seeded ; b : Poona Yellow
x : 2′ × 3″ ; y : 2′ × 6″ ; l : limed
i : inoculated ; m : manured.
Size of plot 20′ × 16′, or 10 rows per plot ; harvested area 16′ × 15′ or 8 rows per plot.
The mean yield is at the rate of 860 lb. per acre.

Jaffna.

ayli- 2·37	bxl- - 1·12	axlim 1·87	by- i- 3·06	ax- - - 0·62	byl-m 2·06	bx-im 1·87	ay- -m 1·81	Block 1. . .
by-im 2·87	aylim 2·81	bx-i- 2·06	bxl-m 1·37	ax- -m 1·75	axli- 1·69	byl - - 1·62	ay--- 1·31	Block II. . .
by- -m 1·94	ay-i- 2·31	ayl-m 1·69	byli- 3·00	bx- - - 0·56	ax-im 2·00	bxlim 0·87	axl- - 0·75	Block III.
bxli- 1·62	ax-i- 1·75	by - - - 1·87	bylim 3·25	ay-im 2·94	bx - -m 1·75	axl-m 1·25	ayl - - 10·6	Block IV. . .

a : Chame ; b : Yellow I
x : 1′ × 1′ ; y : 1′ × 6″ ; l : limed
i : inoculated ; m : manured.
Size of plot 24′ × 7′, or 7 rows per plot ; harvested area 22′ × 5′, or 5 rows per plot.
The mean yield is at the rate of 728 lb. per acre.

TABLE IV.

Effects of main treatments and first-order interactions in lb. of seed

	Difference in yield.	
	Anuradhapura.	Jaffna.
Yellow I—Chame	..	2·91
Poona Yellow—Small seeded	7·27 ..	
Narrow spacing—wide spacing	7·41 ..	13·07 ** (= 323 lb./ac.)
No liming—liming	2·65 ..	2·07
Inoculation—no inoculation	1·01 ..	13·81 ** (= 342 lb./ac.)
Manuring—no manuring	—0·57 ..	5·33 ** (= 132 lb./ac.)
Interaction between—		
variety and spacing	+5·03 ..	+3·83*
variety and liming	—5·73 ..	—0·07
spacing and liming	—0·13 ..	+1·57
variety and inoculation	+2·49 ..	—1·19
spacing and inoculation	—3·63 ..	+4·69**
liming and inoculation	—4·07 ..	—0·69
variety and manuring	—4·81 ..	—3·19*
spacing and manuring	+5·19 ..	+0·21
liming and manuring	+2·63 ..	—1·45
inoculation and manuring	—5·27 ..	—4·09*
Level of significance 1 per cent.	10·94 ..	4·30
5 per cent.	7·85 ..	3·09

None of the differences in the Anuradhapura trial reached the necessary level of significance, and therefore they cannot be relied on. In the Jaffna trial seven differences are greater than the significant level. The odds are 100 to 1 that those differences marked with two stars are real ones, and 20 to 1 on those marked with a single star.

TABLE V.

Analysis of variance of soybean trials

	Jaffna.			Anuradhapura.		
	DF.	Sum of Squares.	Mean Square.	DF	Sum of Squares.	Mean Square.
Blocks ..	3..	0·4668..	0·1556..	3..	3·1416..	1·0472
Main effects and first order interactions	15..	14·7744..	0·9849..	15..	9·2182..	0·6145
Remainder ..	13..	0·8291..	0·0628..	13..	5·3619..	0·4125
Total ..	31	16·0703		31	17·7217	

TABLE VI.

Effect of interaction between factors

Yields are in lb.

Variety and spacing.—

	1′ × 6″	1′ × 1′	
Yellow I.	19·67 ..	11·22 ..	30·89
Chame	16·30 ..	11·68 ..	27·98
	35·97	22·90	58·87

Spacing and inoculation.—

	Inoculated.	Not inoculated.	
1′ × 6″	22·61 ..	13·36 ..	35·97
1′ × 1′	13·73 ..	9·17 ..	22·90
	36·34	22·53	58·87

Variety and manuring.—

	Manured.	Not manured.	
Yellow I.	15·98 ..	14·91 ..	30·89
Chame	16·12 ..	11·86 ..	27·98
	32·10	26·77	58·87

Inoculation and manuring.—

	Manured.	Not manured.	
Inoculated	18·48 ..	17·86 ..	36·34
Not inoculated ..	13·62 ..	8·91 ..	22·53
	32·10	26·77	58·87

TABLE VII.

Effect of treatment on nodule development and distribution

Treatment.	Percentage Distribution of nodules.						Mean Number of nodules per plant.	Mean weight of nodules per plant in gm.	Mean weight per nodule in gm.
	A1	B 1	C 1	A 2	B 2	C 2			
No treatment ..	28	13	1	17	23	18	27·0	0·092	0·0034
Inoculated ..	42	12	—	18	17	11	43·2	0·075	0·0017
Manured ..	21	9	1	9	36	24	45·1	0·120	0·0026
Limed ..	23	14	3	14	27	19	26·7	0·141	0·0053
Inoculated and manured ..	25	9	2	18	28	18	36·6	0·064	0·0017
Inoculated and limed ..	30	16	3	13	23	15	30·6	0·115	0·0032
Manured and limed ..	22	12	1	10	31	24	60·1	0·112	0·0019
Inoculated, manured and limed ..	39	12	1	12	22	14	18·6	0·034	0·0018
Averages :—									
Inoculated ..	34	12·25	1·5	15·25	22·5	14·5	32·25	0·072	0·0021
Not inoculated ..	23·5	12	1·5	12·5	29·25	21·25	39·725	0·116	0·0033
Manured ..	26·75	10·5	1·25	12·25	29·25	20	40·1	0·082	0·0020
Not manured ..	30·75	13·75	1·75	15·5	22·5	15·75	31·875	0·106	0·0034
Limed ..	28·5	13·5	2·0	12·25	25·75	18	34·0	0·100	0·0030
Not limed ..	29	10·75	1·0	15·5	26	17·75	37·975	0·088	0·0023