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Preliminary Studies on Raising *Sesbania Speciosa* for Green Manure in the Laterite Soils

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Introduction: The laterite soils of the West Coast are characterised by their low pH values, poor base status, and low availability of phosphoric acid, though they are well supplied with total phosphoric acid and nitrogen, as seen from the figures of analysis of a typical sample, given in table I. Besides, the soils are very porous lacking in humus and hence have a low moisture holding capacity. To raise their level of productivity it is necessary to build up their organic matter status, for which the best course open is by raising green manures. *Sesbania speciosa,* because of its performance everywhere was considered to be the best for this purpose. But preliminary studies, carried out in the laterite soils of Mangalore showed, that *Sesbania speciosa* did not produce good growth, and nodule formation was also poor even after inoculation of the seeds with the proper Rhizobia.

The reason for the failure of the treated seedlings was thought to be due to the acid nature of the soil. A similar instance has been noted by Fellers (1918) who reported poor nodulation of soya-beans in an acid soil, even though large numbers of the proper bacteria were known to be present. Fred, Baldwin and McCoy (1932) proved that legumes thrive well in reactions at or near neutral point.

Detailed studies were, therefore carried out at the Agricultural Research Station, Pattambi to ascertain the ideal conditions for best nodulation and increased yield of *sesbania speciosa* and the results of these studies are presented in this paper.

TABLE I

Composition of the Laterite soil of Pattambi (Malabar)

Constituents		
pH	5·40	
Moisture	2·55	percent
Loss on ignition	6·40	,,
Insolubles	60·62	,,
Iron (F_2O_3) plus Alumina (Al_2O_3)	29·36	,,
Lime CaO	0·11	,,

TABLE I (Contd.)

Constituents	
Magnesia 'MgO'	0·20 ,,
Total Potash 'K_2O'	0·21 ,,
Soda Na_2O	0·42 ,,
Carbondioixide 'CO_2'	Nil
Total phosphoric acid 'P_2O_5'	0·18 ,,
Sulphuric acid 'So_3'	0·10 ,,
Nitrogen 'N'	0·14 ,,
Available Potash 'K_2O'	0 0024 ,,
Available phosphoric acid 'P_2O_5'	0·0062 ,,

Materials and Methods: The experiment was laid out during 1955 in randomised one cent plots with the following treatments, replicated four times.

(a) Control (no manure)
(b) Lime at 1500 lb. per acre
(c) Superphosphate to give 30 lb. P_2O_5 per acre
(d) Farmyard manure at 5000 lb. per acre
(e) Lime at 1500 lb. plus superphosphate at 30 lb. P_2O_5 per acre
(f) Lime at 1500 lb. plus farmyard manure at 5000 lb. per acre
(g) Superphosphate to give 30 lb. P_2O_5 plus farmyard manure at 5000 lb. per acre
(h) Lime at 1500 lb. plus superphosphate to give 30 lb. P_2O_5 plus farmyard manure at 5000 lb. per acre

The manures were applied in the puddled condition. The seeds were treated with the specific culture of root nodule organisms prior to sowing. The trials were so manipulated that the population of the seedlings in each plot was about the same.

At interval of 15, 30, 45 and 60 days after sowing, 20 plants selected at random were carefully lifted from each plot, the root system washed and the nodules counted (one confluent cluster being counted as one) and the average number of nodules per plant was calculated. The average shoot length per plant was also measured for the same intervals.

At the end of 60 days the plants from each plot were lifted, and after washing the root system, and draining the excess water, the fresh weight of the whole plants was recorded. Moisture was determined in the plant samples and representative samples were collected from each plot for the determination of total nitrogen content.

Soil samples (O - 12″) were collected from the plots before sowing and after harvest of the crop, both for chemical and biological analysis. These samples were analysed for :

(i) Available phosphoric acid, by extraction with 1 percent citric acid.

(ii) Total nitrogen by the Kjeldahl method as modified by Bal (1925),

(iii) Organic carbon as determined by the Walkley and Black's method (Walkley and Black 1934).

Composite soil samples for eacch treatment were prepared by mixing equal quantities of soil samples collected for the purpose of biological analyses, from each of the four replicated polts, under each treatment and the following assays were carried out :

(a) pH in 1 : 5 soil solution by the Beckmann pH meter

(b) Microbial population by planting on Thornton's agar medium (Wasksman 1932)

(c) Biological activity as measured by the Waksman and Starkey's method (Waksman and Starkey 1924).

Results and Discussion : *Nodul formation :* The average number of nodules per plant under the different treatments at different stages of growth are given in Table II. Differences among the treatments are highly significant (at 1% level). The 'no manure' treatment produced the least number of nodules at every stage. The number of nodules per plant progressively increased with the age of the plant, as is evidenced by the period mean.

TABLE II

Average number of nodules per plant

Period	Treatment means								Period mean	C. D. at 1% for comparison of any two treatment for the different periods
	A	B	C	D	E	F	G	H		
15 days after sowing	1·34	3·82	1·94	2·49	4·22	4·38	2·45	3·72	3· 05	1·50
30 days after sowing	2·98	16·80	4·81	4·73	16·76	16·58	6·26	17·91	10·85	3·80
45 days after sowing	10·99	28·29	18·13	18·41	30·30	34·43	20·80	38·31	24·96	11·26
60 days after sowing	37·96	97·50	74·60	57·65	93·80	76·63	53 46	91·43	72·88	31·86

Treatments involvoing lime are distinctly superior to treatments without addition of lime. But there is no significant difference among treatments receiving lime. Superphosphate or farm yard manure either singly or in combination are not superior to the 'no manure' control, but in combination with lime do give better results, indicating the absolute necessity of lime to bring about the full effect of either superphosphate or farmyard manure in promoting the nodule formation. The results are in conformity with those obtained by Fellers (1918) who reported that application of acid phosphate to limed plots was effective in increasing nodulation of soyabean, but exerted little or no effect upon unlimed soil. This also falls in line with the conclusions of Bear (1917) with regard to the beneficial effects of lime on the nodulated system.

Shoot Length: The average shoot length of the plants are presented in table III. It is seen from the data that the response to the different treatments is similar to that of nodule formation trend. The some is also maintained in the vegetative growth.

TABLE III

Average shoot length in Cms.

Period	Treatment mean								Period mean	C. D. 1% for comparison of any two treatments for the differnt periods
	A	B	C	D	E	F	G	H		
15 days after sowing	7·74	9·25	8·40	8·12	9 32	9 95	8·48	9·65	8·86	0·98
30 days after sowing	13·93	21·11	15·88	16 57	22·59	24·95	17·40	26·80	19·91	3·18
45 days after sowing	30·52	36·20	34·38	33·05	48·50	55·07	32·97	60·25	41·24	9·92
60 days after sowing	76·78	112·69	85·53	81·75	126 85	108·70	86·16	120·08	98·56	23·12

Yield of green matter: Table IV gives the average yield of green matter at harvest, after 60 days' growth of the crop. The yield data relating to green matter indicate that effects due to treatments are highly significant at 1% level, There is no significant difference between lime alone or in combination with superphosphate or farmyard manure. Application of superphosphate at 30 lb. P_2O_5 level has not significantly increased the yield over the "no manure" control. Lime combined with superphosphate or farmyard manure is better than lime with super or lime with farmyard manure. All the three combinations are necessary to bring about the maximum advantage in the condition of the soil for the growth and nodulation of *Sesbania speciosa.*

TABLE IV

(Mean yield of green matter in lb. per acre)

Treatment	A	B	C	D	E	F	G	H
Yield (lb.)	19122	27295	19590	·25283	30743	32295	23718	36075
Conclusions	H	F	E	B	D	G	C	A

Nitrogen, carbon and available phosphoric acid contents of soil: The data on the mean content of total nitrogen, organic carbon and available phosphoric acid in soils under the different treatments, collected before sowing and after harvest of *Sesbania* crop are presented in table V.

TABLE V

Average nitrogen, carbon and available phosphoric acid content of soil.

Treatment	Nitrogen		Organic Carbon		Available Phosphoric Acid (Mgm)	
	Before Sowing	After Harvest	Before Sowing	After Harvest	Before Sowing	After Harvest
A	·144	·151	1·16	1·06	51	55
B	·150	·153	1·21	1·07	61	52
C	·141	·150	1·12	1·09	57	55
D	·155	·157	1·14	1·13	71	55
E	·141	·156	1·15	1·15	70	59
F	·139	·162	1·13	1·15	62	53
G	·144	·160	1·19	1·13	57	55
H	·143	·148	1·14	1·12	59	59

From the figures it is seen that there is no significant variation in these soil characteristics, due to the growth of the *Sesbania* crop. However, there is an apparent increase in the nitrogen content of soils after the growth of the legume, which can be attributed to the diffusion of nitrogen from the roots and to the decay of older root nodules in the soil (Virtanen 1947) which undergo mineralisation slowly.

pH and microbial population: The pH of the composite soil samples under the different treatments are given in Table VI

TABLE VI

pH and Bacterial Counts

Treatments	Before Sowing		After Harvest	
	ph	No. of micro organisms in lakhs per gram of soil	PH	No. of micro organisms in lakhs per gram of soil
A	5·80	4·8	5·48	1·4
B	6·18	15·2	5·80	15·3
C	5·64	7·2	5·20	7·3
D	5·78	8·2	5:30	8·5
E	6·28	16·2	5·78	16·2
F	6·29	11·8	5·80	12·8
G	5·99	8·7	5·70	8·4
H	6·14	21·0	5·90	21·2

The microbial population of these soils were estimated by the plating method using Thorntons' agar medium. A dilution of 1 in 100,000 was found to give satisfactory counts on the plates. Four plates were used for each soil. The results obtained are given in Table VI.

It is seen that the limed plots have a higher pH generally. The plots receiving the lime treatment have also recorded a higher yield and better nodulation. This is in agreement with Joffee (1920) who recorded the greatest number of nodules and the greatest gain in nitrogen in the plants growing in soils of nearly neutral reaction. Bryan (1922) made similar observations with alffalfa, clover, cowpea, and soyabeans raised in nutrient solutions of varying concentrations.

Where superphosphate alone was applied there is a slight increase in soil acidity. Though farmyard manure, by itself has not mitigated the condition, in combination with lime, it has improved the soil reaction. The combination of all the three amendments viz. lime, super and farm yard manure has also raised the pH.

The pH of the soils after the harvest of the crop is slightly lower in all the series as compared with that before sowing, probably due to the uptake of lime by the crop.

Microbial population: The figures indicate that all the treatments have recorded higher bacterial numbers in the soil, than the control. Among the treatments the limed plots have higher bacterial numbers than the unlimed series. Super and farmyard manure alone and in combination also exert some influence on the soil population. The highest numbers are present in the plots receiving a combination of lime, super and farmyard manure. The results also indicate that there is very little variation in the numbers found before and after the crop.

Biological activity : The daily evolution of carbondioxide due to microbial activity was determined in the composite soil samples under the different manurial treatments. The experiments were carried out with 100 gm. of the sieved soils, to which organic matter in the form of 1 gram glucose had been added, and moistened to a level of 50% of the water-holding capacity of the soil and incubated at room temperature. Controls with soils alone were also run simultaneously for working out the percentage increases of CO_2 evolved due to biological activity in the samples treated with carbohydrate.

From the estimation of CO_2 evolved, the daily average production of CO_2 was worked out and the data are given in Table VII.

TABLE VII

Daily average production of CO_2

Treatments	Soil Samples Before Sowing				Soil Samples After Harvest			
	Mgm of CO2.		Difference due to glucose	Percentage increase due to glucose	Mgm of CO 2.		Difference due to glucose	Percentage increase due to glucose
	Soil alone	Soil + 1% glucose			Soil alone	Soil + 1% glucose		
A	7·5	19·6	12·1	161·4	5·1	19·3	14·2	278·8
B	17 2	31·2	14·0	82·0	15·5	24·0	8·5	55·2
C	28:2	33·9	5·7	20·3	22·1	31·2	9·1	40·9
D	39·6	41·4	1·8	44·4	33·0	35 0	2·0	8·7
E	37·8	40·7	2·9	7·6	29 5	31·7	2·2	7·4
F	7·0	18·5	11·5	162·5	4·5	18·3	13·8	309·0
G	18·3	28·4	10·1	55·4	19·2	26·0	6·8	35·4
H	33·2	42·9	9·7	29·1	29·9	33·6	3·6	11·8

From the data it would be seen that there is a general increase in the microbiological activity due to the application of the different amendments. In all cases there is a definite response to the added organic matter. The microbiological activity of the soil as revealed by the carbon dioxide evolution and the microbial population seems to be influenced by the amendments than by cropping. There is a general slackening of the biological activity after the harvest of the crop. Considering both the population and activity it is seen the highest counts are found in the treatment receiving lime, super phosphate and farm yard manure. The greatest quantity of carbon dioxide was evolved from the treatment, receiving farmyard manure though the number of organisms was considerably less. This seems to be due to the composition of the micro-organisms such as fungi and bacteria and it is known that acid range of soil reaction is more favourable for moulds than bacteria and vice-versa. The addition of farm yard manure also assists the development of fungal growth. In general it is found that combination of lime, P_2O_5 and farm yard manure provides a good condition in the soil for microbial growth and activity thus tending to increase their fertility.

Analysis of plant samples : The *Sesbania* crop was harvested after two months' growth and the dry matter weight was deduced from the green matter yield and moisture per cent. Representative plant samples under the different treatments were analysed for total nitrogen content. The nitrogen content of the harvested crop in each plot, was calculated. The average figures of dry matter yielded are given in Table VIII.

TABLE VIII

Average dry matter weight
(Expressed in lb. per acre)

Treatment	A	B	C	D	E	F	G	H	C. D. at 1% level
lb./acre	5697	7699	5706	7373	8911	9429	7023	10870	1230
Conclusion		H	F	E B,	D	G	C	A	

Dry matter : The data on the dry matter yield after two months' growth of the crop, are highly significant (at 1% level) and are similar to the green matter yields (vide Table IV).

Total nitrogen content : The data (Vide Table IX) are significant at 5% level. The results indicate that the combination of lime, superphosphate and farm yard manure bring about the maximum return, in the form of nitrogen in the harvested crop, which nitrogen could be incorporated into the soil. It may be seen that nearly 122 lb of nitrogen is obtained by this way as against 78 lb from 'no manure' plot for a two month old crop.

TABLE IX

Average Nitrogen Content of Sesbania Plant
(Expressed in lb. per acre)

Treatment	A	B	C	D	E	F	G	H	C. D. at 1% level
Lb./per acre	78·2	103·1	84·5	102·1	104·4	105·7	89·4	121·8	21·7
Conclusion		H	F	E	B	D	G C	A	

Summary and Conclusion: A field trial was conducted during 1955 at the Agricultural Research Station, Pattambi, to find out the ideal conditions for best nodulation and growth of *Sesbania speciosa* good. The changes in the soil condition were also studied. The extent of groth, green matter yielded and the nitrogen contained in the crop were assessed.

The factors of particular importance for the best performance of legumes are the physical properties of the soil to hold and to release water and air to the plant, the acidity or alkalinity of the soil and its content of necessary nutrients. Provided the soil contains and permits a ready flow of water and air and is free from concentrations of soluble salts, the factors of importance are the pH value and availability of essential nutrients.

There are good indications that legumes for green manure purposes can profitably be raised in the laterite soils of Malabar by providing amendments like lime, and adding organic matter such as farm yard manure and phosphoric acid. As stated by Whyte *et al* (1953) calcium not only sweetens the soil but also facilitates the the release of certain nutrients in an available form. It has been found that if sufficient calcium is available as a nutrient, and the other essential nutrients are not lacking and the soil is in a good physical condition, the degree of acidity or alkalinity may not have much influence within certain limits. The trials have clearly indicated this, namely that for effective nodulation of legumes and improving their growth a combination of lime at 1500 lb. superphosphate at 30 lb P_2O_5, and farm yard manure at 5000 lb. per acre was the best as it increased the yield by 80 per cent over the control adding 44 lb. more nitrogen per acre.

The difference in the contents of nitrogen, organic carbon, available phosphoric acid, pH and bacterial numbers of the soils after application of the amendments, and after harvest of the crop were not significant i. e. these soil characteristics were not influenced by the growing of the sesbania crop.

The excellent growth of green manure seems to be due to the availability of lime and phosphoric acid than due to the change in soil reaction alone which is very little. This is clear from the poor base status and lack of available nutrients in the soils before the use of the amendment and fertiliser. The farm yard manure helps to retain more moisture as well as the soluble plant nutrients. The importance of organic matter content of soil for the better assimilation of phosphate by legumes and the need for phosphate has also been stressed by Sanyasi Raju (1953).

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