AGRICULTURAL DEPT. MADRAS

BULLETIN No. 94

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The Agricultural Department, Madras



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# FIELD EXPERIMENTS WITH CALCIUM CYANAMIDE AS A NITROGENOUS MANURE FOR SOUTH INDIAN SOILS AND CROPS

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MADRAS
PRINTED BY THE SUPERINTENDENT, GOVERNMENT PRESS

PRICE, 4 *annas*] 1929

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Among the more important plant-food elements—nitrogen, phosphoric acid and potash—the one to which crops generally react most readily is nitrogen. The soil surveys carried out by the department point to a general deficiency in this constituent. The locally available natural supplies, now in use, are farm-yard manure, green leaves, fish and fish manures, and oil-cakes. These sources are far too poor to meet the demands and the need for chemical or artificial manures is great. The most important of these are nitrate of soda, sulphate of ammonia, and calcium cyanamide. Agriculturists are familiar with nitrate of soda and sulphate of ammonia but calcium cyanamide is not so well known as it is a recent introduction. This bulletin describes what this manure is and the results of field trials for the information and guidance of those who have to use artificial nitrogenous manures.

Calcium cyanamide, the manufacture of which was first patented in 1905, is the same as "NITROLIM" a patent trade name under which this manure was made familiar to us in this country about ten years ago. The patent name is not now in use. This manure is manufactured by fixing the nitrogen of the atmosphere, which is available in unlimited quantities Large quantities of coke and lime are heated at high temperatures in electric furnaces The coke and lime combine to form calcium carbide—the substance with which users of carbide lamps or acetylene burners are familiar. The calcium carbide thus formed is crushed and heated to a moderately high temperature in contact with nitrogen obtained from the atmosphere. The calcium carbide now unites with the nitrogen and forms calcium cyanamide Any carbide that remains as such is removed and then the calcium cyanamide is oiled to allay dustiness in handling, and offered for sale in drums or bags.

New stocks usually contain about 19 per cent nitrogen but we have experience of old stocks containing 15 per cent or even less.

In view of the possibilities of the development of electric power in this country it was thought likely that calcium cyanamide should be capable of being made cheap and available to the ryot. It was, therefore, considered desirable to investigate its value as a fertilizer for the various crops of this Presidency.

As soon as calcium cyanamide was made in sufficiently large quantities for use as a fertilizer, numerous investigations were carried out in Europe and America and as a result calcium cyanamide is established as a serious rival to nitrate of soda and sulphate of ammonia.

The experience in this country has, however, been different. The results of experiments between the years 1916 and 1920 were of an erratic nature. In some cases the manured plots gave yields lower than the controls, while in others, where an increase was shown, this was so small as to be within the limits of experimental error or, at any rate, insufficient to cover the cost of the manure. Many of the experiments were carried out in single or duplicate plots and hence they could only be considered as trials.

A more rigorous set of experiments was again carried out in the years 1920 to 1922 and the results were again as erratic as those in the previous years The experience with this manure, however, gave rise to certain beliefs or opinions.

(1) A certain interval of time is necessary between the application of manure and sowing or transplanting so as to allow for the disappearance of the toxic substances formed by the decomposition of cyanamide.

(2) Under certain conditions, not well defined, the toxic substances persist in the soil permanently damaging the crop.

(3) Cyanamide is not, therefore, a safe manure.

These views are widely divergent from opinions held in other countries. It was, therefore, considered desirable to investigate the nature of the decomposition of calcium cyanamide in the soil and its mode of action on the crop.

As a first step laboratory and pot culture investigations were carried out to find out whether calcium cyanamide gives rise to toxic substances in the soil and, if so, what their fate is, whether they persist for long in the soil or get changed into other harmless substances. The results of these investigations were published in 1923 and are described in detail in the Memoirs of the Department of Agriculture in India, Chemical Series, Vol. VII, No. 3.

The main findings of these investigations are—

(1) Provided that the manure is thoroughly incorporated in the soil, no harmful results are to be feared and even when such high doses as 3 to 5 cwt. are employed, there is little evidence of any formation of dicyanodiamide, which has been proved to be indirectly toxic to plants.

(2) The process of decomposition takes place in two distinct stages (*a*) the conversion of cyanamide into urea, which is almost

entirely a chemical change, and (*b*) the further conversion of the urea by bio-chemical agency into ammonia and nitrates.

(3) Pot cultures with wet and dry crops, e.g., paddy and ragi, have given distinctly encouraging results, the manured pots in all cases having shown substantial increases of both grain and straw.

(4) The conditions most favourable to the formation of dicyanodiamide are high temperatures and fairly large concentrations of alkali or acid produced as a result of the manure not being thoroughly incorporated into the soil or when very large quantities of calcium cyanamide are employed.

(5) Calcium cyanamide does not affect germination but inhibits nitrification.

The results of laboratory investigations and preliminary pot culture tests having failed to justify the prejudice against calcium cyanamide, field experiments were again instituted to ascertain how far laboratory experience is applicable in actual field practice.

The experiments were on cholam or jonna (*Andropogan sorghum*) at Hagari, on ragi or chodi (*Eleusine coracana*) and paddy (*Oryza sativa*) at Coimbatore on cumbu or sajja (*Pennisetum typhoideum*) at Kovilpatti and on fodder cholam at Chintaladevi.

The manure was tried in two doses of one and two cwt. (112 lb. and 224 lb.) to the acre, and as the soils of our presidency are generally deficient in phosphoric acid, superphosphate was also applied to the plots. To avoid the formation of dicyanodiamide the manure was thoroughly incorporated into the soil the day before sowing or transplanting. Superphosphate was always applied before or after the application of calcium cyanamide or as a top-dressing when the crop is well established, but never mixed together, as when calcium cyanamide is mixed with superphosphate heat is developed and this induces the formation of the toxic substance dicyanodiamide. When superphosphate was applied directly to the soil an interval of 2 or 3 days was allowed between the applications of calcium cyanamide and superphosphate.

The experiments were laid out in long and narrow plots with a view to bring down experimental error. About four to five repetitions were provided in each case. The results are tabulated in Tables I to V and are examined statistically according to Students' method as modified by Engledow. A 30 : 1 chance is considered significant. The results of individual years are examined separately and combined together and statistical estimates of the variations caused by differing weather conditions as well as that due to soil heterogeniety are obtained and given as "Effective error" of the mean differences for the three years. The results are discussed under each crop.

### Ragi (*Eleusine coracana*).

The experiments with this cereal were conducted in Field No. 18 of the Central Agricultural Station. Prior to the date of the starting of our experiments, no regular rotation was practised.

The particular field was for some time under irrigation experiments. Thirty plots were laid out along the general slope of the field each measuring 14 × 357 or 5 cents in area. A three-link interspace was allowed between any two plots. A small area all round the experimental portion was cultivated and harvested as outskirt There were six treatments and five replications. The following are the treatments given per acre. —

(1) Control.
(2) Cyanamide, 1 cwt
(3) Cyanamide, 2 cwt.
(4) Cyanamide, 1 cwt. plus superphosphate, 1 cwt.
(5) Superphosphate, 1 cwt.
(6) Cyanamide, 2 cwt. plus superphosphate, 2 cwt.

Cyanamide was applied about two or three days before planting and incorporated with the soil by passing a junior hoe. Superphosphate was applied later after the seedlings had established themselves. Irrigations were given as required till the crop matured. Harvest was done as far as possible on the same day. The results of three seasons are given in Table No. I. Neither calcium cyanamide 1 cwt. by itself nor superphosphate alone has given significant increase; but each seems to supplement the other, as when combined, they have given an increase of 16 9 per cent sufficient for a 30 : 1 chance. It should, however, be pointed out that calcium cyanamide even in the smaller dose, has given significantly higher yields during two of the three seasons and the effectiveness of its combination with a dose of superphosphate would, on the face of it, appear to be not due to a general phosphate deficiency of the soil, as an application of phosphate alone has not benefited the soil at all. It is possible that a more plentiful supply of phosphate even in the form of super has led to a better assimilation of the nitrogen supplied in the form of calcium cyanamide. The behaviour of the higher dose and the corresponding phosphate analogue is in a line with the explanation above. These two treatments have given almost the same increase, namely 23·1 and 20·9 per cent respectively. With the higher dose of nitrogen, a sufficient supply of nitrogen has been assured and there is little need for an agent which would enable the plant to use nitrogen as and when it becomes available. The effect of the addition of such an agent will hardly be felt and will be the same as though cyanamide were added alone. This has been the case with the application of super along with the higher dose of cyanamide.

It is a significant fact that calcium cyanamide 1 cwt. plus super has not given sufficient increases over cyanamide 1 cwt. alone for a 30 : 1 odds and the merit of the combination seems to lie not in correcting phosphate deficiency alone but in endowing the plant with a better power of utilizing the manures.

This is further supported by the behaviour of bonemeal plots. As will be seen in Table V, bonemeal in combination with calcium cyanamide has given an increase of 33·6 per cent grain and 48·4 per cent straw than bonemeal alone.

### Cumbu (*Pennisetum typhoideum*).

Experiments with this cereal were conducted at the Kovilpatti Experiment Station in Field No. 26, which forms part of a large area of black soil under cotton-cumbu rotation The experimental portion was carefully selected with the assistance of the officers in charge of the station. An idea of the general conditions of the soil could be obtained, from an examination of the yields of the control plots and in the absence of any recorded details, this is the only criterion by which we could judge of the general fertility of the plots. In the particular case, the high averages of the yields of control plots 600 lb. per acre indicate a fairly rich soil—a good representative of the locality.

The experiment was laid on the same lines as with the other millet-ragi with the exception that it was not irrigated but was rainfed. Thirty plots were laid out each measuring (490 × 12½) and 5 cents in area. The following treatments were tried and were replicated five times.—

(1) Control, (2) Calcium cyanamide, 1 cwt, (3) Calcium cyanamide, 2 cwt., (4) Superphosphate, 1 cwt., (5) Calcium cyanamide, 1 cwt. plus superphosphate, 1 cwt., (6) Calcium cyanamide, 2 cwt. plus superphosphate, 1 cwt.

A small outskirt sown to the same crop was also provided all round the experimental area. The results of these are given in Table II.

It will be seen that with the exception of the superphosphate all the other treatments have given significant increases over the control plots. Unlike the previous crop calcium cyanamide alone has given significant increases of 24 per cent even in the smaller dose.

### Paddy (*Oryza sativa*).

Experiments with this cereal were also conducted at the Central Agricultural Station, Coimbatore. Details of the previous history of this block are available. From the year 1910—1918 the plots were under spacing experiments. All these years the land was not standardized and although there was no attempt to assess its variations quantitatively the general observations of the crops indicated a gradual variation, the land becoming poorer as the distance from the tank increases. During the year 1919, the plots were re-aligned into 16 plots of 10 and 12·5 cents, each set lying to the west and east of the irrigation channel. Since that time, the plots were being standardized till the year 1922 when they were handed over for the experiments now under review.

Two sets of eight plots, each measuring 5 cents (42′ × 119′) and 6·25 cents (42′ × 149′) respectively were laid out on the western

and eastern sides of the irrigation channel. Four different treatments were tried and replicated four times. The following are the treatments :—

(1) Control, (2) Calcium cyanamide, 2 cwt. only, (3) Calcium cyanamide, 2 cwt. plus superphosphate, 1½ cwt., (4) Superphosphate, 1½ cwt. only

Calcium cyanamide was applied a day or two before planting and thoroughly mixed with the soil by passing the levelling board. Superphosphate was applied generally a month later as a top-dressing when the plants had established themselves. The variety tried was G.E.B. 24. Some general observations on the crop will be recorded here

Two striking features of a paddy crop manured with calcium cyanamide are the initial set-back in the young seedlings, and their rapid recovery thereafter, attended with a profuseness of tillering. In about a week after transplanting, all the seedlings appear scorched up. This effect lasts for about three weeks, when they gradually recover and put on rapid growth after six weeks. The initial set-back, we have reason to believe, is due largely to the presence of free lime and probably also to acetylene in the calcium cyanamide as old samples of cyanamide in which the free lime would have been converted to the carbonate and acetylene slowly and gradually evolved out, do not produce this effect. The other feature—the greater fecundity of tillers—has also been noted at Rothamstead (Annual Report, 1925–26).

The experiments were in progress for three seasons and the results are recorded in Table III. Unlike ragi even the bigger dose of calcium cyanamide has not benefited the crop. An increase of 17·5 per cent of grain has been noted against this treatment which is a little too small for a 30 1 odds. Like ragi, however, when combined with a small dose of superphosphate, definitely significant increases are noted Superphosphate by itself has again proved of no use. Generally speaking, results with paddy are on the same lines as with ragi; only the causes that make the combination more effective than either of the manures singly, seem to be present in an exaggerated measure. It should, however, be pointed out that during two of the three seasons 2 cwt. of calcium cyanamide has given significant increases.

Another set of experiments was also laid out under the same cereal with slightly different doses of the manures. Ten plots were laid out and five treatments were tried in duplicate. The series could not be replicated a larger number of times owing to want of space and it is further unfortunate that being the earliest of experiments, it had not had the benefits of randomization.

The following are the treatments :—

(1) Control, (2) Cyanamide, 1 cwt., (3) Superphosphate, 1½ cwt., (4) Cyanamide, 1 cwt. plus superphosphate, 1½ cwt., (5) Cyanamide, 2 cwt. plus superphosphate, 1½ cwt.

The results of these experiments are given in Table V.

In the present series of experiments, a treatment is included which for reasons of space again could not be taken up in the regular and better standardized series. The results are largely in a line with the other set of experiments with the same crop.

Here again, while calcium cyanamide by itself has not been effective, when combined with super, even the smaller dose of 1 cwt. has given significant increase of 30 per cent grain. The behaviour of the superphosphate is similar.

### Other Experiments.

Experiments with grain cholam (*Andropogan sorghum*) were conducted at the Hagari Experiment Station and were not a success owing to failure of rains. They were, therefore, given up.

Experiments with fodder cholam were conducted at the Chintaladevi Cattle Farm. Four treatments were tried and replicated four times. The following are the treatments :—

(1) Control, (2) Cynamide, 2 cwt., (3) Super, (4) Cyanamide plus super.

The results obtained are given in Table V It will be found that superphosphate has again proved of no use while cyanamide by itself or in combination with super has been effective.

The consolidated results for the three seasons and for all the stations are given as the average percentage increases over the unmanured control plots in Table IV. It is not correct in reporting experimental results to work up the yields from experimental plots to the acre but for the sake of convenience and for those who are accustomed to look into acre yields, the averages per acre are also given in Table V.

The most outstanding feature of the experiments of all the years, with all the crops and at all the experiment stations is their consistency. Far from being erratic in its action, calcium cyanamide has been found to be quite a reliable manure. The experiments were originally intended to be carried over five years and they are still going on, but in view of the consistency of the results obtained it was considered desirable to report the three years' results and continue the experiments to the full time, limit under slightly modified conditions namely by applying the calcium cyanamide on light basal dressings of bulky organic manures like cattle manure and green manures and report the results at a later date.

Summarising what has already been said it may be stated that—

(1) in the case of dry crops like cumbu, calcium cyanamide is a useful manure. At Kovilpatti even the smaller dose of 1 cwt. has given significant increases,

(2) in the case of irrigated crops like ragi, the smaller dose is not so effective at Coimbatore;

(3) with the exception of paddy, the higher dose of 2 cwt. has been effective in all cases, i.e., under normal variations of climate and soil,

(4) in the case of paddy, however, even the higher dose has failed to give an increase sufficiently significant; and

(5) superphosphate by itself has not given any increase, but it seems to have enhanced the value of calcium cyanamide when both these manures are applied together. Even the smaller dose of calcium cyanamide becomes effective. It is remarkably inert when applied alone and its activity when used along with nitrogen cannot be entirely attributed to a simple soil deficiency in phosphates. It appears to improve the effect of the dose of nitrogen.

We have now to consider the economics of manuring with calcium cyanamide. The economic value of any manure is a fluctuating one, depending as it does on the ruling prices of the manure and the crop produced. The price of calcium cyanamide at the time the experiments were started was about Rs. 360 per ton and that of superphosphate at Rs. 110. The price of calcium cyanamide has now fallen to Rs. 150 a ton and that of superphosphate to Rs. 90 a ton Based on these prices, a profit and loss statement has been worked and presented in Table VI. Except in the case of paddy, the profit obtained is nowhere attractive. Along with superphosphate calcium cyanamide in either dose has given almost the same net profit of Rs. 21 per acre and considering the advantage of a smaller outlay, the 1 cwt. dose is preferable. In the case of cumbu the higher dose is not really advantageous as proportionate increases are not obtained. The small dose of 1 cwt. has given a net profit of only Rs. 2–8–0. Similarly in the case of ragi the smaller dose has given a profit of Rs. 3–10–0 per acre. It will be noted that in these calculations the yields from straw have not been taken into consideration. The money value of cumbu and ragi straws is negligible In the case of paddy the value of straw enhances the profit still more.

Although calcium cyanamide has been shown to be a reliable manure when properly handled and an attractive proposition in the case of crops like paddy, we do not consider that this manure has a very great future, when compared with the other nitrogenous manures like ammonium sulphate and sodium nitrate, unless it is offered at greatly reduced prices. According to our pot experiments with ragi, the efficiency of the three nitrogenous manures is as below —

| | |
|---|---|
| Ammonium sulphate ... ... ... ... | 100 |
| Sodium nitrate ... ... ... ... ... | 70 |
| Calcium cyanamide ... ... ... ... .. | 50 |

As the Manganallur Experiment Station where calcium cyanamide was compared with ammonium sulphate on the field scale the efficiencies are of the following order:—

| | |
|---|---|
| Ammonium sulphate ... ... ... ... | 100 |
| Calcium cyanamide . .. ... ... ... | 90 |

In addition to its inferior position in the scale of manurial efficiency, calcium cyanamide has another disadvantage in that it is

dusty, difficult to handle and demands a certain amount of care in applying it to the field.

It is for these reasons that we consider that this manure has no bright future in Southern India. This need not, however, damp the enthusiasm of those who advocate the utilization of electric power for the fixation of atmospheric nitrogen. Ammonium sulphate, ammonium phosphate and nitrates can be manufactured by the fixation of atmospheric nitrogen directly or by the cyanamide process.

The one great advantage of calcium cyanamide is its high lime content. It exercises a beneficial influence on the texture of the soil and in cases of deficiency of lime it would very often be a paying proposition to apply calcium cyanamide instead of lime purchased from outside at great cost.

When calcium cyanamide is used it is very important that it should be evenly distributed and thoroughly incorporated in the soil. To ensure even distribution the fertiliser may be mixed with 5 to 10 times its weight of dry soil, thoroughly mixed and then distributed on the field. Calcium cyanamide contains caustic lime. It is, therefore, desirable that after using the manure the hands are wiped off with an oiled cloth before washing. In hot, humid climates, it is preferable to slightly oil the hands before the manure is handled as otherwise, the perspiration tends to slake the lime on the body and cause blisters.

## TABLE I.

*Results of experiments with calcium cyanamide applied to ragi (Eleusine coracana) in Field No. 18, Central Farm, Coimbatore.*

Yields per plot in pounds. (5 cents in area)

| | No manure. | | Calcium cyanamide, 1 cwt per acre | | Calcium cyanamide, 1 cwt plus super, 1 cwt per acre. | | Calcium cyanamide, 2 cwt per acre. | | Calcium cyanamide, 2 cwt plus super, 1 cwt per acre. | | Superphosphate, only 1 cwt. per acre. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Grain. | Straw. | Grain. | Straw. | Grain. | Straw | Grain | Straw | Grain | Straw. | Grain | Straw. |
| **1922-23.** | | | | | | | | | | | | |
| Series 1 ... ... .. | 128·8 | 173·0 | 124 0 | 224 0 | 130 8 | 215·0 | 152·0 | 251·0 | 122 0 | 236 0 | 155 8 | 209·0 |
| Do. 2 ... ... | 126 0 | 199 0 | 134 0 | 198 0 | 137 0 | 189 0 | 147·0 | 243 0 | 145 8 | 221 0 | 125·0 | 175·0 |
| Do. 3 ... ... .. | 121·8 | 153 0 | 131 8 | 196 0 | 136 0 | 188 0 | 148·0 | 236 0 | 138·0 | 216 0 | 138 8 | 206·0 |
| Do. 4 ... .. ... | 104·0 | 173·0 | 134·8 | 200 0 | 132 0 | 199 0 | 154 0 | 241·0 | 132·0 | 234 0 | 111·0 | 171·0 |
| Do. 5 .. ... | 117·8 | 162 0 | 118 0 | 168 0 | 155 0 | 173·0 | 131·0 | 218 0 | 1.7 5 | 176 0 | 128 8 | 151 0 |
| Average .. | 121 7 | 172·0 | 128 5 | 197·0 | 138 2 | 198·0 | 146 4 | 238 0 | 133 1 | 217·0 | 131·9 | 182 0 |
| Per cent increase over no manure. | ... | ... | 5·6 | 14 5 | 13·53 | 12 2 | 20 30 | 38·1 | 9·4 | 26 2 | 8 5 | 5·8 |
| **1924-25.** | | | | | | | | | | | | |
| Series 1 ... ... .. | 80 5 | 150 0 | 100 0 | 203 0 | 102·0 | 230 0 | 118 0 | 255 0 | 117 ( | 295 0 | 81 0 | 151·0 |
| Do. 2 .. ... . | 88·0 | 190·0 | 97·5 | 232 0 | 103·0 | 250 0 | 114·0 | 289 0 | 106·0 | 265·0 | 78·0 | 161·0 |
| Do. 3 ... .. ... | 82 0 | 168 0 | 102 0 | 236 0 | 105 0 | 252 0 | 107 0 | 250·0 | 110 0 | 267 0 | 85·0 | 177 0 |
| o. 4 ... ... . | 82 0 | 162 0 | 90 0 | 209 0 | 110·0 | 235 0 | 112·0 | 252·0 | 118·0 | 251·0 | 92·0 | 182·0 |
| Do. 5 ... ... .. | 92 0 | 177 0 | 102·0 | 219 0 | 108 0 | 201 0 | 117 0 | 244 0 | 140 0 | 214·0 | 87 0 | 156·0 |
| Average | 86·9 | 175 0 | 98 3 | 220 0 | 105·6 | 234 0 | 113·2 | 258·0 | 118·2 | 258·4 | 84·6 | 165 0 |
| Per cent increase over no manure. | ... | ... | 13·1 | 25·7 | 21 5 | 33·7 | 30·27 | 47·4 | 36·1 | 47·7 | .. | ... |

1925–26.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Series 1 .. .. ... | 68·0 | 292·0 | 72·0 | 336·0 | 76·0 | 340·0 | 79·0 | 347·0 | 80·0 | 406·0 | 57·0 | 220·0 |
| Do. 2 .. . ... | 61·0 | 233·0 | 69·0 | 345·0 | 74·0 | 335·0 | 77·0 | 395·0 | 81·0 | 391·0 | 59·0 | 234·0 |
| Do. 3 ... . . | 68·0 | 316·0 | 70·0 | 346·0 | 74·0 | 368·0 | 79·0 | 411·0 | 79·0 | 432·0 | 58·0 | 259·0 |
| Do. 4 ... ... . | 63·0 | 267·0 | 77·0 | 336·0 | 74·0 | 350·0 | 75·0 | 381·0 | 82·0 | 367·0 | 61·0 | 263·0 |
| Do. 5 ... ... .. | 64·0 | 275·0 | 76·0 | 378·0 | 80·0 | 357·0 | 71·0 | 374·0 | 82·0 | 389·0 | 61·0 | 248·0 |
| Average ... | 61·8 | 273·0 | 72·8 | 347·0 | 75·6 | 350·0 | 76·2 | 382·0 | 80·8 | 397·0 | 59·2 | 245·0 |
| Per cent increase over no manure. | ... | | 12·3 | 27·1 | 16·7 | 28·2 | 17·29 | 39·9 | 24·0 | 45·4 | . | ... |

Probable error of mean difference .. ... ... 1922–23 .. ± 4·6
1924–25 .. ± 2·1
1925–26 .. ± 1·1

Effective error for 3 years .. ... .. ± 4·6

## TABLE II.

*Results of experiments with calcium cyanamide applied to cumbu (Pennisetum typhoideum) in Field No. 26 at the Agricultural Experiment Station, Koilpatti.*

Yields per plot in pounds. (Each plot is 5 cents in area.)

| | No manure. | | Calcium cyanamide, 1 cwt. per acre. | | Calcium cyanamide, 1 cwt plus super, 1 cwt. per acre. | | Calcium cyanamide, 2 cwt. per acre. | | Calcium cyanamide, 2 cwt. plus super, 1 cwt. per acre. | | Superphosphate, only 1 cwt. per acre. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Grain. | Straw. | Grain. | Straw. | Grain. | Straw. | Grain. | Straw. | Grain. | Straw. | Grain. | Straw. |
| **1923–1924.** | | | | | | | | | | | | |
| Series 1 ... ... ... | 31·0 | 102 0 | 37·0 | 106 0 | 33 0 | 123 0 | 40·0 | 113 0 | 44·0 | 155 0 | 30 0 | 106·0 |
| Do. 2 ... .. ... | 30 0 | 99·0 | 35·0 | 123·0 | 32·0 | 109·0 | 41·0 | 134 0 | 41 0 | 133 0 | 29 0 | 95·0 |
| Do 3 . .. | 29·0 | 91·0 | 34·0 | 120·0 | 37·0 | 127·0 | 38 0 | 116 0 | 39 0 | 138 0 | 25 0 | 94·0 |
| Do. 4 .. .. .. | 26 0 | 100·0 | 34·0 | 119·0 | 28 0 | 101 0 | 37 0 | 129 0 | 37 0 | 133·0 | 26·0 | 93·0 |
| Do. 5 . ... ... | 25·0 | 89 0 | 33·0 | 113·0 | 34·0 | 120·0 | 34 0 | 116·0 | 42 0 | 142 0 | 25·0 | 96·0 |
| Average ... | 28·5 | 96·2 | 34 6 | 116·0 | 32·8 | 116·4 | 38 0 | 122 0 | 40·6 | 140·2 | 27 0 | 96·8 |
| Per cent increase over no manure. | ... | .. | 21·4 | 20·6 | 15·1 | 21·0 | 33·3 | 26 8 | 42·5 | 45 7 | ... | .. |
| **1924–1925.** | | | | | | | | | | | | |
| Series 1 ... . ... | 43·0 | 147·0 | 46·0 | 149·0 | 45·5 | 178·0 | 49 5 | 164 0 | 55 5 | 205·0 | 36 0 | 130·0 |
| Do. 2 ... . ... | 34·5 | 134·0 | 38·0 | 138·0 | 48·0 | 185·0 | 45·0 | 139·0 | 51·5 | 197·0 | 34 5 | 155·0 |
| Do. 3 ... .. ... | 31 0 | 126·0 | 37·5 | 153·0 | 43·5 | 174 0 | 46·5 | 177·0 | 47 5 | 188 0 | 29·0 | 133·0 |
| Do. 4 ... ... ... | 29 0 | 124 0 | 36·5 | 144·0 | 46·5 | 186 0 | 41·5 | 171·0 | 47·5 | 181·0 | 31 0 | 129·0 |
| Do. 5 ... ... ... | 27 0 | 122 0 | 35 0 | 139·0 | 40·5 | 159 0 | 37·5 | 155·0 | 44·0 | 197·0 | 31·5 | 140·0 |
| Average ... | 32·9 | 131·0 | 38·6 | 145·0 | 44·2 | 176 0 | 44·0 | 161·0 | 53·2 | 194 0 | 32·4 | 137 0 |
| Per cent increase over no manure. | ... | ... | 17·3 | 10·7 | 36·2 | 34·4 | 33·7 | 22·9 | 61·7 | 48·1 | ... | 4·6 |

1925-1926.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Series 1 . .. . | 34·5 | 100·5 | 40·0 | 114·0 | 40·5 | 108·0 | 48·5 | 128·0 | 55·5 | 141·0 | 28·5 | 82·5 |
| Do. 2 ... .. ... | 28·5 | 88·5 | 37·5 | 102·0 | 40·0 | 105·0 | 42·0 | 120·0 | 48·0 | 124·5 | 30·0 | 88·5 |
| Do. 3 . . | 28·5 | 82·5 | 34·5 | 93·0 | 31·5 | 85·5 | 40·5 | 111·0 | 45·0 | 115·5 | 25·5 | 72·0 |
| Do. 4 . .. | 22·5 | 69·0 | 37·5 | 97·5 | 40·0 | 96·0 | 39·0 | 111·0 | 48·0 | 133·5 | 30·0 | 81·0 |
| Do. 5 .. .. . | 24·0 | 70·8 | 37·5 | 90·0 | 36·0 | 99·0 | 39·0 | 102·0 | 43·5 | 115·5 | 27·0 | 84·0 |
| Average ... | 27·6 | 82·2 | 37·4 | 99·3 | 37·6 | 97·7 | 40·8 | 115·4 | 48·0 | 126·0 | 28·2 | 81·6 |
| Per cent increase over no manure. | .. | .. | 35·5 | 20·8 | 36·2 | 18·9 | 47·8 | 40·4 | 73·9 | 53·3 | 2·1 | .. |

Probable error of mean difference ... .. ... { 1923–24 . ± 0·8 / 1924–25 ... ± 1·8 / 1925–26 ± 0·3

Effective error for 3 years ... ± 2·1

## TABLE III.

*Results of experiment with calcium cyanamide applied to paddy in A Block—wet lands, Central Farm, Coimbatore.*

### Regular plots.

Yield in pounds per plot.

| | No manure | | Cyanamide, 2 cwt only per acre | | Cyanamide, 2 cwt plus super, 1½ cwt. per acre. | | Superphosphate only 1½ cwt. per acre. | |
|---|---|---|---|---|---|---|---|---|
| | Grain. | Straw | Grain. | Straw. | Grain. | Straw. | Grain. | Straw. |
| **1923–24.** | | | | | | | | |
| Series 1 .. .. | 129 0 | 83 0 | 144 0 | 125·0 | 152·0 | 125·0 | 106·0 | 79·5 |
| Do 2 .. | 168·0 | 121 0 | 192 0 | 138·0 | 169 0 | 141 0 | 123·0 | 86·2 |
| Do. 3 . .. | 129 0 | 77 0 | 160 0 | 106 0 | 190 0 | 135 0 | 136 0 | 86 0 |
| Do 4 .. | 119 0 | 72 0 | 153 0 | 120·0 | 173 0 | 123 0 | 136 0 | 82·0 |
| Average ... | 136 2 | 90·3 | 162 2 | 122 3 | 171·0 | 130·5 | 125·2 | 83·9 |
| Per cent increase over no manure. | ... | ... | 19 1 | 35·4 | 25 6 | 44·5 | ... | ... |
| **1924–25.** | | | | | | | | |
| Series 1 ... ... | 132 0 | 101 5 | 148 0 | 151·0 | 155·0 | 147 0 | 128·0 | 109 0 |
| Do. 2 ... ... | 160 0 | 115 0 | 178 0 | 194 0 | 164 0 | 162 0 | 138·0 | 118 0 |
| Do. 3 ... ... | 145·0 | 99·0 | 168 0 | 130 0 | 194 0 | 164·0 | 140·0 | 96·0 |
| Do. 4 ... .. | 138·0 | 80·0 | 127 5 | 118·0 | 188·0 | 131·0 | 168·0 | 100·0 |
| Average . | 143 8 | 99 4 | 155·4 | 148·5 | 175 3 | 151·0 | 143·5 | 105·8 |
| Per cent increase over no manure. | | ... | 8 1 | 49·4 | 21·9 | 51·9 | ... | 7·4 |
| **1925–26.** | | | | | | | | |
| Series 1 .. | 154·3 | 204 0 | 174·7 | 334 0 | 178·5 | 350·0 | 150·5 | 421·0 |
| Do. 2 ... ... | 155 6 | 244·0 | 195 1 | 310 0 | 157·5 | 233·0 | 155·6 | 224·0 |
| Do. 3 ... . | 120 0 | 152 0 | 160 5 | 291·0 | 175 0 | 367 0 | 128 0 | 166·0 |
| Do. 4 ... . | 106 0 | 123 0 | 139 0 | 206 0 | 160·0 | 238·0 | 129 0 | 145·0 |
| Average . | 133 9 | 180 8 | 167·6 | 285·0 | 167 8 | 297·0 | 140·8 | 234·0 |
| Per cent increase over no manure. | .. | ... | 25·2 | 57 6 | 25·3 | 64·3 | 5 2 | 29·4 |

Probable error of mean difference. { 1923–24 ±5·4; 1924–25 ±7 1; 1925–26 ±5 4

Effective error for 3 years ... ±9·7

## TABLE IV.

*Average per cent increase over "no manure" plots for all the series and for all the years. Field No. 18.*

| | Per cent increase of grain over "no manure". | Per cent increase of straw over "no manure" |
|---|---|---|
| **CENTRAL FARM** | | |
| *Ragi.* | | |
| 1. Calcium cyanamide, only 1 cwt. ... | 9·7 | 21·3 |
| 2. Calcium cyanamide, 1 cwt. plus superphosphate, 1 cwt. ... ... | 16·9 | 18·5 |
| 3. Calcium cyanamide, 2 cwt. ... | 22·8 | 39·4 |
| 4. Calcium cyanamide, 2 cwt. plus superphosphate, 1 cwt. ... ... | 21·5 | 38·5 |
| 5. Superphosphate only ... ... | ... | ... |
| **KOVILPATTI.** | | |
| *Cumbu* | | |
| 1. Calcium cyanamide, 1 cwt. ... | 24 0 | 16·5 |
| 2. Calcium cyanamide, 1 cwt. plus superphosphate, 1 cwt. ... ... | 29·0 | 26·1 |
| 3. Calcium cyanamide, 2 cwt. ... | 37·3 | 28·8 |
| 4. Calcium cyanamide, 2 cwt. plus superphosphate, 1 cwt. ... ... | 59·3 | 48·8 |
| 5. Superphosphate only ... ... | ... | 2 0 |
| **CENTRAL FARM.** | | |
| *Paddy.* | | |
| 1. Calcium cyanamide, 1 cwt. ... | 16·3 | 18·2 * |
| 2. Calcium cyanamide, 1 cwt. plus superphosphate, 1½ cwt. ... | 34·0 | 81·2 * |
| 3. Calcium cyanamide, 2 cwt ... | 17 5 | 50·1 |
| 4. Calcium cyanamide, 2 cwt. plus superphosphate, 1½ cwt. ... | 24·2 | 56·1 |
| 5. Superphosphate only, 1½ cwt. ... | ... | 14 3 |
| **CHINTALDEVI CATTLE FARM.** | | |
| *Fodder Cholam.* | | |
| 1. Calcium cyanamide, 2 cwt ... | .. | 23·74 |
| 2. Calcium cyanamide, 2 cwt plus superphosphate, 1 cwt. ... ... | . | 49·6 |
| 3. Superphosphate only ... ... | ... | 4 9 |

* Taken from the yields of the irregular plots for the year 1925–26 only.

## TABLE V.

*Giving average acre yields for the different crops at the different stations.*

POUNDS PER ACRE.

| | Grain. | Straw. |
|---|---|---|
| ***Ragi.*** | | |
| 1. No manure | 1,822 | 4,200 |
| 2. Calcium cyanamide, 1 cwt. | 1,998 | 5,094 |
| 3. Calcium cyanamide, 2 cwt. | 2,238 | 5,854 |
| 4 Superphosphate | 1,838 | 3,946 |
| 5 Calcium cyanamide, 1 cwt. plus superphosphate, 1 cwt. | 2,130 | 5,180 |
| 6. Calcium cyanamide, 2 cwt. plus superphosphate, 1 cwt. | 2,214 | 5,816 |
| 7. Bonemeal | 1,428 | 5,038 * |
| 8. Cyanamide plus bonemeal | 1,908 | 7,480 * |
| ***Cumbu.*** | | |
| 1. No manure | 594 | 2,062 |
| 2. Calcium cyanamide, 1 cwt. | 638 | 2,402 |
| 3. Calcium cyanamide, 2 cwt | 818 | 2,656 |
| 4. Superphosphate, 1 cwt. | 584 | 2,102 |
| 5. Calcium cyanamide, 1 cwt. plus superphosphate, 1 cwt. | 768 | 2,600 |
| 6. Calcium cyanamide, 2 cwt plus superphosphate, 1 cwt. | 944 | 3,068 |
| ***Fodder cholam*** *(rain-fed)*—Green. | | |
| 1. No manure | | 3,222 |
| 2. Superphosphate, 1½ cwt | | 3 987 |
| 3. Cyanamide, 2 cwt. | | 3,380 |
| 4. Cyanamide, 2 cwt. plus superphosphate, 1½ cwt. | | 4,817 |
| ***Paddy*—Regular plots.** | | |
| 1. No manure | 2,760 | 2,470 |
| 2. Calcium cyanamide, 2 cwt | 3,234 | 3,706 |
| 3. Superphosphate, 1½ cwt | 2,730 | 2,824 |
| 4. Calcium cyanamide, 2 cwt. plus superphosphate, 1½ cwt. | 3,428 | 3,856 |
| ***Paddy*—Irregular plots.** | | |
| 1. No manure | 2,332 | 3,100 |
| 2. Calcium cyanamide, 1 cwt. | 2,713 | 3,663 |
| 3. Superphosphate, 1½ cwt. | 2,663 | 3,763 |
| 4. Calcium cyanamide, 1 cwt. plus superphosphate, 1½ cwt. | 3,125 | 5,650 |
| 5. Calcium cyanamide, 2 cwt. plus super phosphate, 1½ cwt. | 3,488 | 7,650 |

* Separate set of plots.

## TABLE VI.

*Statement of profit and loss.*

| | Ragi. | | | | Paddy. | | | | Cumbu. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N. | N P. | 2N. | 2N.P | N | N.P. | 2N | 2N P. | N. | 2N.P | 2N. | 2N.P. |
| Per cent increase over control | ... | 16 9 | 22·8 | 21 5 | .. | ... | .. | .. | 24·0 | 29·0 | 37 3 | 59·3 |
| Increase per acre .. | .. | 308 | 416 | 392 | ... | 563 | .. | 668 | 144 | 174 | 224 | 350 |
| Value of the increase. ... Rs. | .. | 15·4 | 20 8 | 19·6 | .. | 35·2 | ... | 43 0 | 9 | 10 9 | 14 | 21·9 |
| Cost of manure applied ... Rs. | 7·5 | 11·75 | 15 | 19·25 | | 11 75 | ... | 19 25 | 7·5 | 11·75 | 15 | 19·25 |
| Profit per acre ... | | 3 65 | 5 8 | 0 85 | ... | 23·5 | ... | 21·5 | 2 5 | 0 85 | 1 | 2 75 |

Cost of cyanamide, Rs. 150 per ton.
Cost of superphosphate, Rs. 90 per ton.

The cereals are valued as under—
Paddy at 16 lb. per rupee.
Ragi at 20 lb per rupee.
Cumbu at 16 lb. per rupee.