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Long Range Experiments with special reference to Permanent Manurials at the Agricultural College, Coimbatore

by

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Synopsis: In the light of the results obtained on the long range experiments conducted elsewhere a critical analysis of the performance of crops in the old permanent manurial experiments started at Coimbatore in 1909, on the model of the Rothamsted experiments of England, has been made and presented in the paper.

Introduction: Most agronomic research projects fall into one of two categories with respect to time element, viz., (i) short term experiments such as seed rate and time of sowing, and (ii) long range experiments such as rotations and fertility including permanent manurials. In the early history of agronomic research, much emphasis was placed upon determining the role of major nutrients in plant growth limited to a few relatively simple crop rotations. Long range field experiments are found all over the world, the foremost among them being the classical Rothamsted experiments in England, started in 1843. The Woburn experiments (1876) and Cockle Park rotation experiment (1897) are still being continued. In India, long range experiments were conducted for a period of 50 years in Cawnpore, Uttar Pradesh (1881–1930) and 20 years in Dacca, former undivided Bengal. Among the present day long range experiments, the permanent manurials at Pusa (1908), Dharwar (1908) and Coimbatore (1909 and 1925) stand foremost.

The old permanent manurial experiments started at the Agricultural College, Coimbatore in 1909 and being continued without any change, occupy an important place in agronomic research of the State. Although the plots were not laid out to the standard of modern statistical design, a critical analysis of the performance of the crops raised in the above plots is a long felt need for further research and an attempt is made in this paper on the same regarding agronomic aspects.

Review of Literature: The long range experiments conducted in different parts of the world under different soil and climatic conditions, though of varied nature, have not only contributed information for high level crop production, but also furnished indications for subsequent experimentations and development.

(i) *Yield in relation to nutrients:* Volkerding and Stoa (1947) and Nissen Oivind *et al.* (1950) reported that yield of crops can be maintained indefinitely by manure and fertiliser treatments. According to Lipman and Blair (1921) the crop yield can be maintained at high level even though the total nitrogen content of the soil is not high as the original level. While phosphoric acid and potash

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were limiting factors at Pennsylvania (Anon. 1931), potash was found unnecessary at Pusa and Coimbatore (Iliffe and Nath 1928; Anon. 1931). Millar (1955) reported that while fertilised plots had given more yield than manured plots at Ohio, manure was found better for potatœs and fertiliser for corn at Rhode Island. At Cawnpore, Vaidyanathan (1934) reported higher yield continuously under manures than fertilisers. The effect of fertilisers were found to be modified by soil factors and weather conditions (Anon. 1926; Iliffe and Nath 1928; Anon. 1954). Kellogg (1938) and Bauer and Griffin (1951) reported that the yield in untreated plots declined steadily. Millar (1955) reported that without fertilisers, the yield dropped to a low level and remained virtually constant. Odland and Knoblach (1938) reported that yield of corn can be maintained better by leguminous cover crops than by supply of organic fertilisers at Rhode Island. Smith (1942) and Millar (1955) reported that manures and fertilisers are necessary for profitable yield of high quality crops. On the response of bulky manures, Vaidyanathan (1934) reported that there was no difference between cow dung, sheep dung and poudrette at Cawnpore.

(ii) *Equilibrium concept:* The crop yields and soil organic nitrogen under a given rotation and cropping system tend to come to equilibrium as evidenced by the report of many investigators.

Jenny (1930) emphasised the tendency of soils to come to equilibrium in their nitrogen content as a result of counter balancing the gains of nitrogen from sources such as fixation and addition in rainfall with the losses of nitrogen resulting from the crop removal, leaching and volatization.

Metzer (1935) reported high positive correlation between total crop production and total soil nitrogen and that an equilibrium is attained for total nitrogen. Smith (1942) reported a higher percentage of nitrogen in manured plots and lowest in the continuous corn plot. Prince *et al.* (1941) reported that manured plots were capable of maintaining 87 per cent of original soil nitrogen, the non-manured plots maintained 65 per cent thus indicating the minimum level in which nitrogen is maintained. Giddens *et al.* (1951) while reporting the results of a land building project in Georgia, U. S. A., concluded that "except for the plot with manures applied, there was the tendency for the cultivated soils to approach a constant level, low ones to increase and high ones to decrease".

Bear and Prince (1951) reporting on the organic matter content of New Jersy soils, stated that "by good management, the organic matter of a soil that has a normal value of 2 per cent may be raised rapidly to 2½ per cent but any further rise will be difficult to effect. Under poor management, it may fall as low as 1½ per cent but further loss will be very slow.

Materials and Methods: The old permanent manurial experiments were started at the Agricultural College, Coimbatore in the year 1909. The yield data available from the number of crops raised since its inception upto 1962 were taken into consideration and analysed statistically.

(a) *Layout:* The experimental plot had been laid out near the College hostel in an area of about 0·50 acre. A total number of 10 plots have been arranged (8 parallel to each other and 2 on the western side of the parellel plots). The plots are of 4 cents each in net area. The soil is of red loam and no changes had been effected during the course of 52 years either in design or treatments of manures.

(b) *Treatments:* All the 10 plots are under different manurial treatments as indicated below (Anon., 1962).

1. No manure
2. N — Ammonium sulphate applied at 1 cwt. per acre.
3. N K — Ammonium sulphate at 1 cwt. plus potassium sulphate at 1 cwt. per acre.
4. N P — Ammonium sulphate at 1 cwt. plus super phosphate at 3 cwt. per acre.
5. N P K — Ammonium sulphate at 1 cwt. plus super phosphate at 3 cwt. plus potassium sulphate at 1 cwt. per acre.
6. P K — Super phosphate at 3 cwt. plus potassium sulphate at 1 cwt. per acre.
7. K — Potassium sulphate 1 cwt per acre.
8. P — Super phosphate at 3 cwt. per acre.
9. CM — Cattle manure at 5 tons per acre.
10. CMR — Received cattle manure in the first year only.

There are no replications as required under modern statistical methods. The supply of N,P and K amounts to 22, 60 and 50 lb. in case of fertilisers and 50, 25 and 50 lb. in case of cattle manure.

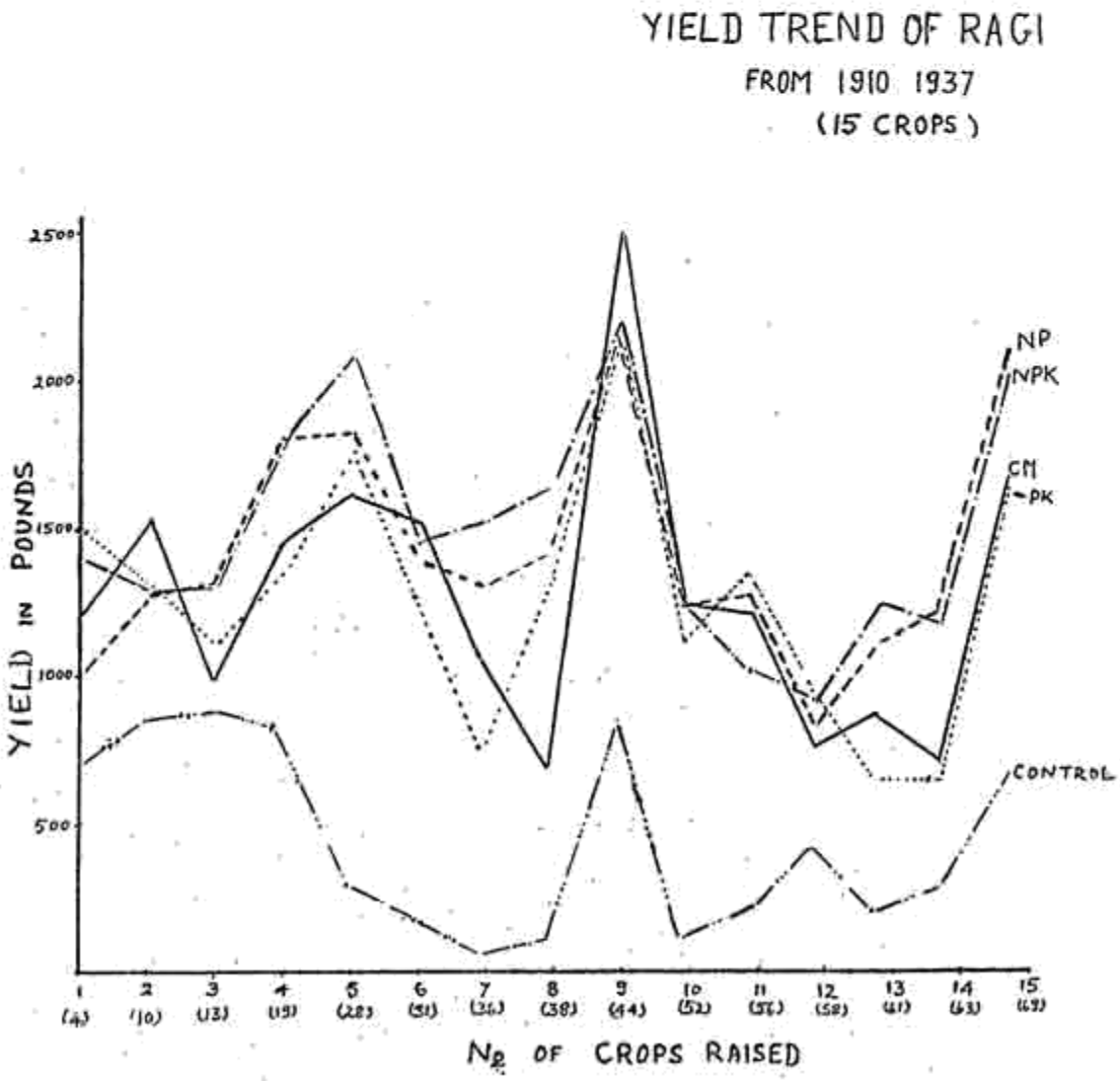
(c) *Crops raised:* During the course of 52 years, a total number of 92 crops have been raised. Out of the 92 crops, 17 have failed completely. Three crops (2 in *Cholam* and 1 in *ragi*) were partial failures. The remaining 72 crops were made up of: *Cholam* (grain) *Sorghum* sp. (20), *Cholam* (fodder) (*Sorghum* sp.) (6), *Ragi (Eleusine coracana)* (15), *Panivaragu (Panicum miliaceum)* (8), Wheat *(Triticum* sp.) (7), *Thenai (Setaria italica)* (4), *Cumbu (Pennisetum typhoides)* (4), Cotton *(Gossypium* sp.) (4), Gogu *(Hibiscus cannabinus)* (2), Tobacco *(Nicotiana tabacum)* (1) and Bengal gram *(Cicer arietinum)* (1). The crops were raised under irrigation up to 1934 only.

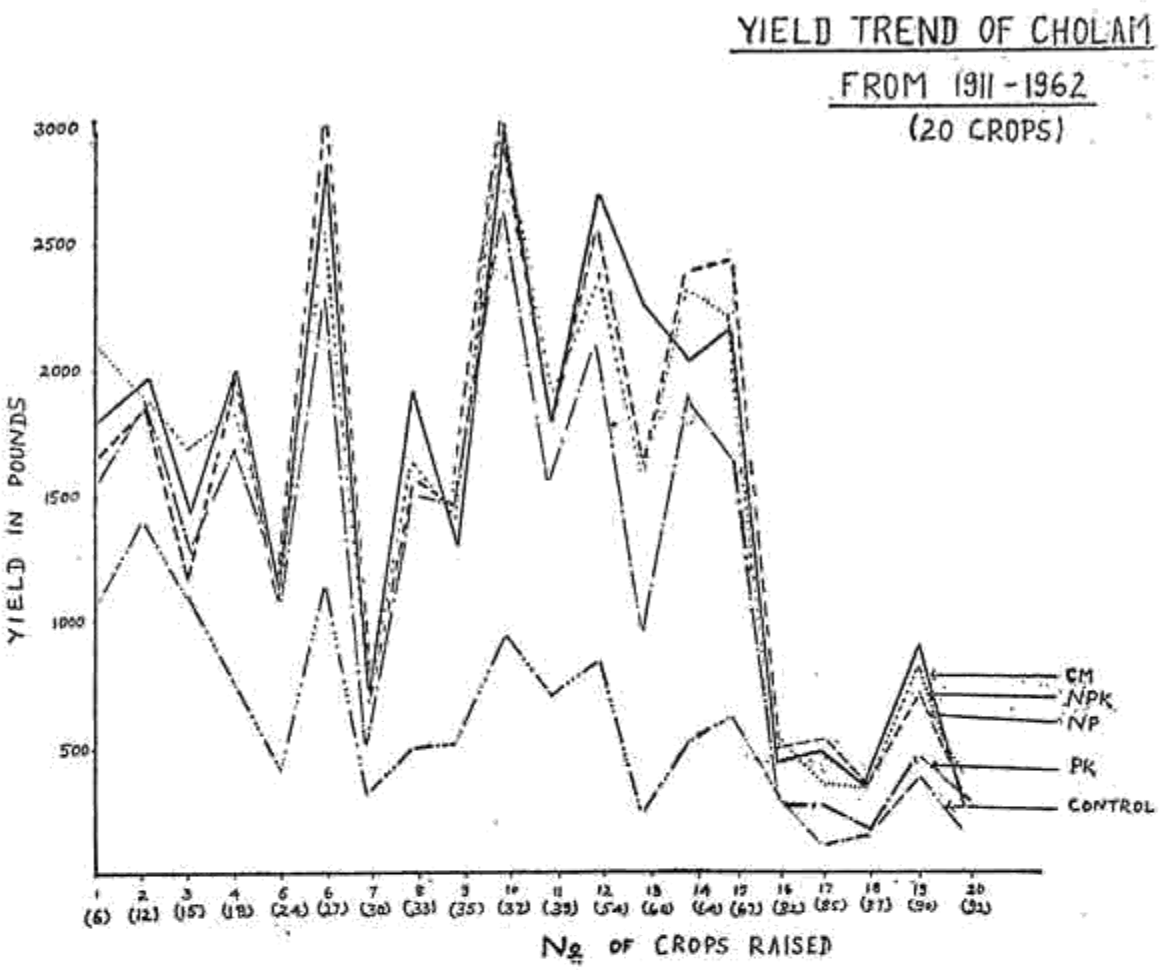
Experimental Results: The average yield of different crops raised during the period 1910-1962 is furnished in table 1. It can be clearly seen that the highest yield is obtained in most of the crops from N P K plots and cattle manure plots, while the no manure (control) plot has given the lowest yield.

TABLE 1.

The average yield in lb. of different crops during the period 1910—1962.

Name of crop.	No. of crops.	Control lb.	N lb.	NK lb.	NP lb.	NPK lb.	PK lb.	K lb.	P lb.	CM lb.	CMR lb.
1. *Cholam* (grains)	20	531	627	636	1413	1444	1189	626	830	1467	845
2. *Ragi* (grains)	15	444	520	569	1434	1480	1243	696	875	1295	655
3. *Panivaragu* (grains)	8	537	598	535	1036	958	916	620	885	1025	635
4. Wheat (grains)	7	410	644	649	917	1006	794	564	660	703	487
5. *Thenai* (grains)	4	162	219	262	418	392	214	231	180	494	182
6. *Cumbu* (grains)	4	140	185	220	319	303	211	168	145	271	201
7. Cotton (kapas)	4	323	335	385	552	472	348	336	291	706	466
8. Gogu (grains)	2	675	775	675	900	888	700	675	756	670	667
9. Tobacco (green leaf)	1	638	475	438	688	625	588	350	575	720	1191
10. Bengal gram (grains)	1	100	175	250	250	175	125	100	50	140	200





The illustrations indicate the yield trends of *cholam* for 20 crops and *ragi* for 15 crops with the important treatments of control; cattle manure, N P K; NP, and P. K. The result clearly shows the decline in yield of control plots and the fluctuation in all treatments indicating clearly the influence of rainfall.

The irregular variation in yield can be separated into three kinds.

1. Steady decline in yield ascribable to soil deterioration.
2. Other slow changes ascribable to factors that vary regularly from year to year such as changes in composition of cattle manure.
3. The residual variation called the annual variation ascribable to factors which vary irregularly from year to year including seasonal weather conditions.

Discussion: *Layout of plots:* Panse and Sukhatme (1961) opined that long range experiments should be well thought out and comprehensive, and the experiments should be so designed that these objectives are achieved through a relatively straight forward analysis of result. They also indicated that frequent changes in design after the experiment is started, usually mar its efficiency rather than increasing its informativeness. The following short-comings are seen in the layout of long range experiments.

1. Plans initiated 25 or 50 years ago may be impractical today in some ways.

2. A continuous crop plot probably contributed valuable information for a period of years, but the disadvantages of continuous cropping as a practice is well known and hardly needs further emphasis.

3. The early experiment frequently called for particular fertiliser ingredients which have since been changed or supplemented by cheaper products.

4. Some of the older plots have been laid out in fields which have since been shown to consist of more than one soil type.

5. Another feature not always properly safeguarded is the possibility of outwash from one plot into another.

Inspite of the above criticism, the results obtained were the basis of many modern field studies and have contributed valuable information which has aided in bringing about the high level crop production experienced in many areas to-day.

Russel and Voelcker (1936) by their experience gained at Rothamsted indicated that one of the outstanding lessons of the Woburn experiments is the necessity for keeping the plan and not changing it during the course of the work.

The results obtained from the various long range experiments have contributed much towards agricultural practice and as such warrant their continuation.

2. *Method of analysis:* In the layout of plots, the treatments lack replication and possibly randomization.

Among the different methods available, the method suggested by Mercer and Hall (1911) cannot be justified as it does not take into account the errors due to soil heterogeneity or the errors due to differences in yield in parallel plot. The method suggested by Engledow and Yule (1926) is also considered unsatisfactory as the influence of soil variation is not taken into account. 'Students test for unique samples' method attempt by Thatcher and Willard (1963) for analysis of long range rotation experiment could not be applied for want of proper rotation of crops within a particular cycle.

However, by treating the annual data as replication, though open to criticism, the results were analysed as per Fisher's analysis of variance method (Fisher and Wishart, 1930) as it seems to be the only logical modern method by which even under conditions of inaccurate lay out, the standard error can be estimated after elimination of variances due to soil fertility.

3. *Results:* By taking into consideration the above facts, the data available on the yield trends indicated :—

(i) Steady decline in the yield of no manure plot agrees with the findings of Russel Voelcker (1936); Odland and Knoblach (1938) and Kellogg (1938).

(ii) The combination of nitrogen, phosphoric acid and potash either in the form of fertilisers or cattle manure is essential for continued production. This agrees with the view expressed by Nissen Oivind *et al.* (1950) and Volkending and Stoa (1947).

(iii) While fertilisers containing N, P and K had given highest yields for *ragi*, wheat and *cumbu*, cattle manure had given highest yields for *cholam*, *panivaragu* and *thenai*. This is in conformity with the results of Ohio and Rhode Island experiments obtained by Millar (1955) on the response in variation of different crops.

(vi) Nitrogen supply alone is not sufficient to improve grain yields. The supply of nitrogen and phosphoric acid are found most essential under Coimbatore conditions, a view supplemented by Vaidyanathan (1934). Both nitrogen and phosphoric acid are considered as limiting factors unlike the results indicated in Pennsylvania where phosphoric acid is more of a limiting factor (Anon. 1931). Potash is not essential for cereal crops studied so far. This is supported by the findings of Iliffe and Nath (1928) in Pusa.

(v) The soil improving values of fertiliser treatments are reflected in the soil nitrogen when the top 9" surface soil is analysed for nitrogen content it is found more under cattle manure (0·051%), followed by N P K plots (0·044%) and N P plots (0·043%) and least under control plot (0·038%).

(vi) The nitrogen has not been found exhausted in the no manure plots, thus indicating the equilibrium concept emphasized by Jenny (1930), Dodge and Jones (1948) and Giddens *et al.* (1951).

Summary and Conclusions: The old permanent manurial experiments were started at Coimbatore in 1909 on the model of the classical Rothamsted experiments of England. So far 92 crops have been raised. In the light of the results obtained on the long range experiments conducted elsewhere, a critical analysis on the performance of crops have been made.

These long range investigations have shown the great significance of maintaining the proper amounts of plant nutrients in soil and have given an opportunity for carrying out chemical, physical and biological studies of the soil to determine the influence of the widely different cropping systems and soil treatments during long period of years.

Although the data give no clear answer, they furnished indications which subsequent experimenters will be able to utilise and to develop. The necessity of keeping the original layout without changes is stressed.

The yield data of 20 crops of *cholam*, 15 crops of *ragi*, 8 crops of *panivaragu* and 7 crops of wheat have been statistically analysed and the results lead to the following conclusions:

1. There was steady decline in the yield of no manure plots and the concept of equilibrium seemed to have already set in indicating the minimum crop producing power of the soil.

2. While the artificial manure containing nitrogen, phosphoric acid and potash had given higher yields for *ragi*, wheat and *cumbu* crops, cattle manure had given increased yield in case of *cholam*, *panivaragu* and *thenai* thus indicating the need for the three important plant nutrients.

3. The performance of crops was poor when nitrogen, phosphoric acid and potash applied separately and that combination of nitrogen and phosphoric acid was found most essential under Coimbatore conditions.

4. The soil improving values of fertiliser treatments are reflected in the soil nitrogen. It is found more under cattle manure treated plots followed by NPK and NP plots.

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AWARD OF Ph. D. DEGREE

Sri K. Rajagopalan, B. sc. (Ag.), M. Sc., Assistant Paddy Specialist, Agricultural College and Research Institute, Coimbatore-3 has been awarded the Ph. D. Degree by the University of Madras for his thesis on "Studies on Drought Resistance in Rice".

Our hearty congratulations to him.