

Manuring Crops

by

Dr. A. MARIAKULANDAI

Agricultural Research Institute, Coimbatore

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[Abstract of the Curzon Lectures]

Potatoes: Experimental work on potato cultivation has been confined to the Agricultural Research Station, Nanjanad which was established in 1917 in the Nilgiris District of the Madras State.

Manurial experiments 1920 — 1930: (a) Organic manures compared with sodium nitrate:— Fish guano at 1120 lb. and cattle manure at 560 lb. per acre were compared with sodium nitrate at 1 cwt. over a period of three years. In two years the former was better while in one year the latter yielded more.

(b) Cattle manure with and without lime or sodium nitrate:— The experiment was done for 5 years and the results indicated a maximum increase of 280% for 10 tons of cattle manure, with the treatment (2 cwt. of sodium nitrate plus 5 tons of cattle manure) coming next. There was no effect due to lime at 4 cwt. per acre.

(c) Fish guano with and without lime or sodium nitrate:— (i) This experiment was also done for 5 years and revealed a similar trend to the above, fish guano at 10 cwts. with 5 tons of cattle manure recording the highest yield (increase of 400%) while the combination of sodium nitrate at 1 cwt. with fish guano at 10 cwt. came next and there was no effect due to lime. (ii) Increasing doses of 1 cwt. to 4 cwt. of sodium nitrate over a basal dressing of (1) 10 cwt. of fish guano; (2) 5 tons of cattle manure and (3) a complete manure of super 15 cwt., potash (as KCl) 2 cwt. and lime 10 cwt. were compared for 3 years.

The results for the first year alone indicated increased yields with increased doses of sodium nitrate over a basal of fish guano, while for the remaining year no effects due to increased doses of sodium nitrate were felt.

(d) *Effect of lime:* The prior experiments wherein lime had been tried in combination with others had proved futile in registering any increase in yield. A separate experiment with lime alone at $\frac{1}{2}$ ton and $\frac{3}{4}$ ton was compared against no manure for 3 years. The increases of 9.8 and 21.0% respectively were not significant over that of the control.

(e) *Complete manure with increasing doses of sodium nitrate*: Complete manures consisting of 3 tons of cattle manure, 15 cwt. of fish guano, 5 cwt. of super and 2 cwt. of KCl were compared with single (1 cwt.) and double doses of sodium nitrate for 3 years. The response to sodium nitrate was not felt and maximum yield was registered for the complete manure only.

(f) *Complete artificials compared against different mixtures*: The idea of having a balanced fertiliser mixture was slowly receiving attention in these years and in a series of experiments conducted separately for 3 years the following 3 treatments were compared:—

- (1) Fish guano 10 cwt. plus super 5 cwts. plus KCl 2 cwt.
- (2) Groundnut cake 250 lb. plus sodium nitrate 240 lb. plus steamed bone meal 200 lb. plus super 200 lb. plus potassium sulphate 120 lb.
- (3) Super., potassium nitrate and ammonium sulphate each at 2 cwts.

Treatment (1) gave the maximum yield but the differences were not significant.

(g) *Niciphos (versus) Ammonium phosphate*: Niciphos which is a mixture of ammonium phosphate and ammonium sulphate was compared with ammonium phosphate with and without the farm mixture (K_2SO_4 —200 lb., fish guano substitute—10 cwt., super 5 cwt.) over a basal dressing of cattle manure. The farm mixture group gave the higher yields with 468 maunds per acre for the niciphos and 365 maunds/acre for the ammonium phosphate treatment.

(h) *Fish guano substitute experiments*: To find out the best level of fish guano to be used in the farm mixture, 5, 10, and 15 cwts. of fish guano were tried in the farm mixture. It was found that the yield increased with increase of fish guano and that 15 cwt. dose gave the maximum yield.

Manurial Experiments 1930—1955: The beginning of this period marked the evolution of the "Nanjanad Farm mixture." Instead of fish guano which was till then used in the old farm mixture, groundnut cake, steamed bone meal and ammonium sulphate came to be included in addition to the concentrated super and potassium sulphate. The experiments that are reviewed in the following paras therefore mainly relate to the series of trials to find out the most efficient and economic combination in the above mixture and also to see whether any alterations in the forms of N, P and K ingredients could be made with advantage.

(1) *Optimum quantity of super and sulphate of potash in the Nanjanad Farm mixture:* Over a basal dressing of 5 tons of cattle manure and a mixture of 500 lb. of groundnut cake, 200 lb. ammonium sulphate and 350 lb. of steamed bone meal, treatments with varying combined dosages of super and sulphate of potash, viz. 3 and 2, 1 and 2, 5 and 2, 3 and 1, and 3 and 3 cwt. of each respectively were tried for one year. Best yields were obtained for 3 cwt. dosage of conc. super and 2 cwt. of K_2SO_4 . No significant increases due to levels of K_2O were observed.

(2) *Muriate and sulphate of potash* were compared in combination with the usual ingredients of the new farm mixture at 0, 1 and 2 cwt. levels. The results indicated slightly favourable yields with potassium sulphate at 2 cwt. level.

(3) *Organic nitrogen versus Inorganic nitrogen in the farm mixture:* The nitrogenous constituents of the farm mixture were tested in either organic or inorganic forms like groundnut cake, ammonium sulphate and sodium nitrate each alone or in combination of organic and inorganic forms, keeping the total nitrogen level constant. The results indicated that better yields could be obtained for combinations of organic and inorganic forms of N than for the inorganic forms alone.

(4) *Cattle manure — Potash experiments:* The N, P and K values contained in cattle manure were tested by substituting with artificials in combination with the usual farm mixture. Treatments with no potash and increasing levels of potash were also included for comparison. The results clearly showed the value of potash and the efficiency of cattle manure.

(5) *Effect of farm mixture containing steamed bone meal and conc. super as against either of these alone, keeping N and K constant at both full and half doses:* The results were favourable for single doses for all the crops seasons excepting the second crop for one year when no advantage over half dose was observed. The use of insoluble steamed bone meal alone gave the worst yield when compared to the farm mixture by the usual combination and super phosphate alone. The phosphates of the farm mixture behave alike when the insoluble portion (i. e. steamed bone meal) is replaced by concentrated super phosphate.

(6) *Manurial Experiments to test the effects of artificials:* N, P and K applied individually and in combination with additions of lime, cattle manure as well as a mixture of both (main and second crop for 4 years) (Main treatments — No manure, N, N + K, P, N + P, N + P + K).

Results gave the following indications :

(1) The response to N is not felt when applied alone on both the crops, but in combination with P and K the yield is considerably increased, the maximum being with N plus P and N plus P plus K.

(2) P alone is significantly better than N applied individually.

(3) N plus P plus K in combination with cattle manure or lime have acted more beneficially than the artificials alone.

(4) No difference is observed between lime and cattle manure plots in the main crop but superiority of cattle manure is felt to a slight extent in the case of the second crop.

(5) Maximum yields of both crops were obtained in plots receiving full doses of cattle manure, lime and artificial.

7. *Relative merits of potato fertilisers of M/s. Parry & Co., and Shaw Wallace Co., as against Nanjanad Mixture with and without cattle manure on equal N basis: (Main and second crops)*

(1) The average yields for 3 years indicate that the Farm mixture with and without Cattle manure has been found to be superior to other mixtures for both the crops.

(2) The relative merits of the mixtures from Shaw Wallace and Parry companies cannot be definitely assessed from this experiment.

8. *Optimum proportion of organic to inorganic N contained in the Nanjanad Farm Mixture and comparison of the Farm mixture with Niciphos mixture: Main and second crops.*

(1) Significant results are obtained in one out of three seasons only with both the crops.

(2) The superiority or otherwise of Niciphos or organic and inorganic nitrogenous manures in any proportion cannot be definitely established owing to the variable nature of the results obtained in the different seasons.

9. *Relative merits of complete inorganic fertilizer mixtures against Nanjanad Farm mixture in different doses (Second crop only).*

(1) Full dose of complete inorganics is not significantly superior to the corresponding dose of Nanjanad farm mixture.

(2) 2/3 dose is significantly poor to the full dose in the case of inorganic mixture only.

(3) Additional 1 cwt. of sulphate of potash has no desirable effect in both the mixtures.

(4) Extra dose of 5 tons of cattle manure applied in the furrows has not appreciably increased the yields.

10. *Effects of quality and quantity of different kinds of phosphates, viz., conc. super, dicalcic phosphate, steamed bone meal and a mixture of conc. super and steamed bone meal in single and double doses with and without lime against the farm mixture: Main and second crops.*

(1) Steamed bone meal is definitely inferior to more soluble forms of phosphate.

(2) The general mean yields of all the 3 years for the limed and unlimed series, show that lime has no beneficial effect on the phosphates.

(3) Both in the limed and unlimed series the full doses of phosphates have proved better than the corresponding half doses.

(4) The farm mixture with Mono and Tri-calcic phosphates is as good as similar quantities of phosphates applied as conc. super or dicalcic precipitated phosphates.

11. *Relative merits of easily available concentrated manures and Nanjanad Farm Mixture in full and $\frac{2}{3}$ doses with cattle manure applied in furrows or broadcast: (Main and second crop).*

(1) Full doses of all the manures give better yields than $\frac{2}{3}$ doses.

(2) Application of cattle manure in furrows is better than broadcasting.

(3) There is no difference between farm mixture and the easily available concentrated manures.

12. *Relative merits of different oil cakes when substituted for groundnut cake in the Farm mixture on equal N basis: (II crop only). All cakes except Neem cake are equal to groundnut cake.*

13. *Effect of broadcasting Cattle Manure versus applying in furrows: (II crop only). Application in furrows is better than broadcasting (vide item 11 above).*

14. *Effect of replacing chemical nitrogen in the Farm mixture by groundnut cake:* Ammonium sulphate in the farm mixture could be fully replaced by groundnut cake without any adverse effect while the replacement of organic nitrogen completely by ammonium sulphate depressed the yield.

15. *Placement of fertilizer mixture or phosphates of Nanjanad mixture at seed level and at 3" below seed in the furrows:* For the five years of study viz., from 1946 — 1951 significantly higher yields for placement of the Farm mixture (3" deeper below seed in the furrows) could be obtained for 2 years only. The increase in yield was however not impressive. In most cases the differences due to treatments were not significant.

16 (1) *Liming Trials:* Lime at 5 levels 0, 5, 10, 15 and 20 cwt. was tried for 5 years (1946 - '50) but no significant increase due to the same was observed.

(2) *Liming experiment:* With higher does, viz. 0, 1, 2 and 4 tons in the form of slaked lime by different methods of application viz. broadcast before planting, band placement in furrows 4 weeks before planting, and application to previous green manure crop of lupin (4 weeks before sowing of groundnut) to be followed by potato was conducted for 2 years. The differences in yields among the various treatments were, however, not significant.

17. *Effect of varying levels of nitrogen and different sizes of seed tubers:* In a one year study (1948 - '49) the effect of application of nitrogen of the Farm mixture at 60, 80 and 100 lb. N levels on the three different sizes of seed tuber viz. $\frac{1}{2}$ oz., 1 oz. and 2 oz. was studied. The results indicated that increases in yield with increases in levels of N and size of tuber could be obtained.

18. *Complex manurial trials for exploring the possibility of reducing the manurial composition and dosage in Nanjanad farm mixture without impairing efficiency in yield and loss in soil fertility:* In the above experiment, which was conducted for 3 years from 1949 - '50, the Potash content of the Nanjanad mixture was kept the same viz. at 100 lb. K_2O . While 2 levels of N (80 lb. and 40 lb.) 4 levels of P_2O_5 (0, 40, 120 and 200 lb.) were tried without and with lime (at 2 tons per acre). The results indicated the following conclusions.

(1) The higher the dose of N, the greater is the yield.

(2) The yield increases with increase of dosage of P_2O_5 .

- (3) Lime by itself or in conjunction with N or P_2O_5 does not influence the yield to any great extent.
- (4) The fertility status of the soil is not impaired after a crop of potato is taken.
- (5) Nanjanad Farm mixture with 80 lb. N, 200 P_2O_5 and 100 lb. K_2O seems to contain the minimum of ingredients necessary for good yields of potato and no further reduction in either nitrogen or P_2O_5 seems possible without detriment to yield.

19. *Replacing nitrogen constituents of the Farm Mixture completely by chemical manures like sodium nitrate, urea and ammonium sulphate and comparing the same against Farm Mixture with and without lime and green leaf (at 1500 lb. and 5000 lb. respectively):* The three years of experimentation gave the following conclusions.

- (1) There were no significant differences between the different basal dressings in two out of three years. In the other year 5000 lb. green leaf either alone or in combination with 1500 lb. lime was better than control and lime alone.
- (2) With regard to nitrogen carriers, in two out of three years Nanjanad Farm Mixture gave significantly better yields.

In general, the supply of N either as $NaNO_3$ or urea was not found useful. Maximum yields were obtained when N was supplied as groundnut cake and ammonium sulphate.

Summary and Conclusion: A review of the various manurial experiments on potato conducted at the Agricultural Research Station, Nanjanad during the past 35 years has been presented here. The earlier experiments have clearly indicated the value of organic manures like cattle manure and fish guano for giving 'good yield of potato. Sodium nitrate was not found useful either alone or in combination with cattle manure or fish guano when compared to the organic manures alone. There was no effect for lime application, although the soils of the tract are lateritic in nature. The need for potash salts and high doses of phosphates was clearly indicated and the first mixture which was formulated and proved successful at this farm consisted of fish guano 15 cwts., super phosphate 5 cwts. and Muriate of potash 2 cwts. for one acre. A series of trials started later on to find out cheaper substitutes for fish guano resulted in the

discovery of the manure mixture which came to be popularly known as Nanjanad Farm Mixture. This mixture for one acre is made of 500 lb. of groundnut cake, 350 lb. of steamed bone meal, 3 cwt. of conc. super, 200 lb. of ammonium sulphate and 2 cwt. of sulphate of potash, to supply 80 lb. of Nitrogen, 200 lb. P_2O_5 and 100 lb. of K_2O per acre. Consistently high yields have been obtained by application of the mixture to the soils of the tract and many experiments conducted to find out better substitutes for this mixture have not so far been successful. As a result of the various experiments conducted up till now the following conclusions have been arrived at: (1) organic forms of N (excepting neem cake) are superior and complete use of chemical nitrogenous manures like ammonium sulphate, urea or sodium nitrate are not beneficial; (2) Insoluble forms of phosphates applied alone are not useful. Steamed bonemeal and super as used in the Farm mixture will however give the best results and can be replaced only by soluble (or available) forms of phosphates; (3) Basal dressing of cattle manure is desirable, while that of lime is not necessary; (4) The use of green manure either alone or in combination with lime has not given significantly higher yields; (5) The Nanjanad Farm mixture is the most economic and useful mixture for giving maximum yield of potato in the Nilgiris district.

Final Discussion and Conclusion: A rapid review of the experiments done in the State on some important crops like paddy, cotton, sugarcane and potato has been presented in this paper. Results obtained in the experiments conducted under the Technical Co-operation Mission programme and the Indian Council of Agricultural Research have also been incorporated.

From this review it should be clear that the problem of correct scientific manuring is not simple. Even for a single crop like paddy the responses to fertilisers vary according to the region, soil and the season. The recent Agronomic Trials and the Free Fertiliser Demonstration Trials (1953-1956) were laid with a view to cover all soil-climatic zones under cultivator's conditions. From these experiments it should be evident that what we need is a localised schedule of manuring for each tract and not one prescription for the entire State. Even within contiguous areas soil reaction may vary due to previous manuring and agronomic history of the land. With the introduction of the Free Soil Testing Service all over India under the auspices of the Indo-American Operational agreement, we now have the tool to fix the manurial schedule for each individual field of land based on its requirement as assessed by soil analysis.

However, the numerous manurial experiments and data presented in this paper are not without benefit. Though they cannot be used for an overall prescription for manuring yet some optimum levels and forms of manuring can be indicated as given in the appendices. These experiments have also given us a clear picture that nitrogen universally does give a response, while P_2O_5 is good for light soils of all types and best in sandy and gravelly soils. In regard to K_2O though there are conflicting results about its response, it cannot be denied that plants do require potash. But as additions of plant residues in the form of trash, green manure, farm waste or ash is invariably the farm cultural practice in practically all holdings, the requirement, of potash is mainly met from this source and no response to added potassic manures is therefore seen in most of the trials with paddy.

Thus at the present moment we are having a mass of data on the forms and levels of fertilisers to be applied to major crops. With a little more research and with the new tool of "Isotopes" in this atomic age, we will be able to trace the fate of added fertilisers in plant nutrition much in the same way as nutrients have been followed up in animal metabolism and in the course of a few years we will have a much clearer picture of the requirements of crops and the mode of supplying them.

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