

Review of Manurial Experiments in India

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The production of more FOOD in India is perhaps the most discussed question now by Government, the Press and the Public alike. "Extensive" and "Intensive cultivations" are suggested, but, as the scope for the former is limited, the latter is obviously the more important method, and again, out of the various means suggested such as use of good seed, proper cultivation, judicious manuring etc. in intensive cultivation, the greatest emphasis is laid on manuring. Propaganda is being done by the Agricultural Department, on the proper conservation of organic manures as well as the extensive use of fertilisers.

Under these circumstances, it will be interesting to know the effect of the various manures and fertilisers under Indian conditions on the important food crops.

More than 5,000 manurial experiments, conducted during the past 40 years at more than 100 Experimental Stations distributed in all the Provinces in India, were examined and the results were reviewed critically to understand the performance of 11 different manures and fertilisers individually and in combinations on 7 important cereal crops and on sugarcane and potatoes. The review was manure-war, crop-war, climate-war and soil-war.

(a) Information from 30 years of manurial experiments upto 1930 conducted in the 100 Government Experimental Stations throughout India is furnished by the Provincial Agricultural Chemists and collated by the Statistician. (b) The reports of the Provinces and States from 1930 to date were scrutinised, and also, the experiments conducted by I. C. I. (Imperial Chemical Industries) from 1930 onwards, and the experimental data from schemes financed by the Indian Council of Agricultural Research from 1930 onwards. All these data were examined to understand the performance of various manures and fertilisers on Indian food crops and to arrive at conclusions which can guide us in the manuring of agricultural crops.

The salient features of the review are mentioned below, but a word of explanation is necessary before we come to it. The first 30 years of experimental work i. e. (a) are often criticised as lacking in statistical precision and experimental layout; but with all the shortcomings, the broad conclusions arrived at by a review of the data are quite valid, as the later experiments serve merely to substantiate the former conclusions. This was the case not only with food crops but with sugarcane as well.

III Salient Features: (1) In India as a whole: Organic manures (like farmyard manure, green manure, oil cakes, bone meal and fish manure) individually or in combinations with one another are in every case 2 to 3 times as effective as artificial fertilisers (such as Ammonium sulphate, Sodium or Potassium Nitrate, Superphosphate, Niciphos and Potassic manures).

2. Organics plus artificials can be said to be intermediate (except in the case of paddy, where they gave maximum percentage increases in yield over No Manure).

3. Amongst artificials phosphatic fertilisers are very beneficial but the rest are not very effective, directly or residually.

4. Potassic fertilisers gave mostly negative results.

5. A more detailed discussion for each crop and with each manure and the direct, residual and combined effects is given elsewhere.

6. Artificials leave undesirable residual effects on the crop yields, and soil composition and structure in contrast to the good residual effects of organics and their steady effects on crop yields and beneficial effects on soil structure.

In India, cropping depends on the vagaries of "Monsoons", and in places of years or precarious rainfall, the use of artificials may be sometimes harmful.

8. There is also the question of the quality or the "Nutritive value" of the produce and the "Cropping capacity of the grain", both of which are very important considerations in the long-term planning of National health and well-being.

9. The response to manuring in general, is more in lands of low initial fertility than on lands of medium and high fertility; and the response in lands of medium fertility is more than that in lands of high fertility.

10. The experiments conducted by I. C. I. and I. C. A. R. from 1930 onwards corroborate the conclusions arrived at by previous experiments upto 1930.

11. Where artificials are to be used, it is always safe to use them in conjunction with organic manures. This is clearly indicated in the case of cereals as well as in sugarcane.

12. The superiority of ammonium sulphate as a manure for paddy and sugarcane is not borne out by the experimental data, (a, b, c and d). By itself, it gave 22.8%, 18.3% and 5.9% increases (considering the direct effects) over No Manure with paddy, jowar and wheat respectively; these are below the increases due to organic manures.

So, the manurial and food problems in India will not be solved by the manufacture of ammonium sulphate alone. Importance has to be attached to the proper conservation of the bulky manures and utilisation of oil-cakes and bone in the country. The experimental technic itself has perhaps got to be remodelled and made simpler, so that an ordinary ryot may carry it out himself and decide which is the best manure for his crops, under his soil and environmental conditions.

Interpretation of Data: On the whole, organic manures either individually (54.5%) or in combinations (85.5%) are nearly 3½ times as effective as inorganic fertilisers individually (16.4%) or in combinations (24.6%), while organics plus inorganics occupy an intermediate (46.8%) position.

Performance of Different Manures & Fertilisers (Individually and
(All-India) Average % increase (+) & decrease (-)

| | Organic manures (alone) | | | (In combinations) | |
|------------------------|-------------------------|----------------|----------------|-------------------|----------------------|
| | (1) | (2) | (3) | (4) | (5) |
| | F.Y.M. | G.M. | Oil cakes | B. M. or Fish | Organic combinations |
| | + - net | + - net | + - net | + - net | |
| <i>Paddy (I crop)</i> | | | | | |
| Direct effect | 85.6-80.0=77.6 | 28.4-7.4=21.0 | 34.6-3.2=31.4 | 35.2-3.1=32.1 | 85.7-4.5=81.4 |
| Residual effect | 27.4-1.7=25.7 | 8.9-6.9=2.0 | 17.0-3.8=13.2 | 29.2-3.1=26.1 | 17.0-12.6=4.4 |
| Total | 113.0-9.7=103.3 | 37.3-19.3=18.0 | 51.6-13.0=38.6 | 64.4-0.2=64.2 | 102.7-16.9=85.8 |
| Average | (218.1 ÷ 4 = 54.5) | | | | (85.5) |
| <i>Paddy (II crop)</i> | | | | | |
| Direct effect | 4.0-?=4.0 | 11.5-?=11.5 | 14.7-?=14.7 | 10.1-3.6=6.5 | 30.8-?=30.8 |
| Residual effect | ?-=? | ?-=? | 49.4-28.8=20.6 | 53.0-20.4=32.6 | ?-=? |
| Total | 4.0-?=4.0 | 11.5-?=11.5 | 64.1-28.8=35.3 | 63.1-24.0=39.1 | 30.8-?=30.8 |
| Average | (89 ÷ 4 = 22.5) | | | | (30.8) |
| <i>Jowar</i> | | | | | |
| Direct effect | 49.6-6.0=43.6 | 8.5-3.2=5.2 | 14.9-?=14.9 | 0.0-?=00.0 | 24.6-?=24.6 |
| Residual effect | 35.8-10.8=25.0 | 50.0-?=50.0 | 14.9-?=14.9 | 12.0-?=12.0 | 16.7-?=16.7 |
| Total | 85.4-16.8=68.6 | 58.5-3.3=55.2 | 29.8-?=29.8 | 12.0-?=12.0 | 41.3-?=41.3 |
| Average | 165.6 ÷ 4 = 41.4 | | | | (41.3) |
| <i>Wheat:</i> | | | | | |
| Direct effect | 49.5-2.8=46.5 | 28.7-12.5=16.2 | 34.4-3.3=31.1 | 26.5-6.7=19.8 | 28.2-?=28.2 |
| Residual effect | 19.6-?=19.6 | 20.8-?=20.8 | 27.2-?=27.2 | 52.0-?=52.0 | 35.0-?=35.0 |
| Total | 68.9-2.8=66.1 | 49.5-12.5=37.0 | 61.6-3.3=58.3 | 78.5-6.7=71.8 | 63.2-?=63.2 |
| Average | (233.2 ÷ 4 = 58.5) | | | | (63.2) |

**in Combinations) on the Important Food Crops in India as a Whole
in yield over No Manure, due to manuring:—**

| Org. man. + Inorg. fertilizers | | Inorganic fertilizers (alone) | | In combination | |
|--------------------------------|----------------|-------------------------------|-------------------|-----------------|------------------------|
| (6) | (7) | (8) | (9) | (10) | (11) |
| Organics plus inorganics | Am. Sulph. | Na or KNO ₃ | Super. etc. | K. fertilizers. | Inorganic combinations |
| + — net | + — net | + — net | + — net | + — net | + — net |
| 42·2-5·3=36·9 | 28·0-5·2=22·8 | 14·6-8·2=6·4 | 39·7-5·7=34·0 | 3·2-5·9=2·7 | 25·9-7·4=18·5 |
| 13·9-4·0=9·9 | 0·6-7·1=6·3 | 1·3-3·0=1·7 | 26·8-16·0=10·8 | 2·2-? = 2·2 | 6·1-? = 6·1 |
| 56·1-9·3=46·8 | 28·8-12·3=16·5 | 15·9-11·2=4·7 | 66·5-21·7=44·8 | 5·4-5·9=0·5 | 32·7-4=24·6 |
| (46·8) | | (65·5 ÷ 4 = 16·4) | | | (24·6) |
| 48·8-3·5=45·3 | 13·0-4·5=8·5 | ? - ? = ? | 18·4-5·4=13·0 | 0·9-? = 0·9 | 12·7-15=2·3 |
| 7·7-18·4=10·7 | ? - ? = ? | ? - ? = ? | 30·0-? = 30·0 | ? - ? = ? | 5·1-2·3=2·8 |
| 56·5-21·9=34·6 | 13·0-4·5=8·5 | ? - ? = ? | 48·4-5·4=43·0 | 0·9-? = 0·9 | 17·8-17·3=0·5 |
| (34·6) | | | (52·4 ÷ 3 = 17·5) | | (0·5) |
| 16·8-8·3=8·5 | 18·8-0·5=18·3 | 16·1-6·0=10·1 | 44·4-6·0=38·4 | 18·6-? = 18·6 | 17·2-5·7=11·5 |
| 23·7-3·3=20·4 | 8·3-15·0=6·7 | 12·0-46·0=34·0 | 8·7-? = 8·7 | ? - ? = ? | 4·4-? = ? |
| 45·5-11·6=33·9 | 27·1-15·5=11·6 | 28·-52·0=23·9 | 53·1-6·0=47·1 | 18·6-? = 18·6 | 21·6-5·7=15·9 |
| (28·9) | | (53·4 ÷ 4 = 13·4) | | | (15·9) |
| 37·0-14·4=22·6 | 13·1-7·2=5·9 | 30·8-6·3=24·5 | 20·0-4·6=15·4 | 21·3-11=10·3 | 50·2-3·1=47·1 |
| 24·9-1·1=23·8 | 6·3-? = 6·3 | 20·0-? = 20·0 | ? - 12 = - 12 | ? - ? = ? | 21·0-19·1=1·9 |
| 61·9-15·5=46·4 | 19·4-7·2=12·2 | 50·8-6·3=44·5 | 20·0-16·6=3·4 | 21·3-11=10·3 | 71·2-22·2=49·0 |
| (46·4) | | (70·4 ÷ 4 = 17·6) | | | (49·0) |

Discussing the direct, residual and combined effects of different manures and fertilisers in more detail:—

Paddy—1 Crop: (Number of experiments reviewed, 3945 for direct effect, plus 470 for residual effect; total 4415).

Direct effect: The maximum percentage (81.4%) increase in yield over "No Manure" is obtained by the application of 'combinations of organic manures'. Farmyard manure occupies the second rank (77.6%) and combinations of organic and inorganics the third rank, (36.9%). Superphosphate (34%), bonemeal (32.1%) and oil cakes (31.4%) are nearly equal, in their direct effects, while green manure is a bit lower (21%). Nitrogenous fertilisers like ammonium sulphate (22.8%) and sodium nitrate (6.4%) are comparatively poorer and potassic fertilisers (—2.7%) are of negative value. Combinations (18.5%) of artificials are not better than ammonium sulphate by itself.

Residual effect: Bone meal gave the maximum (26.1%), Farmyard manure is second (25.7%) and 'super' is the third (10.8%) in rank. The residual effects of artificials are negative, e. g., ammonium sulphate (—6.3%) and sodium nitrate (—1.7%). Combinations of inorganics i. e., nitrogenous plus phosphatic fertilisers left residual effects equal to that of super phosphate (10.8%).

Considering the direct and residual effects together, farmyard manure occupies the first rank, 'combinations of organic manures, the second rank, (85.8%) and bone-meal the third (58.2%). 'Combinations of organics plus inorganics' occupy the fourth rank, (46.8%). Superphosphate follows this closely with 44.8% increase. Oil-cakes, (38.6%), 'combinations (24.6%) of inorganics' green manure (18%) and ammonium sulphate (16.5%) are effective in the decreasing order. Sodium nitrate is not very helpful (4.7%), while K. fertilisers actually decreased (0.5%) the yield.

Paddy: Second Crop: (Number of experiments reviewed, 466 for direct effect, plus 133 for residual effect; Total 599.)

Direct effect: 'Organics plus Inorganics' gave the maximum (45.3%) direct effect; 'combinations of organics' are second (30.8%) and oil-cakes (14.7%) third.

Residually: Bone meal gave the maximum effect, (52.6%), super phosphate second (30%) and oil cakes, the third (20.6%).

Considering the direct and residual effects together: Superphosphate stands first, (43%) bone meal next (39.1%), and organics plus inorganics third (34.6%), with the combination of organics (30.8) closely following.

On the whole organics (22.5%) individually are nearly $1\frac{1}{2}$ times as effective as inorganics individually (17.5%), while combinations of organics (30.0%) are far superior to those of inorganics, (0.5%). But organics (34.6%) plus inorganics are better than either.

Jowar: Number of experiments reviewed: 996 Direct effect, plus 230 for residual effect; Total 1226.

Direct effect: Farmyard manure gave the maximum direct effect (43.6%) and 'super phosphate and combinations of organics' are second and third in rank.

Residual effect: Residual effect was maximum with green manure (50%), next in order are farmyard manure (25%) and organics plus inorganics, (20.4%). The residual effects of artificials (except superphosphate) are distinctly negative, e.g. ammonium sulphate (6.7%) and sodium nitrate (-3.4%).

Considering the direct and residual effects together: Farmyard manure (68.6%) stands first; green manure is second and superphosphate third (47.1). Combinations of organics (11.3%) and oil-cakes (29.8%) and 'organics plus inorganics' (28.9%) come next.

On the whole, organics (41.5%) individually are nearly three times as effective as artificials individually, (13.4%) while the combinations of the former (41.3%) are $1\frac{2}{3}$ times as effective as combinations of the latter (15.9%). Organics plus (28.9%) inorganics' are superior to artificials alone (13.4%), or their combinations, (15.9%).

Wheat: (Number of experiments reviewed: 2468 for direct effect, plus 265 for residual effect; Total — 2733).

Direct effect: 'Combinations of inorganics' stand first (47.1%) followed closely by farmyard manure. Oil-cakes stand third (31.9%) in rank. Ammonium sulphate is the last of all (5.9%).

Residually: The residual effect is the maximum (52%) with bone-meal, 'combinations of organics' are second (35%) and oil-cakes the third (27.2%). Superphosphate is the last (12%).

Considering the direct and residual effects together: Farmyard manure stands first, (66.1%) and Combination of organics (63.2%) and oil-cakes (58.3%) are second and third in rank.

On the whole, organics are individually are $3\frac{1}{2}$ times as effective (58.3%) as 'inorganics individually (17.6%) and 'combinations (63.2%) of organics' are $1\frac{1}{2}$ times as effective as those (49.0%) of inorganics.

Summary: "Organic manures individually or in 'combinations' are invariably 2 to 3 times as effective as inorganics. "Organics plus inorganics" can be said to be intermediate in effectiveness, but with paddy second crop, these gave the maximum increase. Among the artificials, phosphatic ones are very beneficial. The rest are not very effective, either directly or residually. Potassic fertilizers gave mostly negative results.

Results of Manurial Experiments in India

Paday, First Crop: 1. For India as a whole, effect of different manures: When India as a whole is considered: The maximum direct effect on yield has been with organic manures, over no manure. Next, in order come bone-meal combinations of organic manure, Phosphatic manures and farmyard manure but residually green manure gave the maximum effect and farmyard manure the next best. The residual effect of sodium nitrate is practically nil and that of ammonium sulphate is negative.

Considering the direct and residual effects together: Green manure tops the list followed by combinations of inorganic fertilizers, farmyard manure, bone meal and phosphatic fertilizers.

The performance of potassic fertilizers is very poor

2. *Climate-war*: In the arid zone there are no experiments. In semi-arid zones the response of paddy crop to manuring is poor. In humid areas inorganic fertilizers in combinations and individually have given the largest yields; next in order are the organic manures individually and organics plus inorganics. Curiously enough, combinations of organics fared badly in this region, though in the per-humid area organic manures alone topped the list; after which come the inorganic combinations organics plus inorganics and last inorganics alone.

Viewed from the plant-food constituents supplied by the manures, the response of paddy crop to nitrogenous manures (mostly organics) increased from semi-arid to humid and humid to per-humid area. Next in order are N-K-P and N-P. K alone is not of much use.

3. *Soil-war*: The maximum response to manuring is seen in the red, ferruginous, lateritic soils in which organic manures alone and combinations of inorganic fertilizers top the list.

The response in alluvial lands, loams and black soils is comparatively less. Combinations of organic manures though they did well in the alluvials and loams fared badly in black soils.

Complete manure N-K-P gave the highest returns in laterite soils; next in order are N-P and P. In loams there is a fair response to P and N-K-P. Black soils are the least responsive to paddy manuring.

Jowar: (1) *For India as a whole*:— The maximum direct effect on yield has been with farmyard manure, and this effect decreased with the other organic manures, (green manure) and oil-cakes. With bone meal the direct and residual effects are poor, due probably to lack of sufficient moisture for its decomposition. Combinations of organics plus inorganics are the next best to farmyard manure. Green manure, combinations of organic manures or combinations of inorganic fertilizers are on a par with oil-cakes, while ammonium sulphate was slightly superior.

Residually also, farmyard manure topped the list; green manure being the next best. There are some residual effects with organics plus inorganics and inorganic combinations due mainly to the effect of season, that is, the lack of rain or moisture in the year of application. The rest have practically no residual effects.

Taking the direct and residual effects together: Farmyard manure is the best, green manures come next, and combinations of organics plus inorganics, the third. Sodium nitrate is of negative use. Potassic manures are without effect.

2. *Climate-War*: 'Organic manures individually were very good, in semi-arid, humid and per-humid areas, the effect gradually decreasing in the order mentioned. Inorganics alone and combinations of organic manures were ineffective in semi-arid zones but were effective in humid areas, whereas the behaviour of combinations of organic combinations are the opposite to the above in these climatic zones.

(N-K-P (as organics or inorganics) are the best in semi-arid zones, N in per-humid zones and P in humid zones. Behaviour of N-P is the same in semi-arid and humid zones.)

3. *Soil-War*: In all soils, organic manures individually are the best. The effect is more pronounced in black soils.

N-K-P (as Organics or Inorganics) is the best, especially on black soils. The effect of nitrogenous manures increased from alluvial to loams, loams to black soils, and reached the maximum in laterite soils.

Wheat: (1) *Different Manures*: The maximum direct effects are with 'inorganic plus inorganics.' Next is farmyard manure. Sodium or potassium nitrate is next to farmyard manure; and green manure is next to sodium or potassium nitrate.

As regards the residual effects, green manure is the first, farmyard manure second, and bone meal third. Organic combinations and sodium or potassium nitrate also gave some residual effects.

Considering the direct and residual effects together, farmyard manure is the best manure. Sodium or potassium nitrate and green manures are the next. Bonemeal, combinations of organics or inorganics or organics plus inorganics, all behaved alike. Ammonium sulphate, super or K-Manures are not as effective as oil-cakes. Somehow P was of negative use.

2. *Climate-war*: Organic manures individually did well in all the climatic regions except in arid zones, where organics plus inorganics and inorganics alone, were slightly superior. The maximum response to manuring is seen in humid zones.

N-K-P is best in arid and humid zones and N in semi-arid and per-humid zones. P is more effective in semi-arid areas than in other areas.

3. *Soil-war*: The response to manures in general is more in alluvial and black soils and less in loams and laterites. Organics top the list in all the four types of soil. Organics plus inorganics are the next best, inorganics alone or combined are the third, except in laterites, where the performance of inorganics (7%) alone is superior to combinations.

N-K-P is the best in alluvial and black soils and least effective in laterite soils. N. is very effective in all the four types of soils, and particularly in alluvial and laterite soils. In loams, N-P is the best.

List of Experimental Stations:

1. *Madras*: Aduturai, Coimbatore, Hagari, Koilpatti, Mangalore, Sirvel, Samalkot, Palur, Nanjanad, Nandyal, Anakapalle, Maruteru, Guntur, Bellary, Kasargode, Taliparamba, Vellalur.
2. *Bombay*: Alibagh, Arbhavi, Dharwar, Dhulia, Dehad, Jalgaon, Kumpta, Manjri, Mokibaggadu, Nadiad, Ratnagiri, Surat, Poona, Amalsad, Baramathi, Koporgaon, Modibag, Karjat.
3. *Bengal*: Mymensingh, Decca, Comella, Dogra, Faridpur, Chinsura, Bankura, Rajashahi, Berhampur, Nursery, Malda, Amrit, Nurser.
4. *Bihar*: Cuttack, Kanki, Sambalpur, Sabour, Bikramgang, Sepaya, Baliya Purolia, Jamni, Khurda, Gaya, Kharara, Banka Siwan, Nawada, Dharbhanga.
5. *Punjab*: Lyallpur, Hansi, Gurdaspur.
6. *U. P.*: Cawnpore, Muzaffar-nagar, Gorakhpur, Aligarh Meerut, Tarikhot, Pratappgarh, Shajahanpur, Bundelkand.
7. *C. P.*: Nagpur, Yeotmal, Powerkhera, Chindwara, Waraseel, Labhandi, Adhartal, Tharsa, Akola, Berar Farm, Borgaon, Basin, Buldana, Chandkwari, Sindiwahi.
8. *Assam*: Kamrup, Surma Valley, Sibsagar, Goalpara, Nowgong, Khasi and Jaiti Hills, Jorhat, Upper Shillong Karimgang, Titahar.

Manures and Fertilizers:

- | | |
|--|--|
| <ol style="list-style-type: none"> 1. Farmyard Manure 2. Green manure 3. Oil cakes 4. Bone or Fish Meal 5. Organic combinations 6. Organics plus Inorganics 7. Ammonium sulphate 8. Sodium or potassium nitrate 9. Super etc. 10. Potassic fertilisers 11. Inorganic combinations | } Organics } Inorganics |
|--|--|

Important Crops:

Paddy, first crop, Paddy, second crop, Jowar, Wheat, Ragi, Bajra, Maize, Korra, Sugarcane, Potato.