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Review Article

Role of Organic Manures and Inorganic Fertilizers in Maintaining Fertility Status of Paddy Soils*

by

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Introduction: The use of organic manures in crop production is known from time immemorial. Organic manures include different oilcakes with nitrogen content ranging from 2·5 to 6·2 per cent and organic waste of animal origin like dried blood, slaughter-house refuse and fish manure, where the nitrogen content ranges from four to ten per cent. But the largest source of organic manures comprise farm yard manure, compost and green manure. These bulky organic manures, which contribute to a great deal to the organic matter content of the soil, are very necessary for soil fertility. In cultivated soils of the tropics and subtropics the organic matter content is very low because of the rapid and continuous oxidative decomposition taking place. If crop production has to be maintained, the loss of organic matter has to be periodically supplemented to keep up the organic matter content in the soil which is very necessary for soil fertility.

Organic manure as supplier of nutrients: Harrison and Iyer (1913, 1914, 1916) did pioneering work in applying green manure to paddy grown under swampy conditions and found increased yield thereby. They attributed the beneficial effects of green manure to the indirect effect of aeration afforded to the roots by the dissolved oxygen liberated by the micro-organisms thriving on the carbon dioxide given out by the decaying green matter. Later work done by Karunakar *et al* (1951) showed that green manure had also a direct effect by supplying the nutrients required by the plants. This conclusion was arrived at because of the continuous production of ammonia during the decomposition of green matter which was observed to be utilised by the paddy crop. Organic manure also supplies easily replaceable cations, nutrients in organic forms, and the organic acids produced during decomposition are found to extract the nutrient elements from soil minerals (Lyon *et al*, 1956). Apart from the major nutrient elements, organic manures are found to contribute to the maximum crop production. There are also indications to show that organic matter has a chelating effect on the nutrient available in the soil (Rao and Mariakulandai, 1957; Raja and Mariakulandai, 1958 and Mukerji 1960). Recent studies of Kuriakose and Mariakulandai (1962) revealed that a combination of green leaf and micronutrients (Mn, Fe, Cu, Zn, B.) resulted in higher yields than the use of micronutrients alone.

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Effect of organic manures on physical properties of soil: The low plasticity and cohesion of humus have a significant role in heavy soils to alleviate unfavourable structural characteristics induced by large quantities of clay. A small increase in humus has physical effects far in excess of its proportional amount (Lyon *et al*, 1956). Another influence of organic matter on physical properties is that of granulation. Dressings of farm yard manure are of considerable value in assisting in the development of good structure (Hall and Robinson, 1945). They are also found to improve the water holding capacity of soil (Keen, 1946 and Stewart, 1947).

Effect on chemical properties of soils: Humus, as a colloidal complex, carries innumerable negative charges. But instead of being made up principally of Si, O, Al, and Fe, as are the silicates, the humic micelles are composed of C, H, O, N, S, P and other elements. The cation exchange properties of humus is 2 to 30 times as great as mineral colloid and account for 30 to 90 per cent of the adsorbing power of mineral soils (Lyon *et al*, 1956). Humus colloid possesses the capacity to increase the availability of certain nutrient bases, such as calcium, potassium and magnesium.

Effect on biological properties of soil: The organic manures also enhance the biological activities of soil (Waksman, 1952). The organic matter is the main source of energy for soil micro-organisms, without which biochemical activity would be practically at standstill. The appearance of ammonium compounds in the soil is due mainly to their action. Moreover, certain bacteria govern the production of nitrates and sulphates which are indispensable sources of nitrogen and sulphur respectively for higher plants (Lyon *et al*, 1956). Bulky organic manures also supply CO_2 for algae in paddy soil that are important in the supply of O_2 to the roots of rice plants (Wickrama sekara, 1934).

Necessity of inorganic fertilizers: In practice it may not be possible to be self-sufficient in the requirements of organic manure for a large cultivable area and all the available organic manure in the form of cattle manure will not be sufficient even for about a seventh of the area under cultivation in the state. Hence, it necessitates the supplementing of organics with inorganics. Crop production can also be maintained at its best with chemical fertilizers alone as was shown by long term experiments conducted at Pusa, Kanpur and other places (Panse, 1956). But a judicious combination of both is always the best and economical as was shown by the analysis of the permanent manurial trials, both old and new, conducted for the past 52 and 32 years, respectively, at the Agricultural College and Research Institute, Coimbatore (Mariakulandai and Thyagarajan, 1959).

Effect of inorganic fertilizers on soil properties and crop yield: Adding fertilizers to a bare cultivable soil usually reduces the stability of the structure; calcium fertilizers, such as calcium nitrate, being most harmful, with ammonium fertilizer being intermediate (Russel, 1961). It was reported that every 100 lb of ammonium sulphate utilises 110 lb of $CaCO_3$ from soil. The

danger of soil becoming acidic after a number years with the application of ammonium sulphate depends on the total quantity of fertilizer applied annually, the nature of soil and the rainfall (Yawalkar, 1962). Acid forming fertilizers in certain soils may decrease the available phosphorus and increase the available potassium. Basic fertilizers may result in an increase in both available phosphorus and potassium. Liberal application of fertilizers ultimately increase the reserve supply of nutrients in the soils which is particularly true of phosphorus but accumulation of either nitrogen or potash usually is not appreciable, unless the humus content of the soil is increased because these elements suffer heavy losses of leaching. Chemicals (fertilizers) were also found to inhibit the growth and development of fungi, bacteria and other organisms in soils such as earthworms which are of fundamental importance in the maintenance of soil fertilty (Hopkins, 1945).

In the experiment conducted at the Central Rice Research Institute, Cuttack, to study the residual effect of compost and ammonium sulphate, paddy was grown on two sets of plots, one set receiving compost at 8,000 lb per acre and the other, ammonium sulphate at 20 and 40 lb of N. After eight years of continued application of manures and fertilizers, the experimental plots were divided into two portions, one portion receiving the usual doses of compost and fertilizers and other portion receiving no manure. It was found that even with no manuring the extra yield of paddy in the field which had previously received composts was 500 lb over the control unmanured plots in the nineth year and 320 lb in the 10th year, whereas, in the field to which ammonium sulphate was applied for eight years, the yield of the unmanured plot was found to be slightly less than the yield of the no manure control plot (Vachhani *et al*, 1959).

Work in the United States has shown that continuous use of acid forming fertilizer materials will lead to a decrease in pH with an accompanying decrease in crop yield unless lime sufficient to neutralise the acidity thus formed is applied to the soil (Tisdale and Nelson, 1956). It has been well established that the continued use of certain fertilizers causes a residual acidity in the soil which, if not corrected, is eventually injurious to plant growth. Soils that are already fairly acid or sandy soils which are readily made acid, are the first to show decreased crop yield. The soil acidifying effect of fertilizers is due mostly to ammonium compounds. On the other hand, sodium nitrate and calcium cyanamide reduce acidity owing to alkaline or basic effects of sodium or calcium (Ignatieff and Page, 1958).

Though the findings of Sethi, Ramiah and Abraham (1952) have revealed that the application of ammonium sulphate and ammonium nitrate showed no residual effect good or bad, the trials conducted at other research stations in India have not shown conclusively that the application of chemical fertilizer to paddy without organics will not harm the soil.

Comparative effect of organics and inorganics and their combination on yield of paddy: Experiments were conducted in the Madras State on paddy for finding out whether a judicious combination of organics and inorganics

was essential for obtaining increased yields. Oilcakes like groundnut cake, neem cake and castor cake, were tried in various doses in combination with different doses of ammonium sulphate. Besides, ammonium sulphate in various doses was applied in combination with green manures and other organic manures like farm yard manure and compost.

Hanumantha Rao (1948) reported that concentrated organic manures like oilcakes gave progressive increase in yields from 0 to 60 lb irrespective of the nature of cake. But, the optimum dose was found to be 40 lb nitrogen per acre. The Government Agricultural Chemist and Paddy Specialist of Madras State, in their review of manurial experiments for the decennial period of 1930—'40, have reported that with application of oilcake and ammonium sulphate in the ratio of 2:1 of organic and inorganic nitrogen, marked response was obtained at Pattambi. In the complex manurial experiments conducted at Aduthurai, the the trend was that the higher the dose of nitrogen the higher was the yield; and groundnut cake in conjunction with ammonium sulphate over a basal dressing of green manure gave the best yield and of these, cake and sulphate applied in the ratio of 2:1 appeared the best (Mariakulandai 1957).

The results of the combined organic and inorganic nitrogen experiments conducted at Pattambi on the second crop of paddy (1951—'52) (Table I) showed that the maximum yield was obtained when ammonium sulphate was applied over a basal dressing of green leaf in the ratio of 2:1.

TABLE I

S. No.	Treatments	Acre yield	Percentage on control
1.	Groundnut cake at 400 lb	2011	125·1
2.	Leaf at 4000 lb	1917	119·2
3.	Ammonium sulphate at 150 lb	2190	136·8
4.	2/3 of treatment (3) and 1/3 of treatment (2)	2221	138·1
5.	1/3 of each of the treatments 1, 2 and 3	2053	127·7

The results of trial conducted at Aduthurai for studying the efficacy of organics and inorganics on paddy revealed that a combination of ammonium sulphate and green manure was the best. Mariakulandai (1957) has reported that green manure in any form is useful and progressive increase in yield up to 8000 lb can be obtained even though the optimum yield ranged from 4000 lb to 5000 lb. Ammonium sulphate at the rate of 30 lb of nitrogen and 4000 lb of green manure were found to be optimum dose.

Karunakar and Rajagopalan (1948) recommended a basal dressing of 5000 lb of green manure to supply 30 lb of nitrogen and a top dressing of ammonium sulphate to supply another 30 lb of nitrogen. Karunakar *et al*, (1951)

have also shown that a combination of green manure at 5000 lb per acre plus ammonium sulphate to give an equal quantity of nitrogen was found to be the best treatment recording an increase of 11·5 per cent of grain and 18 per cent straw over "no manure" control, in the second year of the trial. This schedule of manuring to paddy has also been recommended by Ball (1950), Hanumantha Rao (1950) and Karunakar (1957).

Experiments with combination of ammonium sulphate and farm yard manure or compost were conducted at Chinsurah in Bengal, Central Rice Research Institute, Cuttack, Labhandi farm in Madhya Pradesh, Kuduvani in Kashmir. At Chinsurah, graded doses of ammonium sulphate to supply 0, 30, 60, 90 add 120 lb N per acre were applied over no basal organic dressing as well as to plots receiving farm yard manure at the rate of 8,000 lb per acre (40 to 45 lb N). The experiment was conducted for three years (1946—'47 to 1948—'49) and the results are summarised in Table II and III.

TABLE II

Grain yield in lb per acre (Mean of three years)

S. No.	Treatments	Doses of N as ammonium sulphate in lb per acre				
		0	30	60	90	120
1.	No Farm yard manure ...	2011	2489	2386	2352	2242
2.	Farm yard manure at 8,000 lb. per acre ...	2252	2629	2585	2156	1937
	Mean ...	2132	2559	2486	2254	2090

TABLE III

Response to one lb N in lbs of paddy grain.

S. No.	Dose of N lb per acre	No organic dressing	8,000 lb of Farm yard manure applied as basal dressing
1.	10	10·1	14·4
2.	20	9·3	12·8
3.	40	7·7	9·6
4.	60	6·1	6·4
5.	80	4·1	3·2

The experiment showed that the response for ammonium sulphate was better when applied over farm yard manure than when applied alone. The maximum expected yields were 2456 and 2638 lb per acre respectively for no farm yard manure and farm yard manure plots. But, the maximum yield

obtained in farm yard manure plots was not attained by no farm yard manure plots even by an increase in the level of ammonium sulphate. This was probably due to other beneficial effects of farm yard manure.

Similar results were obtained at Cuttack, where different levels of ammonium sulphate were tried with and without a basal dressing of compost to supply 40 lb N per acre. Up to 40 lb N per acre; the effect of compost and ammonium sulphate were practically additive, although there was some indication that at lower doses the effect of ammonium sulphate was better when applied over compost. In Madras State, Mariakulandai (1957) reported that bulky organic manures like cattle manure, compost, sheep manure, fish manure and night soil were equal in effect and similar to green manure, the optimum dose being 30 to 40 lb N per acre.

Phosphate fertilizers, like super phosphate and bone meal were also found to increase the yield of paddy when applied in conjunction with green leaf in certain experiments reported by Hanumantha Rao (1950) and Mariakulandai (1957).

From the above review, it is seen that the combined application of organic manures and inorganic fertilizers has proved more beneficial than either of them applied alone. An adequate supply of organics must be ensured to obtain maximum benefit from artificials.

Any system of agriculture that does not include organic manure is improvident and unscientific (Lyon *et al*, 1956). The rationale behind this statement is that the inorganic fertilizers will provide readily available plant nutrients for the immediate use of paddy crop while the organic form will supply a steady stream of nutrients during the entire growth phase of the crop and also provide the physical and biological condition for the maximum growth and production.

Summary: Organic manures are helpful (a) as a supplier of nutrients both major like N. P. K. and minor elements in the form in which it is present in plants, as they are mostly plant residues, (b) as a soil conditioner, since it improves the physical properties of soil, (c) as a chelating agent of important nutrients which would otherwise be lost by leaching, since it converts them into immobilised forms which are available to plants and (d) as a long term provider of nutrients to the plants because of its continued residual action.

Based on the results of several experiments on paddy, a combination of 5,000 lb. of green leaf as a basal dressing to supply 30 lb nitrogen per acre in organic form and a top dressing of chemical fertilizer to supply another 30 lb of nitrogen per acre in the inorganic form is being adopted at present in Madras State. The recommendation also includes phosphate at 30 lb P_2O_5 per acre in the form of super phosphate.

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