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Manuring of Rice with Reference to Different Environmental Factors

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Introduction: There are no two opinions that one of the surest methods of increasing the yields of crop plants is to increase the capacity of the soil to supply nutrients to the plant by manuring. It has also been the experience that identical results are not obtained by identical methods practised.

At the outset it may be stated that in the paragraphs that follow, no distinction is made between the words 'manures' and 'fertilizers'. Manures in this special sense mean substances belonging to plant residues while fertilizers imply those of mineral origin. It is not proposed to give any detailed recommendations about manuring, but certain basic principles based upon past experience at various Research Stations and the crop in general will be presented.

While considering the efficient use of manures, we have to take into account (1) the soil type and (2) the available water supplies. Different soil groups and even soil types within the same group differ in their content of available plant nutrients, and hence respond differently to the same quantity and quality of manures.

It is also essential to consider in the effective use of fertilizers, the long-term effects both direct and indirect, taking the whole rotation into consideration rather than immediate results.

Fertilizing practices may also need revision from time to time to meet changing conditions, crop growth etc. The efficient use of fertilizers and manures on a crop is bound up with proper seed, tillage, protection against pests and diseases, orderly system of water use and disposal, and conservation of organic matter. No one particular practice is always effective, but an intelligent combination of practices brings us the desired result.

Manure and Water: Water and manure form an inseparable couple in agronomy. The best results in manuring are obtainable only when there is sufficient moisture in the soil. Conversely, manured plots do not suffer from drought as much as plots which have not been manured, especially with organic manures. It has been reported that when a dry land crop is converted into an irrigated or garden land crop, the yields have been trebled. This gives a clue that in the interests of the nation as a whole the available short supplies of manures could more advantageously be used in places where there are assured water supplies.

It has also been borne out that the best effects of manuring are secured in well-drained soils. The differences are sometimes very wide. That is why we get the highest yields in very light, shallow soils with intense manuring, as in the soils of Chittoor, portions of Salem, South Arcot etc. This fact is again very important in that the drainage in large areas of the deltaic region had to be improved considerably, for the best results from improved crop practices.

It is found that manuring has a very great influence in the economy of water, especially in the rainfed areas. The following results from a pot-culture experiment conducted in Bengal should be of interest.

Manuring	Water transpired / Dry matter produced	Average yield per plant
Farmyard manure + Amm. Sulphate ...	408	10·0
Farmyard manure + Amm. Phosphate ...	458	10·9
Farmyard manure alone ...	400	9·4
No manure ...	481	6·8

Hence, to ensure the best results of manuring, all water resources, even in the delta areas have to be improved.

Soil and Manuring: Soil types have a profound influence on the action of manures in crop production. The rice soils of the Madras State may be divided into (1) the black cotton soils of the Godavary system, (2) the lighter clay or alluvial types of the Cauvery delta, (3) the light loamy zone of the Central Districts and the Carnatic and (4) the light sandy loams of laterite origin on the West Coast. This being so, it is possible that each of these types requires different treatments as far as manuring is concerned. Rice is a crop which is grown under puddled conditions. The time of planting and the duration under which the soil is in this condition may vary. But there is quite a general agreement in the common requirements of the rice grown in these soils.

Results of Experiments in Madras: From the experiments so far conducted at various stations, the following general conclusions emerge :

(1) There is a universal response to nitrogenous manures in all the stations.

(2) Of the several kinds of nitrogenous manures, green manure is the most economical and up to 8,000 lb. may be applied.

(3) It is found that while 30 lb. of N per acre as ammonium sulphate is an optimum dose with a basal dressing of leaf up to 4,000 lb., even 15 lb. N as ammonium sulphate top dressing plus 4,000 lb. of leaf secures a positive response, by way of increase yields.

(4) The response with P_2O_5 fertilizers is somewhat variable. In some stations, specially on the lighter soils, the yields increased with super-phosphate doses. In combination with leaf the response was still more pronounced.

It is of course possible that there may be minor differences in the several district zones. In the Coimbatore soils green manure was found more efficacious than ammonium sulphate on a 30 lb. N. dosage. On the West Coast ammonium sulphate was more efficacious than leaf at the same dosage in the second crop season.

It is necessary that this difference should be investigated more fully, so as to arrive at the most efficient method of using these natural manures.

Laterite Soils and Liming: The laterite soils of the West Coast require special mention. They are poor in organic matter and the nitrogen content is variable; the P_2O_5 supplies too, are generally low, though K_2O is sufficient. They are poor in bases and acidic in reaction, the intensity varying with different types. These are met with in the high rainfall tracts of the West Coast and on the Hills even if there is no high rainfall. There is a lot of iron and alumina in them. In these types of soils, for good crop production, soil amendments such as lime have to be incorporated and a liberal use of phosphates is also necessary. It is an established fact that a neutral soil or a near-neutral soil is helpful in the fixation of nitrogen from air, conversion of nitrogen into soluble forms and making K_2O and P_2O_5 more available.

Even among 'acid' soils there is some difference; acid soils rich in clay have higher reserves of acidity than sandy soils and a mere pH value may not give us a sure guide of the quantity of lime to be added. For clay soils more lime may be necessary than for a sandy soil, though both may have the same pH value.

In a recent experiment conducted in South Kanara for three seasons the following yields were obtained.

Lime (2,000 lb.) plus green manure (4,000 lb.)	131
Green manure alone (4,000 lb.)	123
Lime alone (2,000 lb.)	117
No lime, No green manure	100

There was residual effect of lime on the subsequent paddy yields, amounting to 11 per cent. There was an improvement in the lime status of the soil after three years.

Nitrogenous Fertilizers: It has been found that ammonium sulphate is effective in increasing the yields of rice, the increases depending upon the soil conditions and cropping practices. In the recent intensive manuring campaign, tests with 30 lb. and 45 lb. doses of ammonium sulphate per acre conducted on ryots fields have given some revealing figures. It has been found the higher the fertility status of the soil, the higher was the percentage increase upto the limit when too much vegetation involves premature lodging. Hence, whenever cultivators are able to purchase ammonium sulphate, they may use it with advantage upto 150 lb. of sulphate per acre with some basal dressing of organic matter, leaf or cattle manure.

Phosphates: In general the response to phosphates is not as great as in the case of nitrogen in most of the research stations. This lack of response is rather surprising since the soils in most of these areas are known to be deficient in available phosphates. This aspect requires further study. In this connection attention may be drawn to one feature of phosphate application to paddy soils. In many of the experiments the phosphate is 'broadcast, top-dressed' either before or even sometime after the transplanting of rice. We are told that in most of the soils about two-thirds of the phosphorus stays in the soil within an inch or two of the place of application and also that it is no longer soluble in water having 'reverted' to an unavailable form. Thus two points emerge: (1) that the phosphate must be placed much below the surface (deeper than 2" if possible) and (2) that every year phosphates may be applied in fairly large quantities, or to get over the loss through

reversion, some other method of applying phosphates has to be thought of. There appear to be one or two methods which may serve these ends. It is reported that if the phosphates are applied to the green manure crops (where such are grown) preceding the paddy crop, they are built up into the green manure crop in a more easily available form (being in the organic state) and as such are absorbed by the plant more readily. Thus, phosphate manuring through the crop of green manure, satisfies the crop requirements in an easy manner.

It is also suggested that the phosphates may be composted with green manure and this compost applied to the soil. The P_2O_5 is said to be in organic combination and so is not reverted. Besides it prevents nitrogen losses in the composts to a great extent. These aspects are now under investigation on a comprehensive scale at several Research Stations.

Thus fertilizers can be of use to indirectly build up the humus of the soil, which is the pivot of crop production in this country, since humus is easily lost by high temperature and erosion etc. It may also be possible that in course of time continuous application of phosphates as outlined above may build up the phosphate status of the soil to a degree where further applications could be smaller.

It is not fully realized that a high nitrogen status can be maintained in a soil only when the phosphate status is maintained at the proper levels. Then again, the quality of humus may depend upon the mineral status and not merely on the quantity of organic matter. Further research on these lines is also necessary.

It is often suggested if we take care of the phosphorus, the nitrogen will take care of itself. In essence, more attention has to be given hereafter to phosphate manuring in rice soils in addition to the other soil amendments that may be considered necessary.

Green Manuring: As already mentioned, green manuring is found to be the most useful for all the rice soils of the State. There is a variety of green manure crops available, to suit different soil types and cropping practices. Sunnhemp is the queen of fodders-cum-green manure crops, being the shortest in duration, but it is suited only to limited areas. Daincha is more or less universally useful. Pillipesara comes up well in rich clay soils with two or three irrigations. Wild Indigo comes in most of the soils but is very slow-growing. *Sesbania speciosa* is drought-resistant and will take kindly to even moderately saline soils but it is rather very slow in growth. It may be possible to grow only a fifth of the area under green manuring in this State due to limitations of soil moisture, at the time of sowing and in later stages of their growth. But an earnest effort is to be made in spite of these handicaps, as sometimes unexpected rains do help us.

One point which must be borne in mind in green manuring is this: where green manure crops are raised in the field itself and puddled in, the the green manure crops remove P_2O_5 as well as K_2O from the soil and so they must be replenished now and then. Though in Indian soils depletion of K_2O may not occur in the near future, the case is different with P_2O_5 in which our soils are woefully deficient in many places. It may also be pertinent to point out that where a portion of green manure is removed for fibre or for cattle food, to that extent the soil loses P_2O_5 and K_2O, unless

these are made good through other sources. This problem of supplying green matter may be approached from another angle which is now engaging the attention of the Agricultural Department of this State. Addition of green leaf got from outside the plot does not involve the handicaps mentioned above, of lessening the P_2O_5 supplies in the soil. Hence it is proposed to utilize the bunds and the edges of the fields for raising quick-growing shrubs as *Gliricidia* and *Sesbania* species for green manure plants. It is possible that a good part of the demand for green matter for rice may be met by a widespread practice of these methods. All waste places, channel, bunds etc., should be made available for producing green leaf, so vital to the rice crop which has to solve the food needs of our country.

Combination of manures: There is a general apprehension, that in the combined application of fertilizers, particularly ammonium sulphate on paddy soils, however rich it may be in the humus content at the beginning, gradual losses of other minerals specially lime, may occur and also probably phosphate which may ultimately impair the crop production. Through there are no facts to prove or disprove this opinion, it stands to reason that a 'single element' nutrition is always risky and it may not be practised continuously or long. A favourable balance between important mineral nutrients, organic matter, suitable physical conditions of the soil, and microflora is one which results in the best crop production. In fact fertilizers by themselves are wasteful on farms that are not maintained by proper farming practices. It is essential that there must always be humus in the soil; and hence a basal dressing of organic matter before 'artificials' should always added to the soil.

As a general practice, it is recommended that whenever possible a basal dressing of 4,000 lb. of leaf should be added to the soil before fertilizers are applied.

It must be admitted that no experiments have been conducted so far, to fix what should be the dosage of compost of farmyard manure that would serve as a basal dressing. Probably we may require as much as 5,000 lb. per acre.

It may also be noted that land to which organic matter is added, requires less of the costly nitrogen and phosphate fertilizers in the long run.

There is some controversy, with no prospect of an immediate solution, regarding the efficiency of 'fresh' or 'rotted' manure to paddy soilds which are under 'anærobic' conditions. We are told that fresh straw stimulates growth of bacteria at the expense of nitrogen, but after the material is decomposed, they release the nitrogen contained in them. Therefore to minimize the losses in bulk in the preparation of rotted manure it may be advantageous to add fresh manure to rice soils. Thus the practice of burying fresh straw or even leaves of palms in some parts of the country, derives some justification in this connection.

Time and method of application of manures: When once it is decided what manure or fertilizers are to be used for a particular crop, the important problem of determining when and how they are to be applied in order to get the maximum benefit, has still to be solved. For an efficient use of the fertilizer, it is necessary that they should be supplied at the right time and in the right way.

In regions of low summer rainfall, nitrogenous fertilizers, it is reported, give the best results when applied 10 – 12 – cms. below the surface. It is always found more advantageous if applications of cattle manure are made shortly before planting than when they are applied earlier.

In China paddy seed is mixed with dry manure and sown in open furrows when the crop is raised by direct sowing.

In a recent communication, some light is thrown on new a practice of applying ammonium sulphate. Prof. Pearsall in studying marsh conditions in Cumberland, found measurable differences in the water-logged soils; oxidation took place at the soil-water surface but reduction lower down. The Japanese have recognised the bearing of this finding on the rice problem. Sulphate of ammonia put on the surface of the mud in the usual fashion was quickly oxidized to nitrate, which was washed down below and reduced to gaseous nitrogen. But if sulphate of ammonia was pushed down through the oxidation zone into the region of reduction it lay there safely till the plant took it up. If nitrates are used they may be used as top dressings later during the growth". — (Russell – World Crops – Vol. I. No. 2. 1949)

This requires some serious thought, as it is at variance with the usual practice of broadcasting ammonium sulphate sometime after the crop is established.

Varieties and Manuring: It is argued that the total amount of nutrient elements contained in a crop cannot be used to calculate its fertilizer requirement as the feeding mechanisms of plants vary from crop to crop, as also their ability to assimilate nutrients from relatively insoluble compounds.

Whether the different strains within a crop variety will show different ability to make use of soil nutrients has not been fully studied in this country. However, an interesting study made some years ago with the 'cultures' from one variety and the ryots' mixed bulk disclosed that the strains were able to a utilize soil nutrients to a greater degree than the control. This supports the results of Paul (1935) who found differential responses of strains of maize and tomato to manurial ingredients.

This raises an important issue. One school of thought contends that the strains 'exhaust' the soil much more quickly than the mixed 'variety' of the ryot, because the former give higher yields. The other view is that the strains are able to to utilize the soil nutrients more officiently. It may be that a strain which has a particular type of root system reaching certain definite depth, possibly depletes soil fertility at this particular zone in course of time. But if some sort of rotation is practised, i. e. using different strains of rice in different years, this contingency may not arise. It may also be possible that the strains might be able to utilize soil nutrients differently. Obviously this important issue requires investigation and work has recently been started in this direction in this State.

However, there are some experiments where different varieties were included under one level of manuring. The results show that

within a particular duration group there are not much differential responses under normal conditions. But in years of insufficient rainfall certain varieties show a greater response than certain others.

Another point which is of some importance in a manuring policy, is that of response of short and long duration crops to manuring. It was found that the short duration groups show a better response.

This result can be explained from the fact that short duration varieties are generally grown at a time when there are no weather disturbances and when more secure conditions of water supply exit. Thus, if a decision has to be taken between application of manure to short duration or long duration crops alone, the choice should be in favour of short duration crops.

Manuring and Quality of Rice: 'Quality' in rice is a very ambiguous term as the conception varies with the several interests concerned in the rice industry. But what we are primarily concerned as consumers is the nutritional aspect, which is governed by the vitamin content, protein, phosphates, calcium, etc. Much of the data in other countries show that where the soil contains a well-balanced supply of plant nutrients or where conditions are optimum for plant nutrients and for plant growth, the vitamin content of the produce is also high. Excessive use of single element fertilizers or of unbalanced fertilizers result in crops of low biological value. It may be treading on ground which is not the legitimate province of a plant breeder, but it may be pertinent to mention some valuable conclusions reached in this regard in rice. Some experiments were conducted under schemes initiated by the Indian Council of Agricultural Research on this aspect of rice in the past and the following figures speak for themselves.

		N.	P_2O_5	Ash	
I.	No manure	8·20	0·674	1·32	Variety Co. 10
	Manured (Super — 224 lb. Amm. Sulphate 112 lb. and leaf 4,000 lb. per acre)	8·76	0·699	1·64	
II.	Leaf at 2,000 lb. per acre	10·28	0·564	1·32	Variety GEB. 24.
	Leaf — Super 112 lb. per acre	10 03	0·584	1·40	
	Leaf + Amm. sulphate	10·88	0·660	1·68	

Thus proper manuring not only gives higher yields but gives also a product of better nutritive value. Preliminary experiments carried out on a number of Agricultural Research Stations with the same manuring and the same varieties, show differences in the chemical composition of grain. Under ill-drained conditions the grain contains lesser P_2O_5 and even less proteins. Again in lighter soils, the manured grain is richer than in unmanured soils; whereas in heavy soils this is not quite so marked. Here again it is obvious that these problems call for detailed investigation.

Conclusion: At the present moment an integrated plan of work is necessary for increasing rice production in this country. To bring home this point, the example may be cited of the Japanese way of rice cultivation, who doubled their per-acre production in four decades. Their soils are no more rich than most of our soils. But the Japanese farmer cultivates his rice field as if it were a garden. There is no slovenly corner in any field. Each crop gets its adequate manuring. The manure he gives to rice would stagger us; viz. 45–100 lb. Nitrogen, 60-80 lb. P_2O_5—in addition to a lot of organic matter in the form of composts of all organic wastes, from man, animal and plant. Rice is inter-cultivated two or three times during its growth. Water is given and taken out as and when necessary. Eighty per cent of the rice area is grown to improved seed, developed by the plant breeders. 50 per cent of the wetlands is cropped twice in a year, with either rice, wheat, sweet potato, peas, or some crop or other. We have, no doubt, record yields of upto 10,000 lb. in some places in the State, but the average has to be pushed up by a co-ordinated plan of efficient cultivation, if the over-all production of rice in our State is to be improved in any definite manner.