GREEN MANURING IN INDIA AND PAKISTAN

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TO supply the soil of the Indian sub-continent with organic manures is one of the major problems of Indian agriculture. Indian soils are very poor in nitrogen and organic matters. Their average nitrogen content ranges from 0.03 per cent. to 0.07 per cent. against 0.1 per cent. to 0.17 per cent. in European and American soils. As for organic carbon, they contain 0.6 per cent. compared with 3 per cent. in Europe or in U.S.A. This short review is intended to give some information upon one possible solution of this important problem. It is not in any way complete, and is based on information gathered on visiting Indian and Pakistani agricultural research stations.

For different reasons, beginning with the vegeterial habits of the population and their worship of the cow, down to the well-known fact that yields of plant products per acre will feed more hungry mouths than if they were transformed into animal products, animal husbandry is a somewhat neglected part of agriculture. There is great waste of farmyard manure since animals live mostly in the open and much valuable manure gets lost, the most important part of what is gathered being used for fuel.

Green Manuring

It seems, therefore, that the only satisfactory substitute could be green manure. In fact, green manuring has been an ancient practice all over India for many hundred years, but the scientific aspects of the problem have not been studied before this century, and it is only recently that some advance in this respect has been achieved.

The simplest form of green manuring—called green-leaf manuring—is the burying of leaves of trees growing either in the vicinity of the field or on channel banks or bunds. This is quite different from the practice of growing plants for green-manuring purposes on the field itself and turning them under at the right time for the following crop to benefit from their manuring effect.

The characteristics of a plant well suited for green manuring should be rapid growth, a high yield of succulent organic matter, the capacity to do well on poor soils and also under water-logged conditions, low water requirements and a high moisture content to facilitate decomposition in the soil. If possible, legumes should be given preference. If the plant could be used also for fodder or as fibre plant, it would be a definite advantage.

Plants Suitable for Green Manuring

Sunn-hemp or sann-hemp (*Crotalaria juncea*) is the plant most extensively used for green manuring all over India and also in some parts of Pakistan. It is generally used as green manure for rice and sugarcane, and is grown also as fodder. Some special strains produce remarkably good fibre, and seeds can be fed to cattle. The seed rate is from 30 to 50 lb. per acre. It is easy to grow—erect with little branches, it reaches a height of 4 to 5 ft. and is generally cut before flowering, when 60 to 90 days old. It can be grown as a rainfed or as an irrigated crop.

Other varieties of crotalaria are also being used for green manure. Of these, *Crotalaria striata* is the most popular especially in moist regions. It is a herbaceous shrub, 3 to 4 ft. high. The seed rate is from 30 to 40 lb. per acre. Rainfed, it is used generally as green-leaf manure. The leaves can be cut after three months. It gives two good cuttings of green matter, of about 8,000 to 15,000 lb. each, and is used also for mulching on tea, coffee and rubber plantations. *Crotalaria verrucosa*, a branching herbaceous annual, can be used also on saline soils. Sesbanias are another important family of plants suitable for green manuring. *Sesbania aculeata* is especially suited for heavy soils. It can be grown on low, wet and badly water-logged and also on saline soils. The approximate seed rate is 10 to 20 lb. per acre. Rainfed, it is ready for cutting within 6 to 8 weeks. Soft and succulent in its early stages, it gets woody very soon and has, therefore, to be turned under in time. Sesbania aegyptiaca can also be grown under water-logged conditions. It is used on the acid soils of tea plantations in Assam, and is a good fodder and fibre plant.

Moth (*Phaseolues aconitifolius*), Black Gram (*Phaseolus mungo*), Mug or Green Gram (*Phaseolus mungo radiatus*) are all used for green manure. A very important variety, the Phillipesara (*Phaseolus trilobus*) is grown mostly in South India. It is a trailing herb with prostrate branches, most valuable and nutritive as green fodder, generally broadcast into the standing crop of late rice, at a rate of 15 lb. per acre. After seven to eight months it can yield about 25,000 lbs. Other pulses rather popular for green manuring are Cowpeas (*Vigna catjang*) and Guar (*Cyanopsis psoraliodes*). Cowpeas do well on poor soils and yield an excellent fodder. Guar is also used for fodder. The seed rate of the latter is about 20 lb. per acre.

Wild indigo (*Tephrosia purpurea*) is used all over South India. The seed rate is 15 lb. per acre. Rainfed, of slow growth, it is used as a single crop on wet land. It has to be cut before flowering. Another species of this family is *Tephrosia candida*, a perennial shrub growing also on high ground up to 4,000 ft. It is generally planted in 1 ft. rows, and is ready for cutting after only one year; it gives four cuttings yearly. *Tam indigofera endicaphylla*, a trailing annual, grows also on high ground up to 6,000 ft. The seed rate is about 20 lb. per acre. It is fast-growing, and the leaves should be cut within three to four months. *Cassia tora*, an annual grows wild up to 4,000 ft. The seed rate is 15 lb. per acre. The leaves should be cut before flowering. Velvet beans (*Stizolobium deeringianum*) a fast growing plant, is used generally for fodder but also for green manuring, giving bulky, easily decomposing crops.

Some winter legumes are also used. Berseem, mostly grown for fodder, giving normally six cuts, is a good green manure plant. If used for this purpose, the fourth cut is generally turned under. Senji (*Melilotus parviflora*), Fenugreek (*Foenicum graecum*) and *Lathyrus salivus* are also extensively used, but only under irrigation.

Non-Leguminous Plants

Hemp (*Cannabis sativa*), sunflower, sorghum and maize are incidentally used for green manuring.

Green Manure Trees and Shrubs

Of these, the following may be mentioned: *Erythrina lithosperma*, *Erythrina Indica*, *Gliricidia maculata*, *Hibiscus tiliaceus*, *Leucaena glauca*, *Calopogonium mucunoides*. These are rapidly growing trees and shrubs of moderate height. They can be lopped after the second year and used for green manuring.

Burying Green Manure

The burial of green manures is a simple operation done with ploughs or disc harrows. As a rule, the green manure crops have to be buried deeper on light soils than on the heavier types. It is also rather important to bury older or woodlier crops nearer to the surface as decomposition seems to be faster if more oxygen is available. A thorough study must be given to the " timing," *i.e.*, the interval needed for decomposition. This is indeed the crucial point of green-manuring, as under tropical conditions a decrease of nitrogen or a reduction of the nutrient produced by the green manuring can happen rather suddenly with the result that the beneficial effect of green manure is lost, and even the yield of the following crop might be affected. On grounds of general experience it can be assumed that eight to ten weeks should be the right interval, especially for Sunnhemps and Sesbanis. Berseem needs much less time for decomposition; two to four weeks seem to be sufficient. Undoubtedly, the risk of green manuring is chiefly connected with the uncertainty of moisture content of the material.

The economics of green manure grown under irrigation are yet to be studied, but it seems to be a paying proposition especially if the improvement of the soil structure is taken into account. One of the reasons why the beneficial influence of green manuring is felt much more on light or sandy soils than on heavy clay is its improving effect on the soil texture and its water-holding capacity. It is still an open question whether green manuring, by growing the green material in another place and carting it for burial to the field provides the same benefits, and if it would be as economic as grown " in situ." But the fact should not be overlooked that under very dry conditions where irrigation is not available, plant nutrients as well as moisture are transferred by this practice. This is applied particularly to parts of the country where it is a common practice to grow green manure plants on waste land or on embankments or bunds which cannot be used for the growing of useful crops.

Effect of Applying Green Manures to Certain Crops

For rice, green manures are beneficial under favourable monsoon rain conditions, or where irrigation is possible.

For sugarcane and wheat they are valuable where burying can be done in time for decomposition to occur and irrigation is available. If used for maize and potatoes the results are also favourable, and it has a good effect on cotton. Other crops can also benefit. Whether the application is worthwhile depends entirely on the economic return of the following crop. Green manuring is widely used in orchards, on coffee and tea plantations, and *its effect on coconut plantations is also most beneficial.*

Under favourable conditions the quantity of green manure is rather considerable. On medium soils it may be as much as 20,000 lb. to 25,000 lb. per acre and 70,000 lb. or more per acre on rich soils. The amount of nitrogen added to the soil in this way ranges from 50 to 75 lb. per acre. The increase in yield of the following crop depends naturally on the success of the green manure crop and the decomposition. Another circumstance to be noted is that the relative increase is generally higher on medium or poor soils than on rich ones. It can be safely stated that an increase in yield of from 30 per cent. to 75 per cent. has been found on rice, 50 per cent. on sugarcane, and 20 to 25 per cent. on wheat. The results with cotton are from 10 to 45 per cent. A great deal more research on this matter is needed as the data available are scanty. On the other hand, the fact that conditions vary to a great extent makes generalisation rather difficult.

The residual effect varies considerably, but though the added nitrogen is probably consumed within six months from burial, other nutrients can have a favourable effect up to four years. A further advantage is the betterment of the soil structure, the tilth and water-holding capacity. The effect of green manuring on alkaline soils needs further research as results differ, but since good response has been obtained in some places this problem should be given careful study, in view of the fact that salination of soils under irrigation, as for instance, in the Punjab, is a steadily spreading danger.

Another aspect of green manuring is the joint use of green manure and fertilisers. It is an established fact that fertilisers, especially phosphate and potash, have a better effect if applied to the green manure crop instead of the main crop. On the other hand, direct addition of phosphate fertiliser to green manures resulted in better yields than green manure alone. Some spectacular results have been obtained with sugarcane by adding sulphate of ammonia to green manure Sunn-hemp. The same success can be registered if castor or rape cake is added, these being widely used as fertilisers in India. It would be of great importance to find out the best way of application and large-scale experiments would also be needed to prove the residual value of fertilisers applied to green manures.

Economic Aspect

The economics of green manuring need more research too, though it has to be kept in mind that generally figures can be of little use, having regard to the extreme variations in application and return. It has been proved that the net saving per acre can be quite considerable—as much as from £5 to £10. The application of green manure has sometimes doubled the net profit.

Another aspect of the problem needing further study is whether the use of green manuring plants for dual purposes is economically sound. Experience seems to show that if, for instance, the fibre is extracted from Sunn-hemp and only tops and roots and other waste material are buried or if the bulk of the green material is cut for fodder and only the residues are turned under, this gives a very reduced manuring effect. Here too, generalisations are difficult, because Berseem, for instance, can be used successfully both for fodder and for green manure.

Conclusion

It can be said that green manuring is, for the time being, one of the best methods of soil improvement in India and Pakistan. Much depends on using the right technique and therefore, though research should be extended in order to answer a number of yet undecided questions, the ultimate success or failure of green manuring will depend on the farmer. The extension of green manuring will have to be incorporated as an important item into the activities of the newly organised advisory service and as so much depends upon the individual only very personal approach can bring satisfactory results.