INTRODUCTION

The rapid population growth particularly in developing countries like India coupled with intense energy crisis leads almost all experts to conclude that a major crisis may present itself around the turn of the century. It is also felt that this crisis can be avoided if sharp increases are made in food production. The additional food has to be produced mainly through increasing crop yields substantially by all possible methods. One of the most important methods would be to improve the fertiliser nitrogen use efficiency, the efficiency of nitrogen being the lowest (30-50% of applied-N) amongst all nutrients. A substantial improvement in the recovery of fertiliser nitrogen is particularly important in view of the acute energy crisis all over the world.

Fertiliser nitrogen has contributed largely towards augmenting food production in India, yet the efficiency of its utilisation is very low because of its losses through mainly volatilisation, leaching and denitrification. The losses are the highest in case of lowland rice (30-50%). Even with the best agronomic practices and strictly controlled conditions, the nitrogen recovery seldom exceeds 60-65 per cent. The losses due to volatilisation could vary from negligible to 60 per cent and due to leaching it could be as high as 70 per cent (Mac Rae and Ancajas, 1970 ; De Datta *et al*., 1974 ; Bouldin and Alimango, 1976 ; Mikkelson *et al*., 1977).

A number of approaches aimed at increasing nitrogen use efficiency have been attempted by workers in both India and abroad. These are viz. use of ammoniacal fertilisers, slow release fertilisers, nitrification retarders, urea briquettes, urea supergranules, sulphur coated urea (SCU), coal based fertilisers and of course, the use of organic manures in conjunction with chemical-N. Most of these materials have given promising results in many crops but their commercial use, so far has not been possible due to their relatively high cost. A rough estimate by Hignett (1974) indicates that the cost per ton of N as SCU is about 16-30 per cent higher that its cost as granular urea. Its cost at present, might be still higher. Unless the costs are brought down, the extensive use of these materials does not appear to be possible in our country.

Therefore, there is need to attempt some alternative approach to combat the problem of low nitrogen use efficiency. Stangel (1976) has estimated that any breakthrough that would result in just 10 per cent improvement in the recovery of nitrogen and other nutrients would lead to a minimum annual savings of US $ 3.2 billion/year.

An alternative economically feasible approach for attaining higher nitrogen use efficiency for particularly developing countries, might be the recycling of crop residues. Field trials have shown that about 50 per cent of chemical fertilisers could be saved in farming, if used judiciously alongwith organic materials (Raychaudhuri, 1977). A large number of cellulosic and lignocellulosic wastes and by products are produced in huge amounts in both agriculture and agro-industry. Most of them are of little direct use and are therefore termed as wastes. They hence, constitute a cheap and renewable source of energy which can be exploited for the development of a variety of products including nitrogen rich materials using simple technologies (Gaur et al., 1978 ; Gaur, 1980 ; Gaur, 1982 ; Vimal and Tyagi, 1983) based on aerobic and anaerobic fermentation . However, the advantage of producing organic nitrogen rich materials from agricultural wastes following the microbial protein production approach over conventional composting, is that, that the final material can be put to a number of uses (feed, food,etc.) including its use as an efficient organic fertiliser (Mateles and Tennenbaum, 1968; Han et al., 1971). Such a material would not only be an efficient nitrogen fertiliser due to its slow acting nature but a carbon dioxide fertiliser too, because of its carbonaceous nature.

It has been observed from several laboratory and green house studies in the West that carbon assimilation by a crop increases as CO_2 concentration around plants is increased upto 1000 ppm (Wittwer, 1970; Takami et al., 1974 ; Fischer and Aguilar, 1976 ; Shivashankar et al.,1976, 1978). Some reports from the temperate regions of the world mainly the U.S. and Europe have proven the deficiency of CO_2 in various crops, in the day time (Chapman et al., 1954 ; Lemon, 1960). The extent of CO_2 deficiency in the tropics would be still higher due to plentiful sunlight and warm ambient temperature thereby stimulating photosynthesis. The available light intensity in the tropics is adequate for assimilation of nearly 2000 ppm CO_2. There is need to understand and appreciate this difference which undoubtedly operates for kharif crops in the northern half of India and for all crops throughout the year for the rest of the country.

A soybean crop can fix appreciably high amount of CO_2 which can increase its grain yield by more than 50 per cent. A corn crop can assimilate more than 500 Kg CO_2/ha/day during the kharif season while its normal rate of CO_2 fixation is hardly 100-125 Kg CO_2/ha/day. It clearly shows how the lack of carbon dioxide fertilisation in the tropics might restrict crop yields. A nitrogen rich material developed from an agricultural waste would decompose further in the soil at a steady rate, releasing not only N but CO_2 also. Since the CO_2 thus evolved would be rather small and would hardly neutralise CO_2 deficiency, the problem of outward diffusion of CO_2 may be ruled out. Moreover, since the molecular weight of CO_2 is much higher than that of moist air, the soil released CO_2 would probably have little tendency to diffuse upwards. It would thus be an inexpensive method of causing CO_2 fertilisation compared to sophisticated CO_2 production and release equipment used in case of green house crops in the West. The nutritional and other benefits associated with organic fertilisation of soils are well known and need not be stressed here.

Incidentally, rice husk is one of the agricultural wastes which offers a high potential for the development of nitrogen rich materials. Paddy being the world's major cereal crop, about 70 million tones of rice husk is produced annually as the largest by product of rice milling industry. About 15-20 million tones of husk is produced annually, in India alone. It poses an enormous disposal problem - about 51,000,000 tones of husk occupies volumetrically, the space taken by over 393,000,000 tones of paddy (FAO/UNIDO, 1973). Surprisingly, though the rice husk has found a variety of possible industrial uses, yet its actual utilisation in relation to its overall production so far, is very small in practice. Its chemical and physical nature is unlike other agricultural wastes (McCall et al., 1951 ; Beagle, 1971). Rice husk is fragile and porous thereby rendering the cost of its storage and transportation to be excessive in comparison to the benefit that can be derived from its use. No other crop residue ever approaches the amount of silica (15-18%) found in husk. The silica is heavily concentrated on the inner and outermost surfaces as cellulose silica membrane. As a consequence, rice husk is very abrasive in character. Due to roughned edges and low nutritional value, it is unsuitable as a cattle feed. Due to low nutrient content (N : 0.3-0.4% ; P_2O_5 : 0.2-0.3% ; K_2O : 0.3-0.5%), it adds very little to the soil as a fertiliser (Rajani and Patil, 1956).

It is clear from the above account that unlike most crop residues, rice husk is a potential waste. The development of a simple low-cost technology to convert it into useful products like nitrogen rich materials right near the rice mill, might be its best use under the present circumstances. Besides, its value as a slow acting nitrogen and carbon dioxide fertiliser, husk based materials might also act as silica fertilisers especially in lateritic acid soils where there is high leaching of silica. Many research workers acknowledge the importance of silica for rice fields (Lian, 1963 ; Okuda and Takahashi, 1965 ; Yoshida, 1975). On an ultisol in Philippines, response to silica was 2 t grain yield/hectare.

A conventional approach to increase nitrogen use efficiency is the coating of fertiliser particles with suitable materials. Another approach is the development of triazines by heating urea in the presence of ammonia to yield six membered ring polymers. The hydroxy groups of these polymers can be replaced with amino groups to form a family of slow release polymers like cyanuric acid, ammeline, ammelide, etc. Their high nitrogen contents and low dissolution rates make them attractive as slow release nitrogen fertilisers. Howev r, in most of the above materials, methods of manufacture are both impractical as well as highly expensive. That is why, they have remained largely of academic interest only. Any attempt to find or develop cheap and easily available materials for coating urea and to develop a simple low-cost method to synthesize urea polymers shall be of far reaching importance.

The present studies were undertaken with the following objectives :

1. To examine the effect of various chemical treatments on rice husk with respect to its nitrogen enrichment through microbial fermentation under room temperature.

2. To attempt to develop nitrogen rich materials using chemically treated husk, with and without various levels of inorganic nitrogen (using different sources) through aerobic and anaerobic microbial fermentation under room temperature.

3. To examine the suitability of rice husk as a substrate for edible mushroom cultivation ; the use of fruit bodies as human food and the left over material as an organic fertiliser.

4. To attempt some cheap substance as a coating material for urea and to develop a simple and cheap method to synthesize ammelide.

5. To evaluate and quantify the effect of various materials on crops as nitrogen and carbon dioxide suppliers in pot culture.

6. To study the residual effect of materials on the following crop.