INTRODUCTION

Increase in population pressure with decrease in per capita land availability warrants intensive cropping, both in time and space dimensions. In intensive cropping, supply of nutrients at desired level and in time is indispensable for realising potential yield. High analysis chemical fertilizers are used due to ready availability of nutrients and quick yield response. Continuous use of high levels of chemical fertilizers often leads to nutritional imbalance and decline in crop productivity (FAO, 1982; Nambiar, 1994). The problem further worsens in acid lateritic soils, which are characteristically low in organic matter content (Mahapatra *et al.*, 1985) and deficient in available nitrogen, phosphorus and calcium content. However, in such soils the fundamental chemical properties like nutrient holding capacity (cation exchange capacity) and pH buffer capacity (lime requirement) are largely governed by the organic matter content of soil (Moody *et al.,* 1997). The implications of low organic matter, cation exchange and buffer capacities of the soils are that, under continuous cultivation, organic matter declines quite rapidly, followed by extensive leaching of basic cations and rapid development of acidity. Further, the chemical fertilization alone could not mitigate the losses of C, N and P while combined application of FYM and chemical fertilizer was effective in this respect (Agbenin and Goladi, 1997). Therefore, the importance of enriching tropical acid lateritic soils with soil organic matter content is increasingly being felt.

Recycling of organic waste in agricultural land brings in the much needed organic and mineral matter to the soil. Until the introduction of chemical fertilizers in mid nineteenth century, organic materials in the form of FYM and green manuring with sesbania were the only recognised sources of plant nutrients (Panse, 1965; Hauck, 1982). Crop residues are also important source of nutrients, which are readily available and in quick succession particularly under intensive cropping. In rice growing areas azolla, an aquatic fern, is also being used as a potential source of organic matter. This bio-fertilizer can be grown and incorporated in-situ or as compost before transplanting of rice. Development of one layer of Azolla can yield a biomass of about 5-t ha^{-1}, which is equivalent to about 30 kg nitrogen. In this high rainfall region, water hyacinth is abundantly available in aquatic bodies, which is another natural biomass and potential

organic source. These organic materials with different C:N ratios and bio-chemical composition release nutrients at different pace (Azmal *et al.*, 1996). Further, addition of chemical fertilizers and coal ash may bring changes in decomposition process and hence, the nutrient availability to the crop. Therefore, important aspects like optimum time of application of organic materials in combination with coal ash and chemical fertilizers is imperative for augmenting crop production and soil productivity. However, information pertaining to advantages derived by the crops in a cropping system is lacking. Besides, investigation on direct and residual effect of the combined fertilization sources is imperative from the point of view of saving of chemical fertilizers under different cropping systems.

It is recognised that chemical fertilizers are not a substitute for organic materials and vice versa, rather, their role is complementary. Organic materials being low in nutrient content, application in large quantity is necessary to meet the crop demand. Limited availability of organic materials on one hand and high price of chemical fertilizers on the other warrants their integrated use. Organic matter can be used to regulate the nitrogen supply to rice plant as a nitrogen repressor in early growth stage as well as generator in latter growth stage. Addition of nitrogen through chemical fertilizers accelerates the pace of mineralization by reducing the C:N ratio and meets early nutrient demand of both plant and the soil microbes (Sahrawat, 1979). Thus, in integrated nutrient supply system, combined use of chemical fertilizer and organic materials in appropriate proportion is necessary to derive the desired benefits.

The acid soil infertility is largely attributed to high availability of iron, aluminium and manganese with deficiency of phosphorus, potassium, calcium and magnesium besides some micronutrients. Therefore, to overcome the twin problem deficiency and/or toxicity, the acid soils are often treated with lime and enriched with fertilizers. Any material, which is cheap and has the dual properties of amending and enriching the soil, may prove to be desirable and effective in retaining the soil productivity. Coal ash a waste of thermal power plants is one such material for use in agricultural land. Coal being fossilised vegetation, its ash is expected to be rich in minerals essential for plant growth. Besides its nutrient supplying capacity, coal ash having alkaline pH can amend the acid soil (Schnappinger *et al.*, 1975 and Molliner and Street, 1982). Therefore, addition of alkaline coal ash is expected to change favourably the inherent nutritional imbalance in acid soil. Lack of organic carbon and nitrogen in coal ash can be

supplemented by organic materials. However, it is necessary to study the effect of coal ash in agricultural land with proper scheduling of doses and mode of its application and monitoring of nutrient uptake by crops including toxic elements and heavy metals and their residual effect on soil and crops. The changes in physical and chemical properties of soil on application of coal ash is also required to be studied.

Coal ash being devoid of organic carbon may not be helpful in retaining the land productivity. Therefore, different organic materials and chemical fertilizers can be combined with it to regulate the supply of nutrients and provide balanced nutrition to the crop. The beneficial role of organic materials in improving the soil physical and chemical properties is well established. The favourable soil pH through coal ash application, ready availability of nutrients through chemical fertilizers and organic materials as substrate for soil microbes may provide congenial conditions leading to release of nutrients as required for desired crop performance. Therefore, it is imperative to integrate coal ash, different organic materials and chemical fertilizers to establish the complementary role of these sources in improving the soil productivity on long term basis.

Under dynamic multiple cropping system, the choice of crops in a sequence is important for high and stable yield without impairing land productivity. In high rainfall region, cultivation of rice during *Kharif* (wet season) is indispensable under excess water stress and hence, rice based cropping system is in vogue. Any high value winter crop, which can be grown in sequence to *Kharif* rice and is also of regional importance should be chosen. Keeping this in view, mustard as rainfed and potato as irrigated winter crops in sequence to *Kharif* rice can be selected to ascertain the influence of coal ash on yield and quality of produce of both the crops. Moreover, the nature of growth and final produce of the two crops being different, their differential response to added coal ash either singly or in combination with chemical fertilizers and organic matter need to be investigated.

It is generally conceived that fertilizers applied to one crop may meet a part of the requirement of the succeeding crop grown in sequence. Residual effect of organic matter is more common because of fixation and accumulation of organic N (Savant and DeDatta, 1982). In a cropping system, management of residual P is important because of its fixation particularly in acid lateritic soil. Application of P in any form and at any level built-up a higher residual P (70-80 %) in soil (Singram and Kothandaraman, 1992). The

added organic matter to soil is favourable for improving P reserve as a long term effect in a cropping system. Therefore, it is implied that in calculating the fertilizer needs for crops in a cropping sequence, a judicious combination of both organic and chemical fertilisers is necessary and thereby a discount on the basis of residual effect may be possible for saving and attaining economy in fertilizer use.

Keeping the above points in view, an investigation was planned with the following objectives:

1. to study the direct and residual effect of coal ash, organic materials and chemical fertilizers on nutrient uptake and crop yield in rice based cropping systems.
2. to evaluate the efficiency of different organic materials in combination with coal ash and chemical fertilizers under integrated plant nutrition system
3. to study the effect of time and mode of application of coal ash and organic materials for increasing nutrient use efficiency
4. to study the influence of coal ash, organic materials and chemical fertilizers on heavy metal content in the crop produce and on physical and chemical properties of soil