Agriculture, the major livelihood activity of human beings, is the base of economic development of India. Particularly, more emphasis was given to agricultural growth after independence, and as a result, green revolution was achieved invariably by growing high yielding varieties and introducing chemical fertilizers and pesticides in the farmlands. In addition, agricultural mechanization and improved irrigation facilities also added to the success in achieving self-sufficiency. Presently, the prime attention is focused on the sustainability of crop production as expected the over utilization of lands may loose their temper to produce any crop in near future. So, reviving the soil productivity and to make it sustainable for near future to produce more and more crop is the need of the hour to sustain its population.

In this connection, organic farming is prescribed to be the way to reduce the pollution of soil as well as health hazards. While its objectives is to reduce the application of chemicals to the soil and crops, the practice also strive to increase of soil shelf-life and agricultural harvest. Moreover, organic farming supports the organisms which inhabit the soil and give suitable aeration to make the soil and its ‘living components’ to maintain sustainable crop production.

Though chemical fertilizers are common in other parts of India, in northeast India the use of chemical fertilizers are very limited due mainly to its high cost and availability in proper time and place that led the farmers do their cultivation by avoiding any type of fertilizers to their crop fields. As a result, the poor productivity of crops was evident from this region. Moreover, the hilly parts of northeast India face the threat to loose its treasure of flora and fauna, as a result of shifting cultivation. Due to such improper management of hill slopes, the farmers use to gets less production from the second year onwards in a newly developed land, so they shift their cultivation to newly cleaned hill slopes.

The present research was conducted in the densely populated Papum Pare District of Arunachal Pradesh to found out suitable way to increase the crop production and to reduce the loss of natural components to make balance agriculture. While the state of Arunachal Pradesh is always noticed for its rich
flora and fauna, the rich cultural diversity of the resident communities have also led to differential land us and agricultural practices (Arunachalam et al., 2002). One of the adaptive strategies to combat the ill-effects of chemical fertilizers in the agro-ecosystems is possibly the agricultural waste recycling. This has been widely agreed upon in the context of sustainable crop production (Arunachalam and Arunachalam, 2005).

The study attempted to study the vegetation in the agro-ecosystem in terms of diversity of crops and weeds. Estimation of both major crop and livestock wastes was also done to get a clear picture on resource availability for organic farming. Suitability of various waste products for recycling was elucidated by analyzing their respective nutritional quality. The suitable way of recycling of waste material to plant available form was amongst others was composting that could very well suit to this region. An attempt was also made to test the efficiency of agricultural waste product to crop production and to compare the results with that of the chemical fertilizers. Over all, the present study recorded vast sources of organic waste products in Arunachal Pradesh, which can be utilised successfully to enhance crop production, which will help to increase the productivity of crops as well to maintain the sustainable agriculture by viably reducing the external inputs particularly the chemical fertilisers.

The major findings have been summarized in the foregoing sections.

Summary

- In Arunachal Pradesh, various types of agricultural land use system were found namely lowland valley, upland valley, jhum cultivation and terrace cultivation systems.
- Valley cultivation is prominent in the foothills and plateau of Arunachal Pradesh. Both the lowland valley and upland valley system of cultivation were seen in this area depending upon the water source and other resource availability. In the lowland areas, people use to do mono-cropping of rice i.e. wet land rice (more than 45 % of the land) as a settled cultivation system.
- Depending upon the water source double cropping and/or triple cropping is practiced by the farmers of this area.
Shifting cultivation (*jhum* cultivation), a type of slash-and-burn cultivation system is widely practiced by the indigenous communities mostly in the humid tropical region, where the peoples reap higher production in the first year that however decline in the subsequent years due to the improper fertility management and also due to top soil erosion.

In *jhum* cultivation, the diversity of crops is witnessed as the farmers do grow more than three crops i.e. mixed cropping.

Terrace cultivation is a newly introduced system of cultivation in Arunachal Pradesh, which can be very successfully used by the farmers as a substitution to *jhum*. This is a form of settled cultivation, where farmers can grow crops year after year with proper management practices. This is a less labour intensive system when compared to *jhum* cultivation.

Most of the farmers of Arunachal Pradesh practice their cultivation (57%) without using any organic and inorganic amendments. Rarely people use chemical fertilizer (8%) and organic fertilizer particularly cow dung (25%), Crop waste (8%), vermicompost (2%) to their crop lands.

In low land valley, farmers prefer monocropping of rice between July to October. The rice density was found maximum in lowland valley as compared to terrace and *jhum* cultivation system.

The weed density was found more in upland valley compared to other land use system.

Low soil bulk density and highest water holding capacity (WHC) was observed in the lowland valley among other systems. On the other hand, highest bulk density and lesser WHC were found in *jhum* cultivation system. Sand content was greater in the *jhum* lands which may be due to the erosion of finer soil particles in the slopes, especially from the top soil. On the other hand, the sand content was found lowest in the lowland valley systems. This may be due to standing water on the field for maximum part of the year, and so wind erosion is also less.

The soils of lowland valley have superior nutritional quality compared to other systems. The organic carbon and total nitrogen was found to be more in lowland valley system.
• The estimated amount of agricultural crop waste was 261865 t per year which possibly could be harvested from the cereals and legumes cultivated in entire Arunachal Pradesh.

• Among the cereal residues, rice straw, which is a common agricultural waste of Arunachal Pradesh, contains 0.65 % N, 0.29 % P and 1.40 % K, which was more than that of the other cereal residues.

• In terms of nutrient content, pulse residues contain comparatively more nutrients, especially N compared to other cereals and vegetable crop residues. Therefore, it is a good source of N and other plant nutrients, if recycled to the soil.

• Among the common plant residue highest amount of N was recorded from Musa spp. (0.68%), P was highest in Pyrus communis (0.45%), and K was highest in Litsea monopetela (1.43%). Among common weed biomass highest amount of N, P and K were recorded from Eichornia spp i.e., 2.70% N, 1.99% P and 2.50% K.

• In pulse crops, the C/N ratio was recorded lowest among other residues. In the pulse residues, it ranged from 21.87 to 25.67. Amongst the pulse residues, the lowest C/N ratio was recorded in pea residues (21.87). In rice, the C/N ratio was recorded 52.97. In other crop residues, it ranged from 46.13 to 98.58. Over all, in the plant residues, the C/N ratio varied between 27.06 and 92.21.

• Paddy residues accumulated maximum amount of N amongst all other selected crop residues i.e. 895.18 t per annum, followed by maize residue (402.85 t). The millet, wheat and pulse residue accumulated 153.17 t, 23.27 t, and 83.94 t accordingly. Phosphorus accumulated by paddy residues was 399.39 t and for maize 230.20 t. the potassium accumulation of rice was more that is 1928.08 t and lowest in pulse crops (96.50 t). A total of 1558.41 t of N, 729.51 t of P and 3552.45 t of K were accumulated per annum by available crop residues.

• On an average 2221440 t of wet dung per annum and 1382520 t of urine per annum are produced from the total number of livestock available in the area. The total livestock waste beings 3603960 t per year in Arunachal
Pradesh. Therefore, this is a good source of organic manure for crop production.

- The poultry droppings had more N (1.27%) and P (1.96 %) among easily available livestock wastes. Poultry manure, however, needs to be applied to the soil as soon as possible as it ferments very quickly. In exposed condition, it may lose up to 50 percent of its N within 30 days (Gaur et al., 2002).

- As a whole, 14883.75 t of N is accumulated in urine 1698738 t of N in accumulated in dung annually, 404.26 t of P accumulated in urine 12699.33 t of P in dung and 10743.00 t of K in urine and 18467.55 t in dung in the livestock available in entire Arunachal Pradesh.

- Conventional methods of composting take relatively greater time and produce low quality manure as compared to vermicompost.

- Among the three types of compost prepared, it was found that the vermicompost takes lesser time for decomposition as compared to other methods of composting. The decomposition is fast in vermicompost due to use of earthworm, which have the enormously efficient rate of organic matter recycling.

- Vegetable waste decomposed faster as compared to weed biomass and rice straw in case of vermicomposting.

- The nutritional quality of vermicompost was superior when compared to other composts irrespective of substrate used excluding the phosphorus content. Phosphorus content was however greater in the phospho-compost, may be due to the use of 5% pyrite and 10% rock phosphate.

- Most of the farmers of India in general and Arunachal Pradesh in particular are marginal and poor. For them, it was sometimes not possible for construct a concrete vermicomposting tank for producing vermicompost due to lack of Government subsidy. Therefore, it was advisable to construct a unit by utilizing less cost, which would be suitable for the resource poor farmers of this region. By utilizing locally available materials and resources a non-tank vermicomposting unit (bamboo beam) could be constructed and can utilized the agricultural waste from their own
The growth and yield component of rice is markedly influenced by rice straw and vermicompost incorporation. More grain yield was the plots amended with vermicompost as compared to rice straw incorporation.

All the growth characteristics showed an increasing trend with the increase levels of NPK.

Different crop residues and levels of NPK influenced the nitrogen content of rice plant. For instance, nitrogen content was higher in early stage of growth that decreased with age irrespective of crop residue, vermicompost and chemical fertilizers.

Incorporation of crop residue increased the phosphorus content in soil.

At early stage of crop growth, the potassium content was less that however increased gradually with time.

Availability of nitrogen in soil of rice field increased with rice straw incorporation, vermicompost application and chemical fertilizers. At maximum tillering stage, available nitrogen in soil was higher than the initial value and it gradually decreased with the advancement of crop age.

Available phosphorus in maximum tillering stage is higher, which further increased up to panicle initiation and then decreased with crop age.

Various organic amendment and different level of NPK significantly influenced the available potassium content in the soil during all the growth stages. Available potassium decreased up to flowering stage, thereafter again increased during the harvest.

Based on above study following recommendations and conclusions can be done.

- Rice is most prominent crops cultivated by the indigenous farmers of this region. Abundant quantities of rice crop residue are available. Moreover, a huge amount of agricultural wastes both from other crops and from animals is available in entire Arunachal Pradesh. So, it may be recommended to incorporate the organic residues to the field by adopting efficient recycling mechanism.
Available crop residues and animal waste accumulated a huge amount of N, P and K. Therefore, it would be a good source of nutrients for crop production if recycled to the crop field by utilizing proper management practices.

Vermicompost is the most suitable way of compost preparation in terms of time and nutritional status. So, it might be recommended to the farmers to use ‘vermicompostig technique’ as a method of recycling of agricultural waste.

It is advisable to construct a non-tank vermicomposting unit (bamboo beam) by utilizing locally available materials and resources by spending less cost, which would be suitable for the resource poor farmers of this region.

Application of organic amendment and NPK together is better than only NPK application in terms of crop yield and improvement of soil physico-chemical properties.

Application of vermicompost irrespective of dosage gives better yield than the application of pure rice straw. So, this can be used effectively where there is a constraint for chemical fertilizers.

Application of vermicompost along with 50% chemical fertilizer gives better yield compared to 100 % NPK application alone. This showed that 50 % reduction of chemical fertilizer could be made if vermicompost is applied to the soil.

Incorporation of vermicompost alone gives better results compared to control and pure rice straw application. So, it may be recommended that vermicompost shall be applied in the soil instead of pure organic residue for getting better yield in the situation which completely depends on organic fertilizers.

Over all, the study recommends vermicomposting as an adaptive strategy to overcome the ill-effects of chemical fertilizers in the agro-ecosystems. This, if done, could viably enhance the scope of organic farming that could benefit the farmers from both ecology and economic perspectives. In order to get greater benefits of the crop residue recycling for soil nutrient enrichment, it is however
necessary to test a wider range of crop residues across different agro-ecosystems in varied agro-climatic regime to finalise and short-list recommended residues of the crops for wider application in the agro-ecosystems.