“INTEGRATED NUTRIENT MANAGEMENT OF CROPS BY USING AGRICULTURAL WASTE AND PLANT BIOMASS.”

"The farmer works the soil, the agriculturist works the farmer."

- Eugene F. Ware

India is basically an agriculture oriented country. About 70% of Indian population lives in villages and engaged in agricultural pursuits. Their livelihood depends mainly on agriculture therefore “agriculture is not only merely an occupation; it is the way of life which for centuries has shaped the thoughts and outlook of millions of peoples” (Jhingan 1976). Development of agriculture plays a predominant role in development and socio-economy of the country.

Modern Agriculture relies heavily on fertilizers, so the consumption of chemical fertilizer is increasing during passing years. The use of chemical fertilizer is the quickest way of boosting crop production. The chemicals no doubt increase the production, quantity and reduce the occurrence of diseases but also produce many harmful effects like air, water and soil pollution. The chemical fertilizers are manufactured by using coal and petroleum as a source of energy which themselves are decreasing very fast.

It is disturbing that farmers’ suicides which first caught the nation’s attention in the 1990s in a big way continue to occur in large numbers even today. According to official figures at least 2,70,940 farmers have taken their lives since 1995 and the trend that is discernible. There is a steady increase in farmers’ suicide over the years with a host of factors intensifying the pressure on them. (Online editorial article date 20 may 2013, Millennium post no half truths, New Delhi). To enhance more agricultural yield, farmers had to spend more money for buying pesticides, chemical fertilizers, some part of money is used for eradication of weeds and buying herbicides. Thus increasing production value of agricultural produce results in higher debt burden on farmers, falling prices of the product and rising cost of production squeezed the farmers even further debt and hence finally resulting into suicides. We can minimize cost of production, increase output per hectare by using plant biomass and agricultural wastes for the preparation of organic manures like compost, vermicompost, neem cake and biofertilizers like Azotobacter and phosphate solubilizing bacteria.

Continuous increased and imbalanced use of chemical fertilizer without adding adequate amount of organic manure is causing side effects on the soil like becoming more and more hard and impervious to water, decrease quality of the feed due to increasing total
nitrates and nitrites in the fodder and become toxic to live stock and human being (Jadhav and Joshi, 1982).

Enhancement and maintenance of soil fertility is a pre-requisite for increasing and sustaining the crop production. To sustain the agriculture, it becomes imperative to take care of soil health and environment. Sustainable crop production is possible when the natural resources on which the production activity depends is not eroded or harmed in any manner, which will damage it or jeopardize production and progress at any time in the future. Hence organic farming is the wise answer to the aforesaid problems (Bhattacharya and Pandey, 2004).

**Organic agriculture is natural in the Indian contest. It is not just a philosophy but is also a mean to stabilize our food products through maintenance of soil health and avoiding the use of hazardous chemicals, fertilizers and pesticides which are disturbing our ecosystem on large scale.** Organic farming means the use of biomass to increase, improve and maintain the soil fertility along with increase in the crop production.

The term **biomass** includes every organic matter derived biologically which include weeds, plant residues, wood and wood residue, leaf litter and animal manure. Since this type of biomass is a renewable source of organic carbon, there is no fear of its exhaustion by its continuous bioconversion into food, feed and fuel. The major part of biomass is drawn from the land and provides the primary energy source. Biomass is composed of mainly cellulose, hemicelluloses and lignin along with starch, protein and other useful nutrients. Recycling of biomass for the preparation of compost, vermicompost for increasing soil fertility has gained importance in recent years due to high cost of fertilizer.

Various organic sources of natural or organic fertilizers include residues from harvests, crop straw, stalk and vegetable matter and urban or kitchen wastes, brush woods and animal manures among others which makes these materials advantageous and they are always available (Tennakoon 1988).

**Weeds** are the terrestrial biomass available during monsoon. Weeds are the plants which grow in places where they are not wanted. They compete with agricultural crops for moisture, light, food nutrients and thus reduce the yield of main crops up to 20% to 70%. Weeds add the cost of cultivation, impair the quality as well as reduce the market value of the farm produce, harbour insects, fungal and viral pests that attack on crop plants. **Weeds form a crop of great potential value, it is highly productive crop that require no tillage, fertilizer, seed collection and cultivation.** Weeds occur in all types of soil and in all seasons along with the crops, on wet land, waste land and along with the road sides.
Noxious weeds are major barrier to food production and economic development. A weed in a general sense is a plant that is considered by the use of the term to be nuisance and normally applied to unwanted plants in human made settings. This lot of biomass which is considered as unwanted plants which infesting croplands, water bodies, woodlands, gardens, orchards, airfields, if we utilize this wasting biomass for the preparation of organic manure like compost and vermicompost, it will act as good resource of nutrients to the crop. *Achyranthes aspera* L.commonly known as aghada and *Tephrosia hamiltoni* Drumm. Unhali, *Cassia auriculata* L. Tarawad, are common invasive weeds in irrigated and dry areas growing along road sides and on waste land. In this research work these weeds have been used for the preparation of compost and vermicompost. In these experiments we are not using weeds which are used as cattle feed for grazing animals. When agricultural waste, tree leaves and weeds used for composting and vermicomposting, it will reduce the bulk and volume. Therefore our motto is to reduce, reuse and recycle wastes for effective, efficient and economical use of bio-resources for the preparation of compost and vermicompost which will give rugged, reliable, profitable and better solution for the maintenance of soil fertility and additional environment benefits that flow from compost use.

**Compost** is one of the nature’s best mulch and soil amendment which encourages organisms whose activity help plants to grow strong and healthy. It also provides nutrients and improves the soil. Compost can be prepared from cattle shade waste, agricultural waste, domestic waste and other waste from wet and waste land.

**Vermicomposting** is a simple biotechnological process of composting in which certain species of earthworms are used to enhance the process of waste conversion and produce a better end product (Gandhi *et al*, 1997). Vermitechnology is both ecologically and economically viable process and can be adopted least technically by a common man, it also plays a significant role in ecological soil management and organic waste recycling. Vermicompost will not only improve the soil fertility and water retention but also reduce the out lay on chemical fertilizers. **Earthworms** are able to convert even organic part of municipal solid waste into rich manure (modena, 1978; Talukdar and Goswami, 1995) They are also able to deodorize the composting process (Bhawalkar, 1992). While White and Frunkel (1994) say that though the earthworms are repulsive chain in energy flow in presence of them plant grows better than in their absence. Vermicomposting is the cost effective pollution abatement technology (Azarmi R. *et al*, 2008).

*Earth is here so kind, that just tickle her with a hoe and she laughs with a harvest*  
* - Douglas Jerrold
Various tree leaves and seed cakes are rich source of nutrients to the crops as like neem. **Neem cake** (*Azadirachta indica* A. Juss) is the residue of seed kernel left after extraction of oil. Neem seeds are produced in huge amount. Neem cake most frequently used and worked as satisfactory nematode control, often comparable to that obtained with chemicals. In a comparative study on the nematicidal efficacy of neem oil cakes against *Meloidogyne incognita* on tomato (Bhattacharya and Goswami; 1987) found a significant Improvement of plant growth for neem treatment over the nematicide.

The judicious combination of chemical fertilizers, organic manures and **biofertilizers** will worth avoiding the risk of non-renewable forms of energy and demerits of chemical fertilizers. **Azotobacter**, Azospirillum, Rhizobacteria etc. are important micro-organisms and are actively engaged in nitrogen fixing and supply of nitrogen nutrient to the plants. Next to nitrogen and phosphorus, micro-organisms also responsible to provide important nutrients for plant. The bacterial species belonging to the genera *Bacillus* and *Pseudomonas* possess the ability to bring insoluble phosphates in soil into soluble form by secreting organic acids like formic, acetic, propionic, lactic, glycolic, fumaric and succinic acid (Sathe T.V., 2004). Previous information about the biofertilizers is used in the experiments for sustainable agriculture by Bhat and Chauhan (2000). Balemi (2003) reported that inoculation of efficient *Azotobacter* strain (CDB-15) could save up to 50 per cent N fertilizers without significantly affecting plant growth and yield. At present researchers in agriculture, biological sciences, biochemistry, physiology, biotechnology and even genetic engineering taking interest in this widely emerging area of research.

Attempts were made to use different manures available in market as well as manures prepared from different weeds to increase yield and quality of crop by reducing input of chemical fertilizers and increasing the soil fertility for sustainable agriculture.

The thesis comprises following chapters.

Chapter I: Gives the brief introduction of the subject.

Chapter II: Dedicated to review of related research references named as “review of literature”

Chapter III: Dedicated to cover the topography of the region and meteorological records like temperature, humidity, rainfall, wind velocity, sunshine hours during experimentations etc.

Chapter IV: Gives information of weeds used for the preparation of Compost, Vermicompost, Neem cake, biofertilizers like Azotobacter, phosphate
solubilizing bacteria and information about crops used to study the effect of these fertilizers on its yield.

Chapter V: Study of the effect of different organic manures viz. Vermicompost, Neemcake and Biofertilizers on growth of *Vigna unguiculata* (L.) Walp. (Cowpea). Vermicompost have shown better results for Dry matter production and nutrient uptake as compare to NPK.

Chapter VI: has been devoted to Study of growth response of *Pennisetum glaucum* (L.) R. Br. (Bajara, Pearl millet) to organic manure. Vermicompost have shown better results for Dry matter production and nutrient uptake as compare to NPK.

Chapter VII: has been devoted to study the growth response of *Trigonella foenum-graecum* L. (Fenugreek) cultivated on compost (ATC) and vermicompost (ATV) prepared from *Achyranthes aspera* L. and *Tephrosia hamiltoni* Drumm. in 1:1 proportion, as well as neemcake + half dose of NPK, biofertilizers, Azotobacter and Phosphate solubilizing bacteria double dose with respect to recommended dose of NPK. Results have shown that increased yield and nutrient uptake in Biofertilizer, Weed Compost, Weed Vermicompost and Neem Cake were better as compare to NPK.

Chapter VIII: has been devoted to the study of growth response of *Raphanus sativus* L. (Radish) to weed compost (ATC) and weed vermicompost (ATV) manure prepared from *Achyranthes aspera* L. and *Tephrosia hamiltoni* Drumm. in 1:1 proportion as well as neemcake + half dose of NPK (NCCF), biofertilizers as Azotobacter and Phosphate solubilizing bacteria double dose with respect to NPK. The results have shown that the increased yield and nutrient uptake in Weed Vermicompost, weed compost, Neem cake and Biofertilizers over NPK.

Chapter IX: has been devoted to evaluate the performance of *Phaseolus aureus* Roxb. (Mung bean) to various manures like weed compost (ATCB) and weed vermicompost (ATVB) prepared from *Achyranthes aspera* L. and *Tephrosia hamiltoni* Drumm. in 1:1 proportion + biofertilizer 25 kg ha\(^{-1}\) to both treatment, as well as neemcake + 25 kg biofertilizer ha\(^{-1}\), biofertilizers Azotobacter and Phosphate solubilizing bacteria double dose viz. 50 kg ha\(^{-1}\) with respect to NPK and control. Grain yield was highest in Biofertilizer followed by Weed Vermicompost, Weed Compost and Neem Cake as compare to NPK. Total biomass production and nutrient uptake recorded
highest in Weed vermicompost, Weed compost, Biofertilizer and Neem Cake over NPK.

Chapter X: Gives detail information about growth response of *Vigna unguiculata* (L.) Walp. (Cowpea) to the different organic manures treatments like Cassia Weed Vermicompost + Biofertilizer, Cassia Weed Compost + Biofertilizer, Biofertilizer single dose, Biofertilizer double dose with respect to NPK and Control. Experiment was conducted in pot with three replicates. Observations were recorded the increased yield in Weed Vermicompost, Weed compost and Biofertilizer double dose over NPK.

Chapter XI: Consists of summary of the work undertaken by the author along with brief conclusion.

Chapter XII: Gives Bibliography at the end which covers the references cited in the text.

All the experimental results are presented in the form of tables, graphs and photographs. The data obtained has been statistically analyzed for obtaining useful conclusions. All experiments have shown better results for Weed Vermicompost and Biofertilizers as compare to other treatments.

Conclusions have been drawn from the present study are as:

1. Biofertilizers are a novel tool for agriculture
2. It has the ability to fix atmospheric nitrogen in the soil and make it available to the crops.
3. Biofertilizers enhance the nutrient availability to crop plants and impart better health to plants and soil thereby enhancing crop yields in a moderate way.
4. Biofertilizers have very good water holding capacity as compared to other manures.
5. Phosphate solubilizing microorganisms (PSMs) convert insoluble phosphates into soluble forms through the process of acidification, chelation, exchange reaction and production of gluconic acid
6. Neem cake was used as good supporting organic manure. 1000 kg ha$^{-1}$ along with half dose of NPK in radish and *Trigonella* proved better to increase yield but alone 5000 kg ha$^{-1}$ also can not compete with other fertilizer because it releases nitrogen very slowly it works better in long duration crop as sugarcane. Neem Cake in combination with Azotobacter and phosphate solubilizing bacteria significantly increase the grain yield in *Phaseolus aureus* (Mung) over control and NPK. Neemcake can be used in combination with NPK or biofertilizer.
7. Research has shown that neem tree (*Azadirachta indica* A.Juss) has pesticidal properties.

8. The Neem leaves act as a very good source of nutrients for crops along with boosting the Total reducing sugar content specially in maize and sugarcane in previous research.

9. Vermicompost available in market shows better results over NPK to increase yield of crop, reducing sugar, nitrogen and crude protein kg ha\(^{-1}\).

10. Weeds form a free crop of great potential value. A highly productive crop that requires no tillage, fertilizer, seed collection and cultivation. The weed biomass is an open treasure for crop plants which can be used as a nutrient source.

11. Weeds are undesirable plants but since they grow everywhere so freely and in abundance. Weeds are valued for increasing organic matter content and soil fertility, checking soil erosion, inducing soil formation. They can be used as food, feed and also have the medicinal values.

12. Green plant material benefits many soil characteristics including drainage, water retention, nutrient storage and level of microbiological activity in the soil and supplies soil organic matter.

13. Compost is the organic matter of the plant and animal origin. It offers a favourable medium for microbial activities in the soil. This is essential to maintain the fertility of soil. Compost provides many essential micro-nutrients which are not made available by any other chemical (inorganic) fertilizer.

14. The vermicompost is the rich source of plant nutrients and growth promoters. Vermicompost is not only the fertilizer but also reduces the use of chemical fertilizers and increasing the soil porosity, tilth, structure and water holding capacity of soil.

15. *Achyranthes aspera* and *Tephrosia hamiltoni* was successfully used as source of Compost and Vermicompost.

16. The application of *Achyranthes aspera* and *Tephrosia hamiltoni* mix weed Vermicompost (VC), Compost (COMP) and Biofertilizer performed better for Phaseolus and radish than that of other treatments and it acts as ideal substitute against inorganic fertilizers.

17. Biofertilizers and compost has been effectively used as a source of nutrients increasing yield of *Trigonella*, nutrient uptake with improvement in the soil fertility.
18. Bio-fertilizers in strict sense are not fertilizers which directly give nutrition to crop plants. These are cultures of micro-organisms like bacteria, fungi, packed in a carrier material.

19. The application of Vermicompost and Neemcake has been found ideal manure enhancing the yield of radish root vegetable. *Achyranthes aspera* and *Tephrosia hamiltoni* mix weed organic manures are highly advantageous, beneficial and profitable in successful crop production of radish and mung grain.

20. The application of Cassia vermicompost along with biofertilizer was more effective in increasing the growth and productivity of cowpea and better utilization of cassia weed.

21. Double dose of biofertilizers is the cheapest source of plant nutrients.

22. Vermicompost increases the growth rate because of water and mineral uptake such as nitrogen and phosphorus which lead to the biological yield improvement.

23. Organic manure is an alternative renewable source of nutrient supply and it can deliver agronomic and environmental benefits both through structural changes and tactical management of farming systems.

24. In organic farming systems pest and disease management strategies are largely preventative rather than reactive. In general pest and disease incidence is less severe in organic farms compared to conventional farms.

25. Application of organic manure reduces the dependence of the farmer on inorganic fertilizer use. It also reduces the exposure of the soil to the consequences of inorganic fertilizer application.

Organic agriculture offers comparative advantage in areas with less rainfall and relatively less soil fertility levels. Organic farming does not need costly investments in irrigation, energy and external inputs. By adopting organic agriculture farmers are challenged to take on new knowledge and perspectives and to innovate the farming system. This leads to an increased engagement in farming which can trigger greater opportunities for rural employment and economic fulfillment. Thus through greater emphasis on use of organic manures definitely contributes to the empowerment of financial status of farmers and local communities and will help to reduce suicide incidents of the farmer.