IMPACT OF SOIL AMENDMENT WITH ORGANIC WASTES ON GROWTH OF VEGETABLE CROPS IN IMPHAL WEST DISTRICT, MANIPUR

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DEPARTMENT OF ENVIRONMENTAL SCIENCE

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IMPACT OF SOIL AMENDMENT WITH ORGANIC WASTES ON GROWTH OF VEGETABLE CROPS IN IMPHAL WEST DISTRICT, MANIPUR

BY

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Submitted

in partial fulfillment of the requirement of the Degree of Doctor of Philosophy in Environmental Science of Mizoram University, Aizawl

DECLARATION

I, **Yaiphabi Akoijam**, hereby declare that the thesis entitled **"Impact of Soil Amendment with Organic Wastes on Growth of Vegetable Crops in Imphal West District, Manipur"** is a record of work done by me during 2015 to 2019 under the supervision and guidance of **Dr. Angom Sarjubala Devi,** Associate Professor, Department of Environmental Science, Mizoram University. The thesis is an authentic record of work done by me and that no part thereof has been presented for the award of any previous degree or to the best of my knowledge to anybody else, and it has not been submitted by me for any research degree in any other University/Institute.

The thesis is submitted to the Mizoram University for the degree of Doctor of Philosophy in Environmental Science.

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CERTIFICATE

This is to certify that **Yaiphabi Akoijam** has submitted the Ph.D. Thesis entitled, **"Impact of Soil Amendment with Organic Wastes on Growth of Vegetable Crops in Imphal West District, Manipur"** under my supervision, for the requirement of the award of the Degree and Doctor of Philosophy in the Department of Environmental Science, Mizoram University, Aizawl. The work is authentic, content of the thesis is the original work of the Research Scholar. It is further certified that the thesis or part thereof has not been submitted by her for any degree in Mizoram University or any other University or Institute. She is allowed to submit the thesis for the award of Doctor of Philosophy in Environmental Science.

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1. INTRODUCTION

Waste is generated from consumer based lifestyle (Hoornweg and Ghada, 2012), that are generated from all our daily activities in a large variety (European Information and Observation Network, 2013).

Large amounts of wastes are associated with environmental and public health problems. The reuse of wastes for agricultural purpose to improve soil properties and increase crop yield is a good solution for minimizing these problems. The organic waste of plant and animal origin provides a good source of nutrients to improve soil productivity.

Soils in many parts of the world are increasingly stressed from long-term cultivation practices, and the resulting losses of soil C are leading to inevitable degradations of soil structure (Clapp *et al.,* 2005). Organic matter can be added to soil by incorporating plant material, animal residues, manure, sewage sludge or municipal solid waste. These additions as well as the agricultural management practices can affect soil microbial communities. Changes in microbial communities can in turn influence soil fertility and plant growth by increasing nutrient availability and turn over, disease incidence or disease suppression (Pankhrust *et al*., 2005).

The organic matter content in soil can be increased by the addition of organic wastes (Achiba *et al*., 2010; Srivastava *et al*., 2016) such as municipal solid waste, food wastes, biowaste, manure, sewage sludge, etc. The quality of soil and improvement of soil health can be restored by incorporation of recycling organic wastes in the soil (Zhang *et al*., 2014).

Organic waste materials mainly plant or animal origin are potential sources of organic matter and plant nutrients. Traditionally, the waste materials are used as a source of nutritional elements and/or soil conditioner directly or indirectly in the field. The benefits derived from utilization of organic materials for improvement of soil fertility and crop production have been well discussed by many authors (Tandon, 1992; Tian *et al*., 1992; Maftoun *et al*., 2005; Bastida *et al*., 2008; Chaturvedi *et al*., 2009).

High organic matter content in soil has been associated with increase in water-holding capacity, cation-exchange capacity, aeration, and root depth as well as decrease in soil crusting and erosion (Parr *et al*., 1980; MacRae *et al*., 1985). Effects of compost on crop production can vary according to the feedstock, compost production methods, storage and use rates. (Wang *et al*., 1985; Vege-Sanchez *et al*., 1987; Diaz-Ravina *et al*., 1989).

Municipal solid waste compost with high organic matter content and low concentrations of inorganic and organic pollutants allow an improvement of physical, chemical, and biochemical characteristics and constitute low cost soil recovery (Lakhdar *et al*., 2009). The amount of organic wastes required to meet the crop nutrient need is high and therefore cannot be met by most farmers. Some of the materials are not easy to handle or apply and may produce unpleasant odour. Organic materials contain low levels of nutrients that are slowly released when applied to the soil. Processing of these wastes by composting will provide an opportunity to reduce bulk and odour, while increasing the nutritive values of materials (Gray and Briddlestone, 1981; FAO, 1987; Parr *et al*., 1986).

Supplementing the nutrient requirement of crops through organic fertilizers such as crop residues, manures and composts plays a key role in sustaining soil fertility and crop productivity.

The effect of composts on soil properties may be further modulated by soil type, that is, a sandy soil may respond differently to a compost than a clay soil. So, it is important to understand the relationship between compost properties and their effect on soils and plants for effective use of composts.

1.1 Amendment of organic waste

Using organic wastes, as soil amendments is an important alternative to land filling with benefits to soil structure, water retention, soil nutrient and organic matter concentrations. With the present global shift towards green energy production and utilization, there is need for emphasis on the economics, health and environmental benefits of proper utilization of decomposable waste as a resource that can be utilized (Egun, 2009).

Organic wastes should be stabilized using composting techniques before being applied to the soil. The use of composted organic wastes produces changes in soil physical, chemical and biological properties and can enhance plant growth after its application. However, the influence of C rich materials like municipal organic wastes compost, on soil physical, chemical and biological properties depend upon several factors, amount and components of added organic materials, soil type and weather conditions (Unsal, 2001 and Drozd, 2003).

Soil organic matter plays a crucial role in retaining nutrients, maintaining soil structure, and plant water availability. Soil organic matter content is strongly influenced by agricultural management practices with intensive cropping often leading to loss of soil organic matter. Cost and environmental risk associated with the use of chemical fertilizers have renewed the interest in using organic soil amendments such as plant residues, manures and composts.

The initial location of crop residues in soil, e.g. the presence or absence of mulch on the soil surface, or the spreading of fragments in the soil, modifies the physical, biological and chemical properties of soil, such as water content, temperature, O_2 content (Allmaras *et al.*, 2004), N content, pH and the composition of the decomposer community (Holland and Coleman, 1987).

Organic wastes of various origins can be added to the soil with the exclusive aim of eliminating refuse as well as that of exploiting this organic matter as a fertilizer. Addition of organic matter to soil through incorporation of plant residues or manure improves soil physical properties (Celik, *et al.*, 2004).

A balanced use of organic and mineral fertilizer could enhance stable soil chemical, physical and biological properties in addition to a large and rapid rate of nutrient turnover and high fertility status within the soil-plant system.

Current production systems for many vegetables have evolved in response to declining soil fertility, imbalances in soil nutrients and crop yields. Organic fertilizers have been reported to have beneficial effects on soil structure and nutrient availability; they help maintain yield and quality of product and are less costly than chemical fertilizers (Thy and Buntha, 2005).

Sustainable management of agricultural ecosystems requires incorporation of plant residue in soil. Compost is considered as a valuable fertilizer, supplying nutrients for the crop and hence saving substantial amounts of mineral fertilizer (Lillywhite *et al*., 2009; Odlare *et al*., 2011; Paterson *et al*., 2008).

Soil organic matter management is therefore very important for the development of a sustainable low-input agriculture system and for the improvement of soil quality (Ouedraogo *et al.*, 2001).

Amending the soil with suitable substrates helps in immobilization of heavy metals and thus reducing the uptake by plants. There is need to identify suitable soil amendments which can reduce heavy metal uptake and enhance yield.

1.2 Plantation of crops in wastes amended soil

Sustainable agriculture is, nowadays, an urgent requirement to minimize the environmental pollution that has increased as a result of inadequate agricultural practices including the extensive use of mineral fertilizers. Application of organic manures with fast nutrient release-characterizing mineral fertilizers have been advocated. The beneficial effects of this practice in terms of improved crop productivity, soil fertility and sustainability, and balanced plant nutrition have been reported (Rady, 2011a; Moyin-Jesu, 2015; Dotaniya *et al*., 2016; Kalaivanan and Hattab, 2016; Kumar and Chopra, 2016).

Agricultural organizations are trying to develop practices to reduce heavy metal uptake in food crops growing on contaminated sites or irrigated with wastewater. Improving soil quality with organic or inorganic amendments is a cost effective strategy to prevent transfer of heavy metals to the food chain (Mahar *et al*., 2015).

Many current farming practices exist where increased plant yield and productivity are obtained by amending the soil with a variety of organic amendments such as animal and/or plant manures (Bulluck and Tistaino, 2002; Li *et al*., 2000).

Crop production has been found to rise on addition of compost to cultivated land, with an effect at least comparable to that derived from the addition of more traditional organic fertilizers such as animal manure. The increase in crop productivity, though less marked and less immediate than that obtained with the addition of mineral fertilizers has been found to be long-lasting, probably due to more progressive release of the nutrients. Composts have been shown to be beneficial in fruit, vegetable and ornamental crop production (Roe, 1998; Titzpatrick *et al*., 1998).

Manure can maintain soil fertility in organic farming systems (Gopinath *et al*., 2009). The addition of municipal solid wastes and organic matter increased nutrient content, improved soil fertility and crop yield (Papafilippaki *et al*., 2015).

Organic matter contributes to plant growth through its effect on the physical, chemical and biological properties of the soil (Benito *et al*., 2005). It would be necessary to develop economically and environmentally suitable integrated nutrient management packages for sustaining the changing needs of intensive vegetable production. The improvement of soil quality is critical to sustaining agricultural productivity and has recently received much attention (Pulleman *et al*., 2000).

1.3 Scope and Objectives

Scope of the study – The disposal of organic waste is rapidly becoming one of the major unsolved problems in Manipur. The wastes are collected and disposed off in open dumping sites without any pre-treatment causing problems such as unhygienic condition and odour. Decomposition process creates a moist and humid environment for the growth of various insects and micro-organisms which can transmit communicable diseases.

Some fruits which have hard coverings are not easily decomposable and therefore persist in the environment for a long period of time and improper dumping can be a threat to environment. The peels of the pineapple which are available abundantly are being discarded off.

Fish wastes in Imphal are discarded off in large amounts as fish is one of the favourite food of Manipur. Flowers are a compulsion for religious activities in Manipur. Large amount of floral wastes are discarded off everyday due to frequent religious activities at homes and in temples.

The wastes can be utilized for sustainable management of agricultural ecosystems as well as wasteland which requires incorporation of plant residues in soil. Agricultural sector needs a secure, long-term supply of nutrients and organic matter to compensate losses (Marmo, 2003). Resources have to be recycled as much as possible for a sustainable development of society. Soil organic matter plays an important role in maintaining soil functions and to prevent the progress of some degradation soil processes. Soils need additional organic matter to support agricultural practices.

The present study therefore, was undertaken to assess the usability of sugarcane bagasse, fruit waste specially pineapple peels, fish wastes and floral waste as soil amendment since the wastes are available abundantly throughout the year. The study also undertakes the crop cultivation in the wastes amended soil so as to investigate whether these wastes can be effectively used in agricultural fields.

Objectives

The study envisaged the following objectives:

1. To determine the impact of soil amendment with organic wastes on mineral quality of soil.
2. To determine the impact of soil amendment with organic wastes on yield of selected vegetable crops.

1. MATERIALS AND METHODS

2.1 Study site

Earthen pot experiment was carried out in Dhanamanjuri College of Science, situated in Imphal West district. The Imphal West district has an area of 558 sq. km. situated at an elevation of 790m above mean sea level. It lies between $24^0 49'35''$ N to $24^0 49'40''$ N latitudes and $93^0 56'20''$ E to $93^0 56'50''$ E longitudes (Fig. A).

The district enjoys moderate temperature throughout the year. The district is under the influence of monsoons characterised by hot and humid rainy condition during summer and cool and dry condition during the winter. The annual rainfall ranged from 108.5 to 143.4 cm and average temperature was 20.4^0 C.

2.2 Experimental design

Wastes of sugarcane bagasse, pineapple, fish and flower were collected and air dried till constant weight and chopped into small pieces having sizes of 1 to 2cm. Amendment of each type of wastes were done in three pots. Three pots for control were also maintained. In total there were 15 pots.

The pots were filled up at a ratio of 50g of each type of wastes per kg of dried soil and kept for one month in order to let the wastes decompose. The soil waste mixture were watered regularly for complete decomposition. Watering was done after every three days with equal amount of half a liter of water.

Plate 1: Flower waste.

Plate2: Sugarcane bagasse.

2.3 Crop plantation

The following three types of seasonal crops were selected for detailed investigation: Saplings of the same growth stages were selected for each type of crops and planted in three pots for each control and wastes amendments.

1. Cabbage – *Brassica oleracea* planted during winter season: January, 2016 till March 2016.
2. Chilli - *Capsicum annum* planted during rainy season: June, 2016 till August, 2016.
3. Brinjal – *Solanum melongena* planted during summer season: March, 2017 till May, 2017.

The growth pattern on the basis of height and number of leaves were determined after every fifteen days for all the crops. Productivity of the crops were determined based upon the dry biomass and root length of tap root measured from the level of soil recorded after harvesting at the end of growing period. Completely randomized block design was used for the study.

2.4 Soil analysis

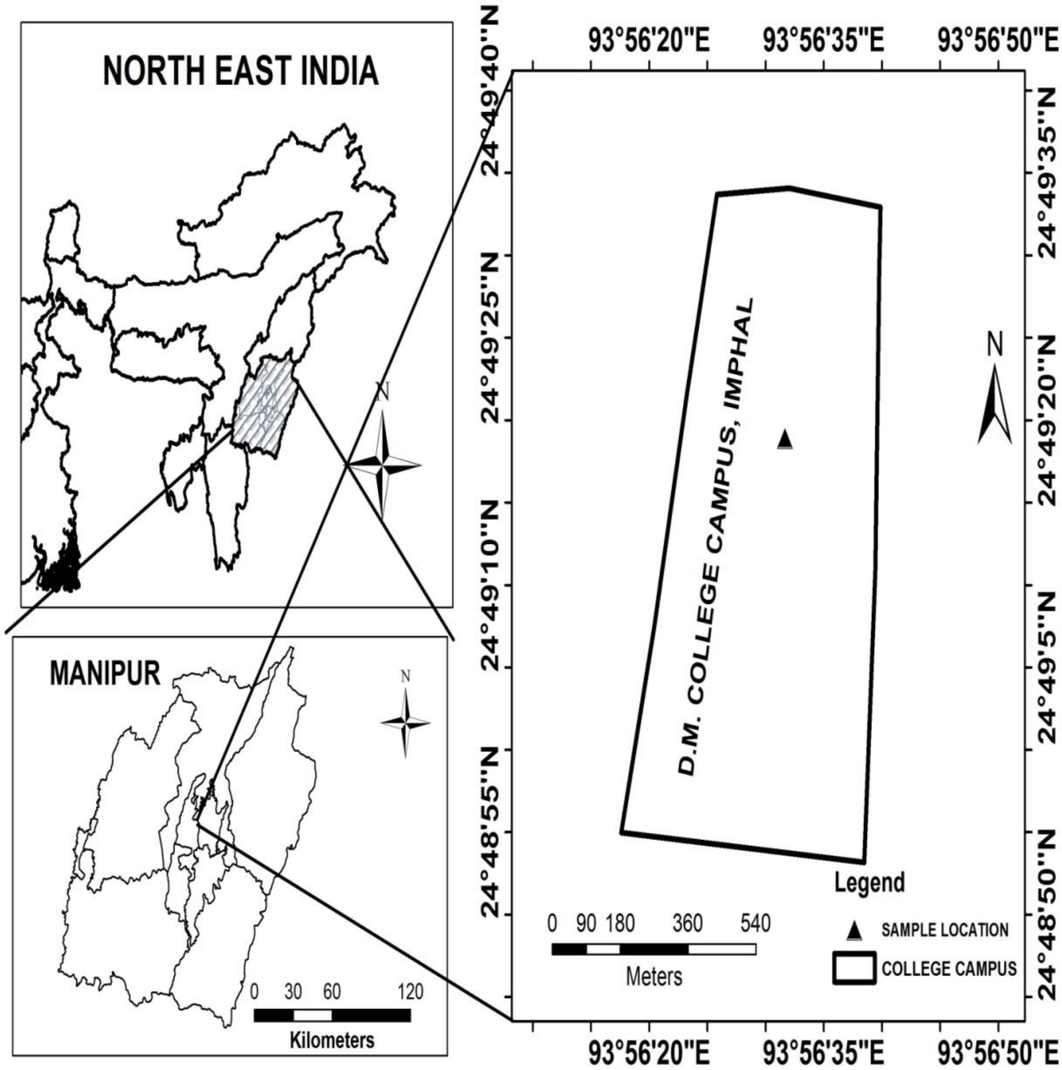
The soil samples from the different pots were collected every month and analysis were done for the following parameters: Soil pH by using pH meter, soil moisture content by using oven dry method, bulk density by using soil corer method,

Soil porosity from bulk density, organic C by following Walkley and Black's Rapid Dichromate Oxidation Method, total N by following Kjeldahl's Digestion Method, available P content by using Olsen's Method and exchangeable K by using Flame Photometer. All the analysis were done from Anderson and Ingram (1993).

2.5 Statistical analysis

The data computed were analysed by using SPSS in order to check the significance and validity of the results. Co-efficient of correlation was done to determine the inter- relationship between different parameters of soil and crop.

Fig. A. Location of study site.



2.6 Climate

The monthly rainfall varied from 0.5 (Jan.) to 737 mm (Sept.) during the year 2016. During 2017 it varied from 0.0 (Jan. and Dec.) to 803 mm (July) (Fig. B). The average minimum air temperature ranged from 7.8^{o}C (Jan.) to 21^{o}C (June) and average maximum air temperature ranged from 21^{o}C (Jan.) to 29^{o}C (April) (Fig. C) during the two years.

Fig. B. Monthly variation of rainfall (mm) during the years 2016 and 2017.

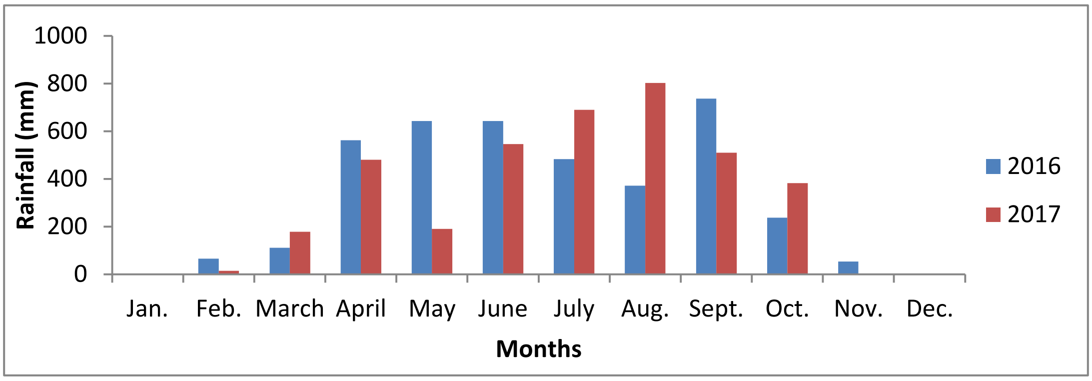
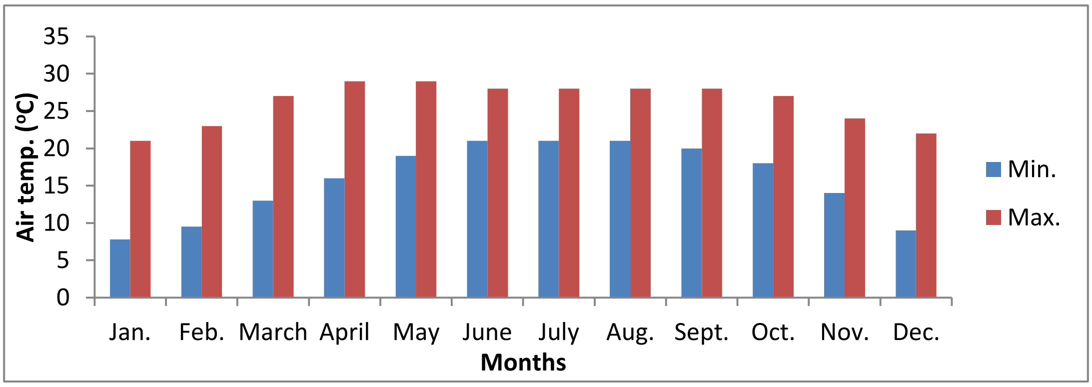


Fig. C. Average monthly variation of Air temperature (^{o} C) during the years 2016 and 2017.



2. REVIEW OF LITERATURE

Generation of solid wastes in urban as well as rural areas has increased manifold due to the increase in population and economic growth. With the diminishing availability of storage space for safe disposal of wastes, recycling of municipal wastes will not only contribute to solve our waste storage problems but could provide economical sources of organic soil amendments for crop production (Colin *et al*., 1997).

The growth and yield of tomato could be improved with amendment of food waste composts. The quality of tomato increased when compared to the other organic manures or only with chemical fertilizer. However, the mechanism of food wastes compost increases crop yield and quality and greater sodium content in food wastes compost treatment in restriction of crop growth, yield and quality needs further study.

Proper selection of wastes, soil and judicious management processes can avoid most of the potential problems. There is a need to examine the composition of wastes and properties before application of municipal solid waste into agricultural fields. Municipal solid waste can be considered as a valuable resource for use as a source of nutrients (Goswami and Sarma, 2008).

Addition of the composted soil amendments significantly increase soil pH, organic matter and available supplies of phosphate and magnesium in soil (Colin *et al*., 1997).

The general rise in temperature of the compost in the early stage of composting was caused by rapid mineralization of organic carbon and nitrogen in the presence of adequate aeration and moisture as required by microbes responsible for the breakdown of organic compounds. This probably would have generated reactions whereby CO_2 and heat were released into the compost system, therefore rising the temperature in the system (Edward, 1970; Foth, 1980).

The soil pH can also influence plant growth by its effect on activity of beneficial microorganisms. Bacteria that decompose soil organic matter are hindered in strong acid soils preventing organic matter from breaking down, resulting in an accumulation of organic matter and the tie up of nutrients, particularly nitrogen, that are held in the organic matter (Bickelhaupt, 2016).

The value of soil pH is directly influenced by all five soil-forming factors (parent rock, climatic conditions, organisms, topography and time) and further the value of soil pH is dependent on the season, way of management, tested soil horizon, soil water contents and time limit of sampling for analysis (Troeh and Thompson, 2005).

Soil water holding capacity is the amount of water that a given soil can hold for crop use. Soil texture and organic matter are the key components that determine soil water holding capacity. The larger the surface area, the higher is the water holding capacity. The water holding capacity for sand is low (Christina, 2011).

The physical, chemical, biochemical properties of soils improved in the plots amended with urban waste compost (Givsquiani *et al*., 1995; Maynard *et al*., 1995)

Organic matter decomposes faster in climates that are warm and humid and slower in cool, dry climates. Organic matter also decomposes faster when soil is well aerated (higher oxygen levels) and much slower on saturated wet soils. Soil organic matter generally increases where biomass production is higher where organic material additions occur. Excessive tillage destroys soil aggregates increasing the rate of soil organic matter decomposition. Soil organic matter decomposition is accelerated by measures that increase soil moisture, soil temperature and optimal aeration (USDA-NRCS, 2014a).

Bulk density which is an indicator of soil compaction affects infiltration, rooting depth, available water capacity, soil porosity and aeration, availability of nutrients for plant use and activity of soil micro-organisms, all of which influence key soil processes and productivity. Bulk density can be managed by using practices that minimize compaction, improve soil aggregation and increase soil organic matter content (USDA-NRCS, 2014b).

The effects of composts from various wastes on soil properties and crop production have been studied by several researchers. The wastes studied in composting includes municipal solid waste, sewage sludge or bio solids, coffee processing residues, fly and coal ash, pulp and paper sludge, newsprint, fish wastes, leaves and branches, sugarcane filter cakes, etc. (Beaver, 1994; Levanon *et al*., 1994; Maynard 1995; Giusquiani *et al*., 1995; Stoffella *et al*., 1996).

Organic and inorganic fertilizers applied to preceding crops has a remarkable residual effect on yield and yield contributing components of succeeding crop (Ramamurthy and Shivashankar, 1996). According to Ghosh (1980), the residual effect of green manure may double the yield of subsequent cereal crop. In another study, residual effect was equivalent to 20% of NPK as chemical fertilizers on the yield of succeeding wheat and winter maize in rice-wheat and rice-maize cropping systems (Prasad, 1994).

In nitrogen mineralization, the organic nitrogen contained in soil organic matter as well as freshly added crop residues is converted into plant-useable inorganic forms (ammonium and nitrate) as a result of the activities of soil micro-organisms (Deenik, 2006).

According to Sierra (2001), the resulting NH^{4+} may be oxidized to NO^{3-} through nitrification. In contrast to mineralization of organic N, micro-organisms use inorganic N to build up their bodies, resulting in N immobilization. Net N mineralization is the outcome of the two concurrent but opposite directed processes: gross n mineralization and gross N immobilization.

The ability of soil organisms to respire and cycle nitrogen can be interfered by poor aeration. If more than 80% of the pore space is filled with water, soil respiration declines to a minimum level and denitrification occurs. This results in loss of nitrogen as gases, emission of potent greenhouse gases, decreased yields, and an increased need for N fertilizer, which increases cost (USDA-NRCS, 2014b). According to Linn and Doran (1984), soil respiration and nitrogen cycling increase with the increasing soil moisture.

Nitrogen mineralization from litter and soil organic pools represent the vast majority of nitrogen inputs into non-leguminous terrestrial ecosystems (Grace and Merz, 2001). An additional source of mineral nitrogen may be added in the form of fertilizers in the case of managed crops, forests and grass pastures, which is either taken up directly by plants or may be assimilated by micro organisms during an immobilization event and possibly mineralized at a later date. The transformation of organic and mineral nitrogen through the mineralization and immobilization processes as described is therefore the main driver of carbon and nitrogen change in soils as it involves a wide range of substrates from litter and soil.

Crop residues may be incorporated partially or completely into the soil depending upon methods of cultivation (Dormaar and Carefoot, 1996). Incorporation of straw, unlike removal or burning, increases soil organic matter and soil nitrogen, phosphorus and potassium contents (Mandal *et al*., 2004).

Incorporated soyabean green manure could be used to substitute N fertilizer as first side dressing to tomato, but after eight weeks N fertilizer was required to obtain high yields (Thonnissen *et al*., 2000). According to Singh *et al*., (2004) incorporation of residues before planting of the next crop generally decreases yield due to nitrogen immobilization.

The experimental results of Kannan *et al*., (2015) clearly evidenced that poultry manure and rock phosphate combination compost increased the seed yield of blackgram more than poultry manure compost alone. The phosphor-poultry-manure compost application increased the soil available nutrients, especially more soil-available phosphate due to rock phosphate addition, and desirable soil physical changes were responsible for the yield increase in black gram. A similar response was also reported by Mishra and Bangar, (1986) through the combined use of rock phosphate with composted farm wastes.

The C:N ratio of plant residues is most often used as an index to assess whether the residues will release or immobilize inorganic nitrogen. According to Green *et al*., (1995), a number of researchers differently quoted different C:N ratios at which net mineralization and immobilization occur. When plant residues with C:N ratios greater than approximately 20 parts C to one part N are added to the soil, available N is immobilized during the first few weeks of decomposition (Green *et al*., 1995). It has also been observed that incorporation of corn stover into soil resulted in rapid immobilization of all available inorganic N during the rapid decomposition period (Green *et al*., 1995). They attributed this to the fact that the microbial population decomposing the plant residue had increased exponentially in response to the carbon source, essentially needing the nitrogen much like cattle require protein in a balanced feed ration.

According to Douglas *et al*., (1980), all of which incorporated straw, surface straw is often exposed to greater fluctuations in temperature and moisture and lower nutrient availability (may reduce microbial activity and, hence, the rate of decomposition). Leaving crop residues at the soil surface can reduce soil temperature and increase soil moisture, which in turn may restrict the decomposition of soil organic matter (Angers and Recous, 1997). However, Lal (2008) pointed out that any practice that involves removal of crop residues, leaving soil unprotected even for a short duration, would increase risks of accelerated erosion, depletion of soil organic carbon pool, disruption in cycling of nutrients, decline in activity and species diversity of soil fauna and flora, and decline in water retention capacity while jeopardizing the sustainable use of soil resources.

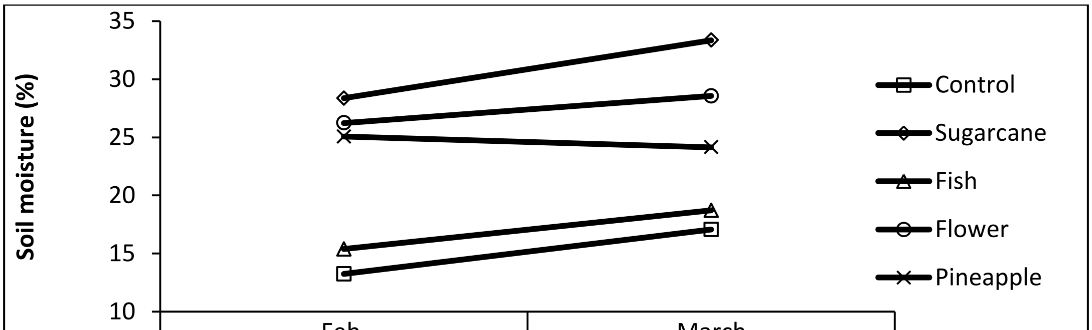
3. RESULTS AND DISCUSSION

4. A Cabbage (*Brassica oleraceae)*

4. A.1 Monthly variation

Soil moisture in the control (Fig.1.1) ranged from 12.63% (May) to 21.22% (April). In sugarcane waste amended pots, the soil moisture ranged from 27.5% (May) to 33.77% (April). Soil moisture in the fish waste amended pots ranged from 15.01% (April) to 18.3% (March). In flower waste amended pots, it ranged from 28.05% (April) to 30.84% (March). The soil moisture in pineapple waste amended pots ranged from 23.2% (May) to 24.66% (March). By comparing between the control and waste amendments there was an increase in level of soil moisture in the waste amended pots.

Fig.1.1. Monthly variation of soil moisture in the control and different amendments for cabbage.



	Feb.	March
Control	13.24	17.07
Sugarcane	28.36	33.36
Fish	15.39	18.72
Flower	26.23	28.56
Pineapple	25.06	24.15

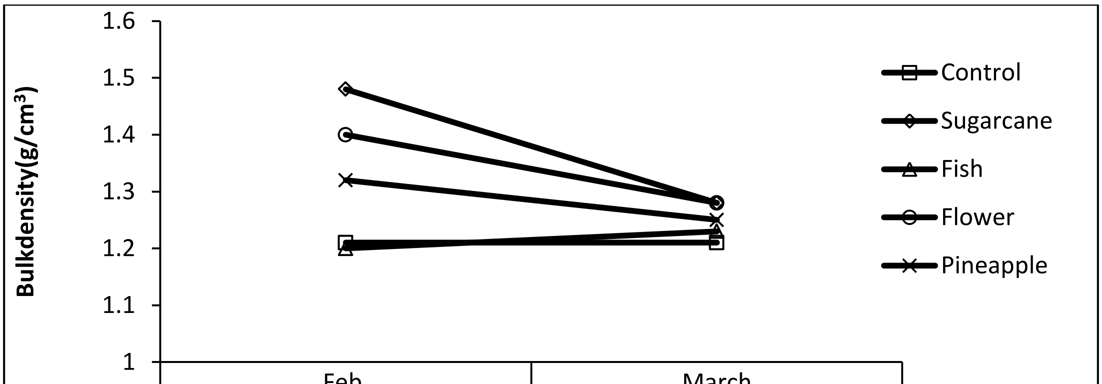
Plate 3. Growth of cabbage in first month.

Plate 4. Growth of cabbage in second month.

Plate 5. Growth of cabbage in third month.

Bulk density in control pots (Fig.1.2) was observed to be same in all the months (1.2 g/cm^3). The bulk density in the sugarcane waste amended pots ranged from 1.28 g/cm^3 (March) to 1.48 g/cm^3 (February). In the fish waste amended pots, it was observed to ranged from 1.2g/cm^3 (February) to 1.23 g/cm^3 (March). The bulk density in the flower waste amended pots ranged from 1.28 g/cm^3 (March) to 1.4 g/cm^3 (February). It was observed that the bulk density in pineapple waste amended pots ranged from 1.25 g/cm^3 (March) to 1.32 g/cm^3 (February). By comparing between the control and waste amendments there was increase in bulk density in all the amendments in both the months except in fish waste amended pots during February.

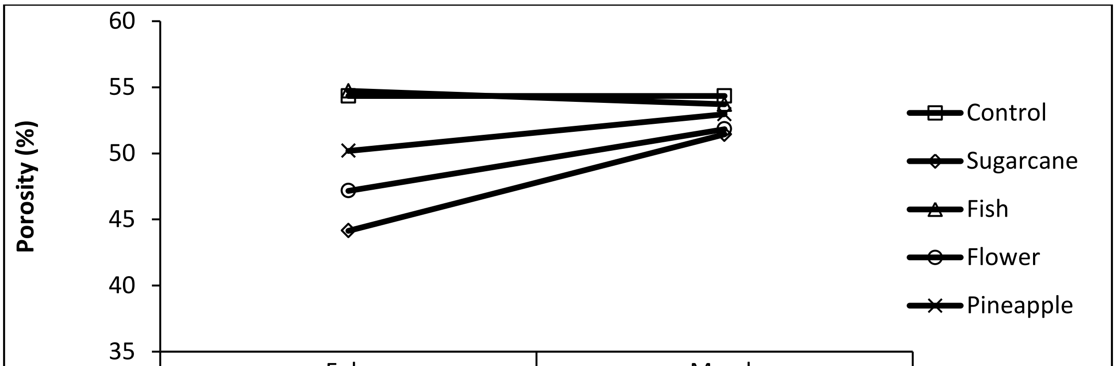
Fig.1.2. Monthly variation in bulk density of soil in the control and different amendments for cabbage.



	Feb.	March
Control	1.21	1.21
Sugarcane	1.48	1.28
Fish	1.2	1.23
Flower	1.4	1.28
Pineapple	1.32	1.25

Soil porosity in the control pots (Fig.1.3) was observed to be same in both the months (54.34%). The soil porosity in the sugarcane waste amended pots was found to ranged from 44.15% (February) to 51.44% (March, 2016). In the fish waste amended pots, it ranged from 53.71% (March) to 54.72% (February). Soil porosity in the flower waste amended pots ranged from 47.17% (February) to 51.83% (March). In the pineapple waste amended pots, it was observed to ranged from 50.19% (February) to 52.96% (March). In all the amendments soil porosity was found to increased in both the months except in fish waste amendment during the month of March.

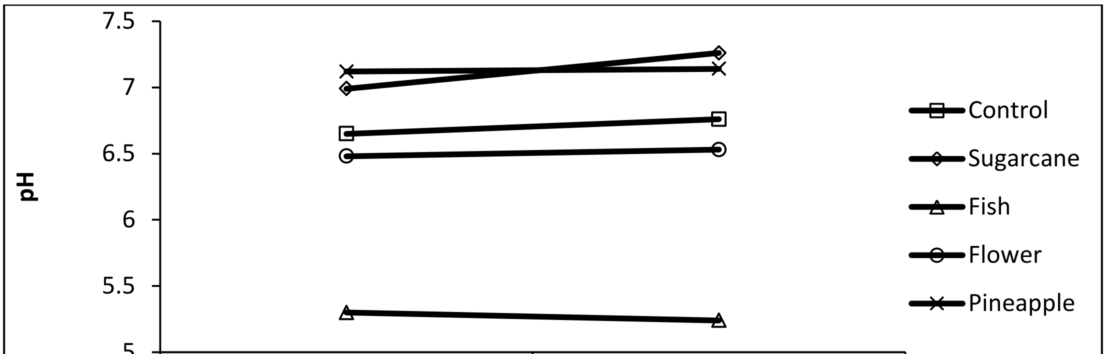
Fig.1.3. Monthly variation of soil porosity in the control and different amendments for cabbage .



	Feb.	March
Control	54.34	54.34
Sugarcane	44.15	51.44
Fish	54.72	53.71
Flower	47.17	51.83
Pineapple	50.19	52.96

The pH in the control pots (Fig.1.4) ranged from 6.65 (February, 2016) to 6.76 (March). In sugarcane waste amended pots, the pH was observed to range from 6.99 (February,) to 7.26 (March). Soil pH in the fish waste amended pots was recorded to vary from 5.24 (March) to 5.3 (February). In the flower waste amended pots it ranged from 6.48 (February) to 6.53 (March). In the pineapple waste amended pots, the pH was observed to ranged from 7.12 (February) to 7.14 (March). In the fish and flower wastes amendments there was a decline in pH level from control indicating more acidity of soil due to these wastes whereas in the flower and pineapple wastes amendments there was increase in pH level from control (Table 8).

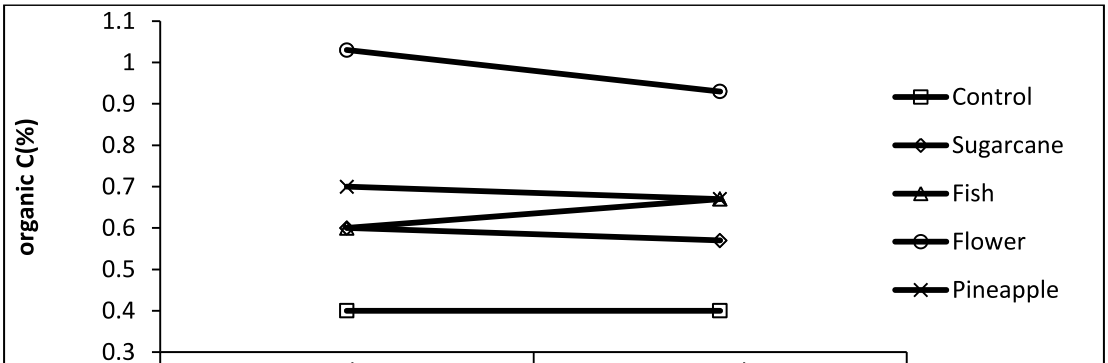
Fig.1.4. Monthly variation of pH in the control and different amendments for cabbage.



	Feb.	March
Control	6.65	6.76
Sugarcane	6.99	7.26
Fish	5.3	5.24
Flower	6.48	6.53
Pineapple	7.12	7.14

In the control pots, the organic C (Fig.1.5) was found to be same in all the months (0.4% in February and March). Sugarcane waste amended pots ranged from 0.57% (March) to 0.6% (Feb.). Organic C in the fish waste amended pots was observed to ranged from 0.6% (February, 2016) to 0.67% (March). In flower waste amended pots the range of organic C was from 0.93% (March) to 1.03% (February). The organic C in the pineapple waste amended pots was observed to ranged from 0.67% (March) to 0.7% (February). By comparing between control and wastes amendments there was an overall increase in the level of organic C in all the amendments.

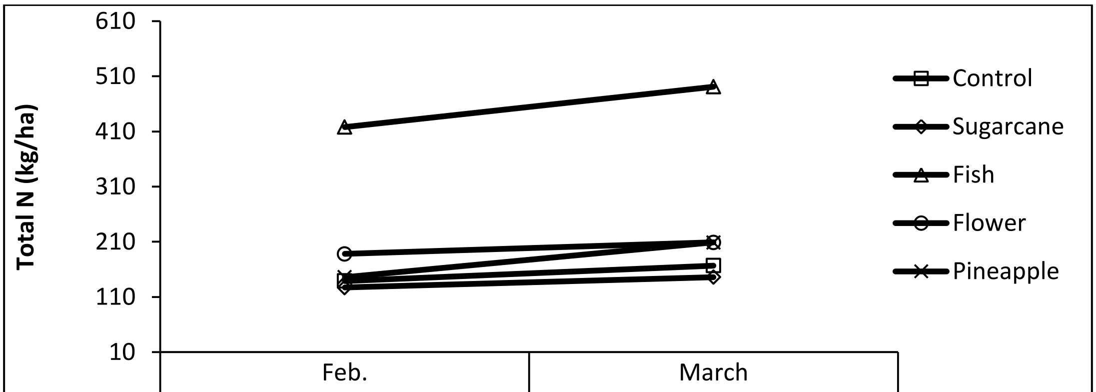
Fig.1.5. Monthly variation of soil organic carbon in the control and different amendments for cabbage.



	Feb.	March
Control	0.4	0.4
Sugarcane	0.6	0.57
Fish	0.6	0.67
Flower	1.03	0.93
Pineapple	0.7	0.67

The range of total N in the control pot (Fig. 1.6) was observed to be from 139 kg/ha (February) to 167 kg/ha (March). Total N in the sugarcane waste amended pots ranged from 127 kg/ha (February) to 146 kg/ha (March). It was observed that the N in the fish waste amended pots varied from 418 kg/ha (March) to 491 kg/ha (February). The range of total N in the flower waste amended pots was from 188 kg/ha (February) to 209 kg/ha (March). Total N in the pineapple waste amended pots ranged from 146 kg/ha (February) to 209 kg/ha (March). By comparing between control and wastes amendments there was an overall increase in the level of total N in all the amendments. However in sugarcane waste amendment there was a decline from the control.

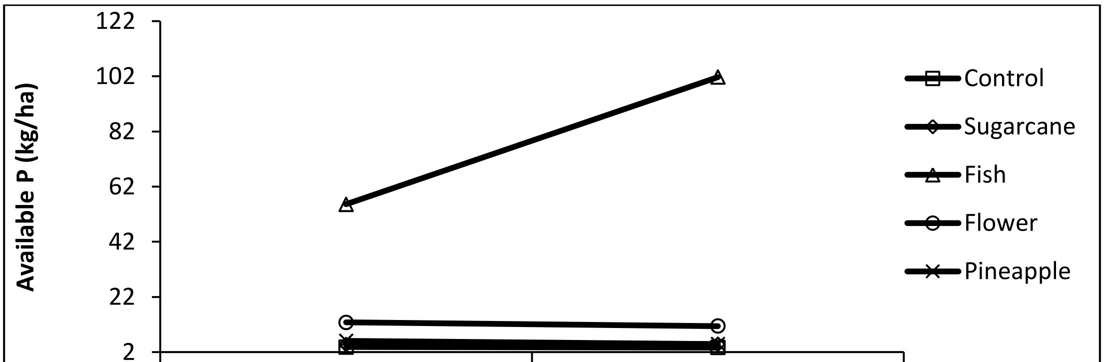
Fig. 1.6. Monthly variation of total N of soil in the control and different amendments for cabbage.



	Feb.	March
Control	139	167
Sugarcane	127	146
Fish	418	491
Flower	188	209
Pineapple	146	209

Available P (Fig. 1.7) was observed to ranged from 3.7 kg/ha (March) to 3.87 kg/ha (February) in the control pots. In the sugarcane waste amended pots, available P ranged from 4.77 kg/ha (February) to 4.87 kg/ha (March). Available P ranged from 55.6 kg/ha (February) to 101.7 kg/ha (March) in the fish waste amended pots. In the flower waste amended pots the range of the available P was from 11.47 kg/ha (March) to 12.77 kg/ha (February). The available P in the pineapple waste amended pots ranged from 4.93 kg/ha (March) to 6.13 kg/ha (February). In all the wastes amendments available P increased from the control.

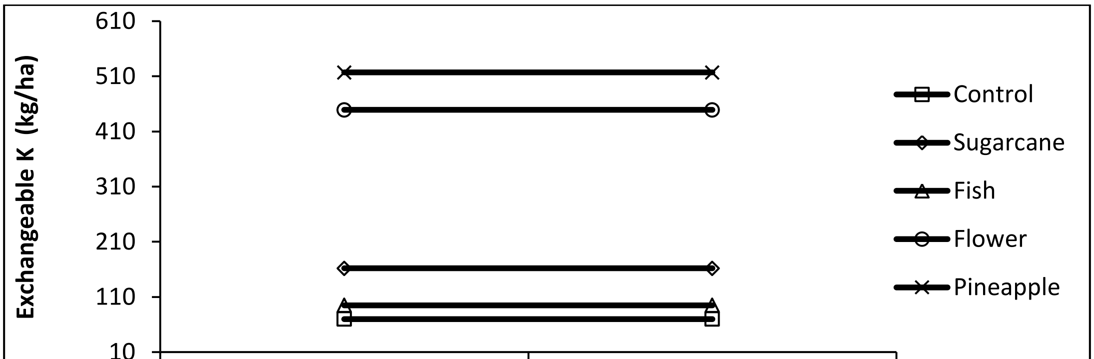
Fig.1.7. Monthly variation of available soil P in the control and different amendments for cabbage.



	Feb.	March
Control	3.87	3.7
Sugarcane	4.77	4.87
Fish	55.6	101.7
Flower	12.77	11.47
Pineapple	6.13	4.93

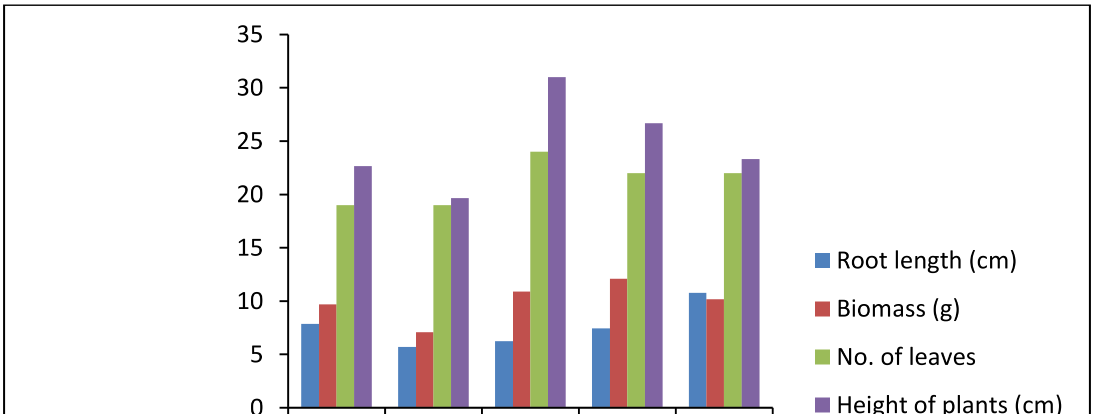
Exchangeable K in the control pots (Fig. 1.8) was observed to be in the same range (70 kg/ha in February and March). In sugarcane waste amended pots the range of the exchangeable K remained the same (162 kg/ha). Exchangeable K in the fish waste amended pots was observed to be same in both the months (95 kg/ha). The range of exchangeable K in the flower waste amended pots was also observed to be in the same range (449 kg/ha in February and March). The exchangeable K in the pineapple waste amended pots in both the months was also observed to be in the same range (517 kg/ha). In all the wastes amendments exchangeable K increased from the control.

Fig. 1.8.Monthly variation of exchangeable K in the control and different amendments for cabbage.



	Feb.	March
Control	70	70
Sugarcane	162	162
Fish	95	95
Flower	449	449
Pineapple	517	517

Fig.1.9. Monthly variation of characteristics of cabbage in the control and different amendments.



	Control	Sugarcane	Fish	Flower	Pineapp.
Root length (cm)	7.87	5.7	6.23	7.43	10.77
Biomass (g)	9.7	7.07	10.9	12.1	10.17
No. of leaves	19	19	24	22	22
Height of plants (cm)	22.67	19.67	31	26.67	23.33

4. A.2 Anova

Analysis of variance in soil moisture (Table 1.1 and 1.2) for all the amendments showed significant variation in sugarcane waste amended pots (F=6.957; P<0.05) and pineapple waste amended pots (F=4.644; P<0.05). Significant variation was not observed in control, fish and flower wastes amendments.

Table 1: Anova for soil moisture in the different amendments for cabbage.

Table 1.1. Sugarcane waste amendment.

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	37.50	1	37.50	6.95	P<0.05
Within Groups	21.56	4	5.39		
Total	59.06	5			

Table 1.2. Pineapple waste amendment.

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	13.50	1	13.50	4.64	P<0.05
Within Groups	11.62	4	2.90		
Total	25.12	5			

No significant variation of bulk density was observed in control and the wastes amended pots for bulk density. Significant variation of the soil porosity was observed only in the sugarcane wastes amended pots (F=7.716; P<0.05) (Table 2.1).

Table 2: Anova for soil porosity in the different amendments for cabbage.

Table 2.1. Sugarcane waste amendment.

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	79.78	1	79.78	7.71	P<0.05
Within Groups	41.36	4	10.34		
Total	121.15	5			

Analysis of variance in soil pH showed significant variation in the control, sugarcane waste amended pots and the flower waste amended pots (Table 3.1 to 3.3).

Table 3 Anova for soil pH in the control and different amendments for cabbage.

Table3.1: Control

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.02	1	0.02	3.86	P<0.05
Within Groups	0.02	4	0.005		
Total	0.04	5			

Table 3.2: Sugarcane waste amendment.

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.11	1	0.11	4.36	P<0.05
Within Groups	0.10	4	0.03		
Total	0.21	5			

Table 3.3: Flower waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.050	1	0.050	2.410	P<0.05
Within Groups	0.084	4	0.021		
Total	0.134	5			

Significant variation of organic C was observed in the fish waste amended pots (Table 4.1).

Table 4: Anova for organic C in the different amendments for cabbage.

Table 4.1: Fish waste amendment.

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.015	1	0.015	4.500	P<0.05
Within Groups	0.013	4	0.003		
Total	0.028	5			

Significant variation of total N was observed only in the pineapple waste amended pots (F=9.694 ; P<0.05) (Table 5.1).

Table 5: Anova for soil total N in the different amendments for cabbage.

Table 5.1: Pineapple waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	8066.66	1	8066.66	9.69	P<0.05
Within Groups	3328.66	4	832.16		
Total	11395.33	5			

Significant variation of the available P was observed only in fish waste amended pots (F=76.963; P<0.05) (Table 6.1). No significant variation was observed for exchangeable K.

Table 6: Anova for soil available P in the different amendments for cabbage.

Table 6.1: Fish waste amendment.

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	3187.81	1	3187.81	76.96	P<0.01
Within Groups	165.68	4	41.42		
Total	3353.49	5			

4. A.3 Correlation

It was also observed that soil moisture was not correlated with any of the characteristics of the crops (Table 7.1). Significant correlation was also not observed for bulk density and porosity with crop characteristics. Soil pH was found to be significantly and negatively correlated with all the characteristics except the root length (Table 7.2). The regression lines for the significant correlation were also shown in Figs. a, b and c.

Organic C was found to be significantly correlated with all the characteristics of the plants except the root length (Table 7.3). The regression lines for the significant correlation were also shown in Figs. d, e and f. Total N was observed to be significantly correlated with the height of the plants and the no. of leaves (Table 7.4). The regression lines for the significant correlation were also shown in Figs. g and h. Available P was found to be significantly and positively correlated with the height of the plant and the no. of leaves (Table 7.5). The regression lines for the significant correlation were also shown in Figs. i and j. Exchangeable K was found to be positively and significantly correlated only with the root length (Table 7.6). The regression lines for the significant correlation were also shown in Fig. k.

Table7 .1: Correlation (r, n=5) between soil moisture and characteristics of the crop cabbage.

	Soil moisture (%)	Height of plant (cm)	No. of leaves	Root length (cm)
Soil moisture (%)	1			
Height of plant (cm)	-0.35	1		
No. of leaves	-0.09	0.95	1	
Root length (cm)	-0.04	-0.16	0.23	1
Wt. of dried plants (g)	-0.32	0.86	0.74	0.28

Due to amendment of the wastes the growth of cabbage was regulated. Significant positive correlation of plant height and number of leaves with organic C, N and P showed that amendment of the present types of wastes does not pose any negative effect on cabbage.

Table 7.2: Correlation (r, n=5) between pH and characteristics of cabbage along with the regression charts (Figs. a, b and c).

	pH
pH	1
Height of plant (cm)	-0.81
No. of leaves	-0.73
Root length (cm)	0.42
Wt. of dried plants (gm)	-0.48

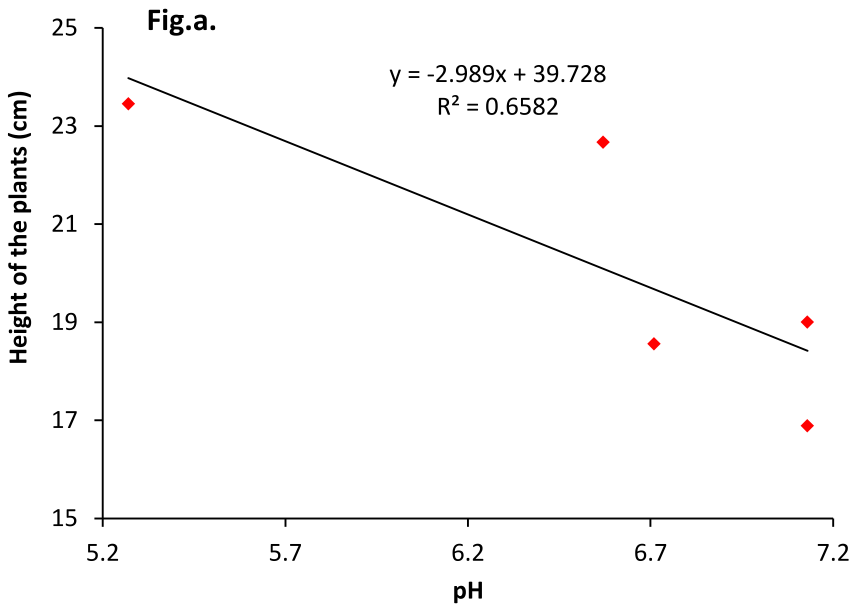


Fig.a.
y = -2.989x + 39.728
R² = 0.6582
Height of the plants (cm)
25
23
21
19
17
15
5.2
5.7
6.2
6.7
7.2
pH

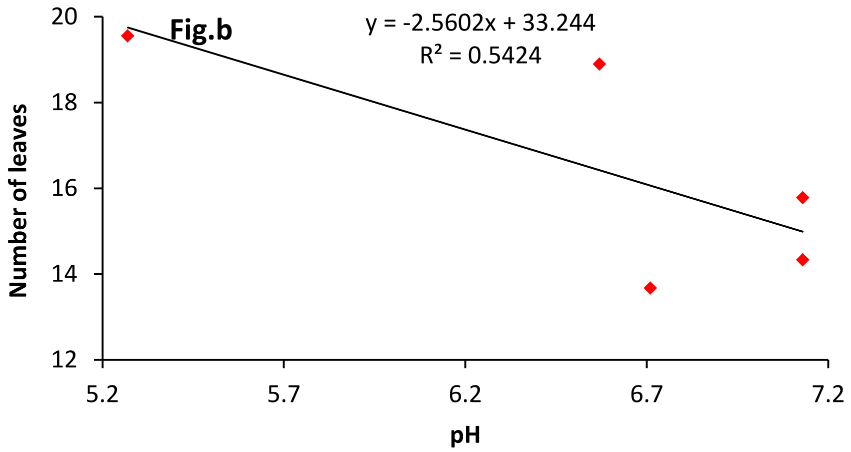


Fig.b
y = -2.5602x + 33.244
R² = 0.5424
Number of leaves
20
18
16
14
12
5.2
5.7
6.2
6.7
7.2
pH

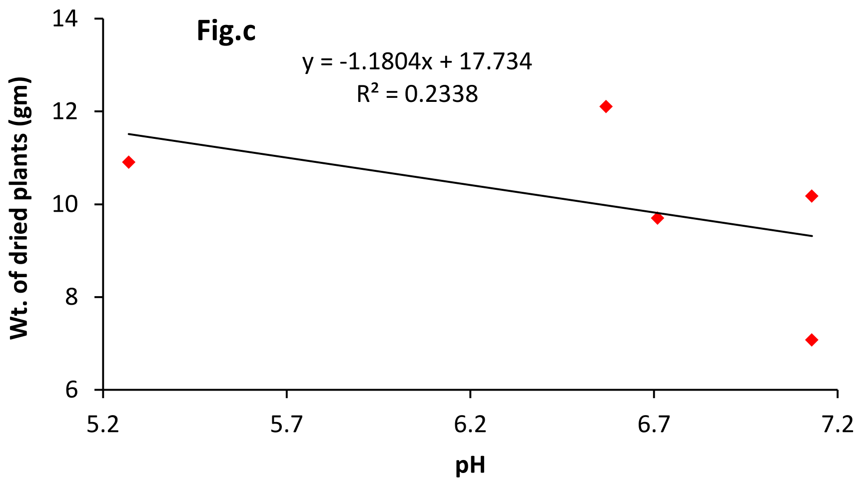
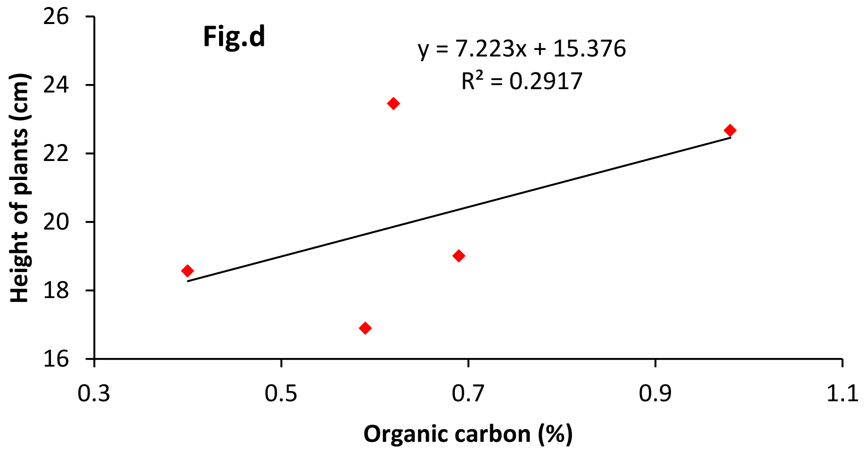
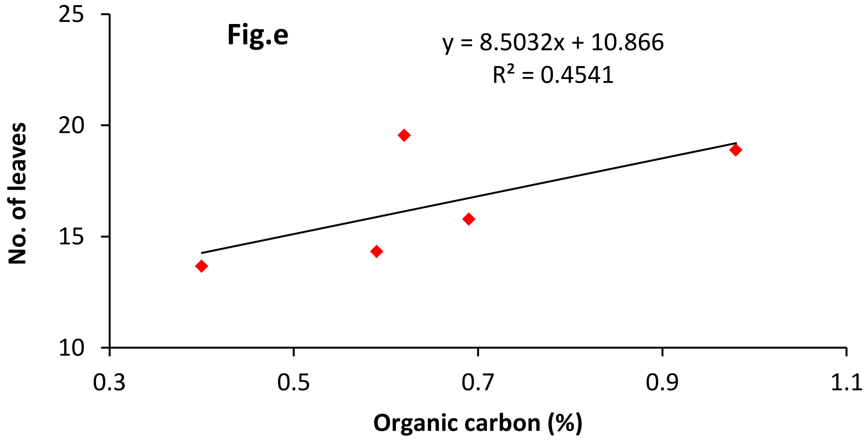


Fig.c
y = -1.1804x + 17.734
R² = 0.2338
Wt. of dried plants (gm)
14
12
10
8
6
5.2
5.7
6.2
6.7
7.2
pH

Table 7.3: Correlation (r, n=5) between organic C and characteristics of cabbage along with the regression charts (Fig. d, e and f).

	Organic C
Organic C (%)	1
Height of plant (cm)	0.54
No. of leaves	0.67
Root length (cm)	0.01
Wt. of dried plants (g)	0.58





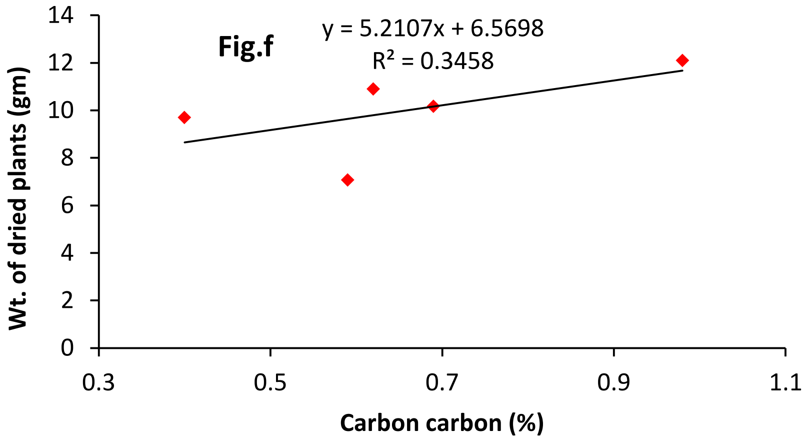
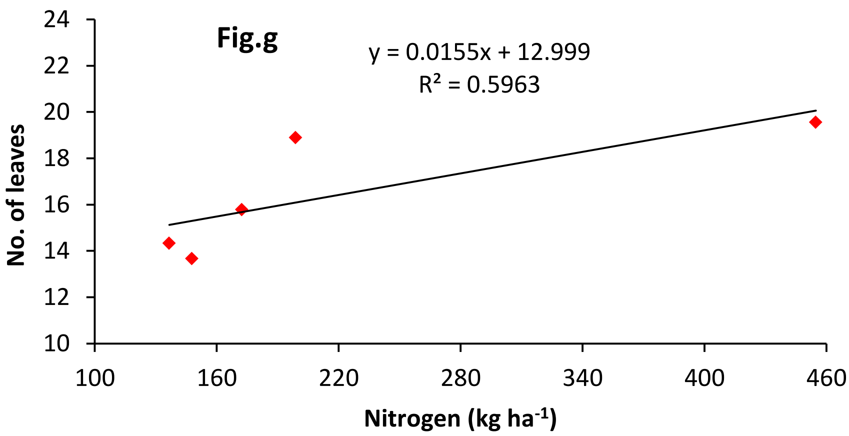


Table 7.4: Correlation (r, n=5) between total N and characteristics of cabbage along with the regression charts (Fig. g and h).

	Total N (kg/ha)
Total N (kg/ha)	1
Height of plant (cm)	0.78
No. of leaves	0.77
Root Length (cm)	-0.35
Wt. of dried plants (g)	0.43



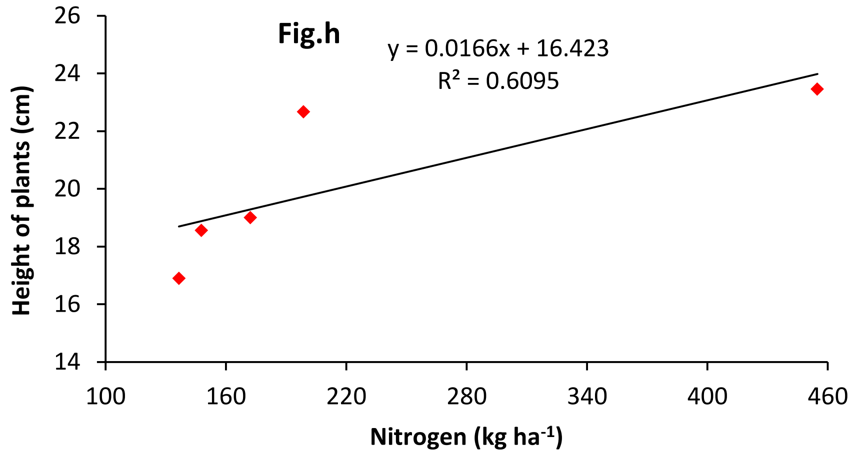
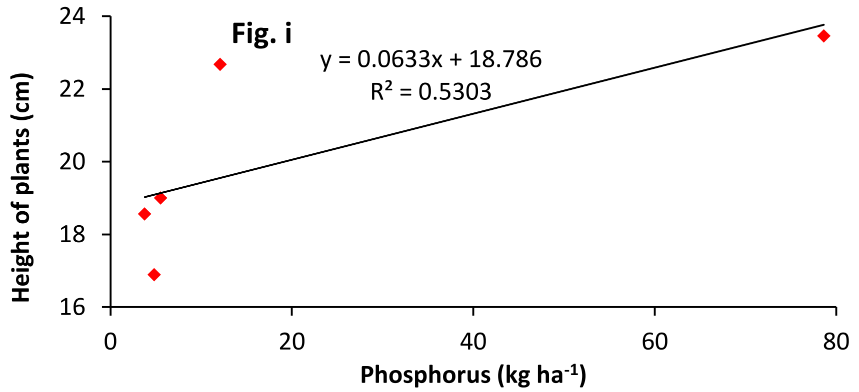


Table 7.5: Correlation (r, n=5) between available P and characteristics of cabbage along with the regression charts (Fig. i and j).

	Available P (Kg/ha)
Available P (kg/ha)	1
Height of plant (cm)	0.72
No. of leaves	0.72
Root Length (cm)	-0.42
Wt. of dried plants (g)	0.34



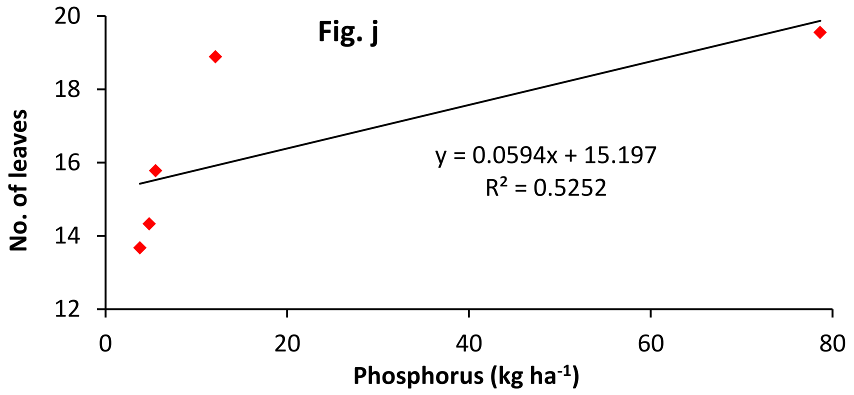
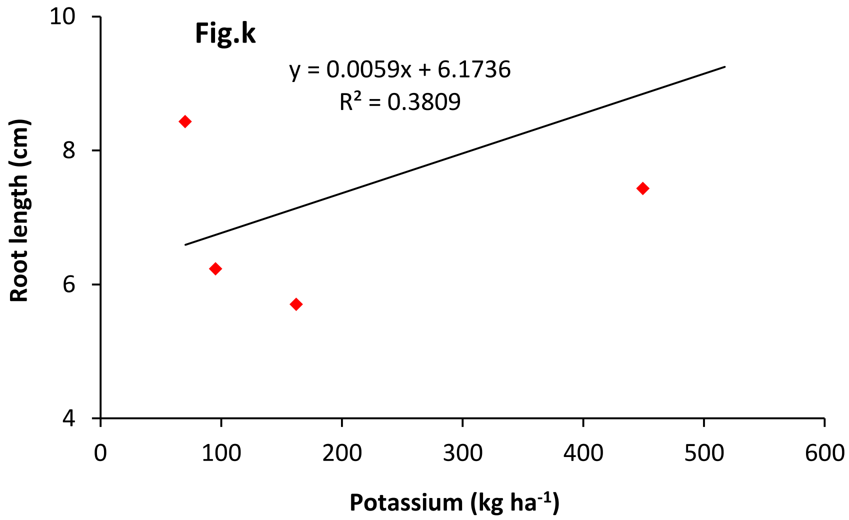


Table 7.6: Correlation (r, n=5) between exchangeable K and characteristics cabbage along with the regression chart (Fig.k).

	Exchangeable K (kg/ha)
Exchangeable K (kg/ha)	1
Height of plant (cm)	0.10
No. of leaves	0.23
Root Length (cm)	0.61
Wt. of dried plants (g)	0.40



The graphical representation of soil moisture with reference to height, number of leaves, root length and biomass of cabbage were given in Figs. 2.1 to 2.4.

Fig.2.1: Graphical representation of height of plant with respect to soil moisture.

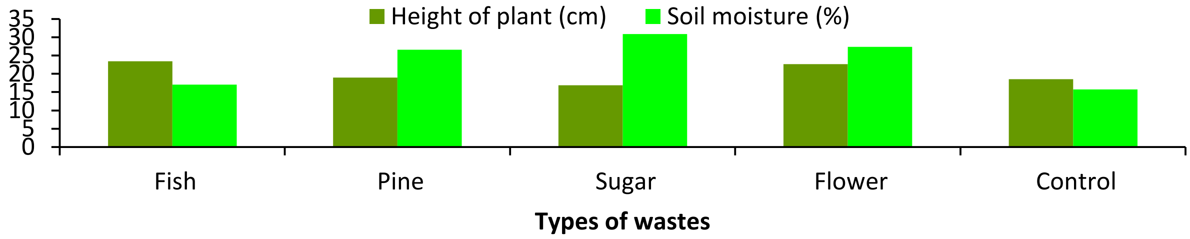


Fig.2.2: Graphical representation of no. of leaves with respect to soil moisture.

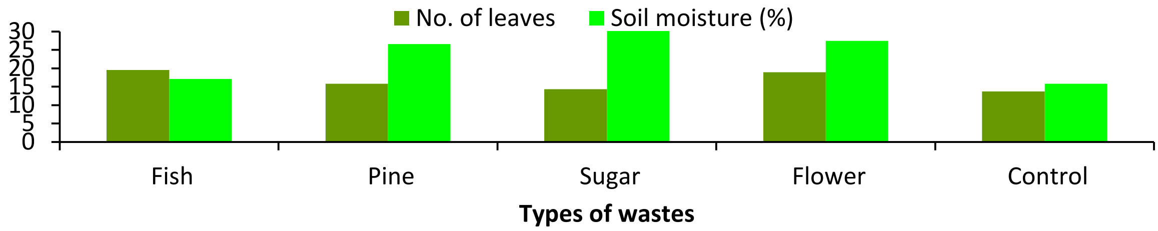


Fig.2.3: Graphical representation of root length with respect to soil moisture.

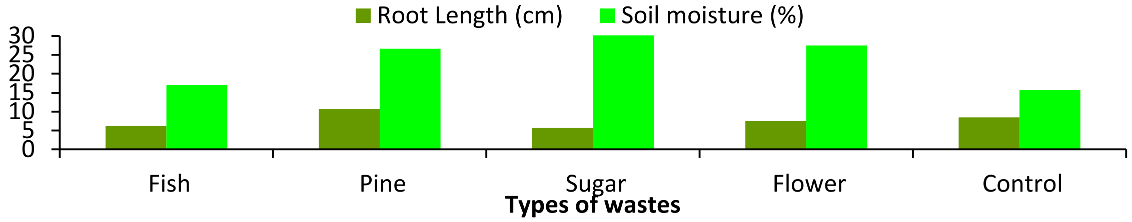
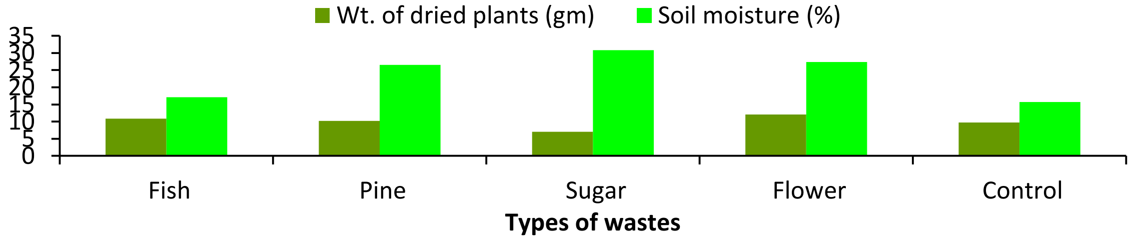


Fig.2.4: Graphical representation of biomass with respect to soil moisture.



The graphical representation of soil porosity with reference to height, number of leaves, root length and biomass of cabbage were given in Figs. 3.1 to 3.4.

Fig.3.1: Graphical representation of height of plant with respect to soil porosity.

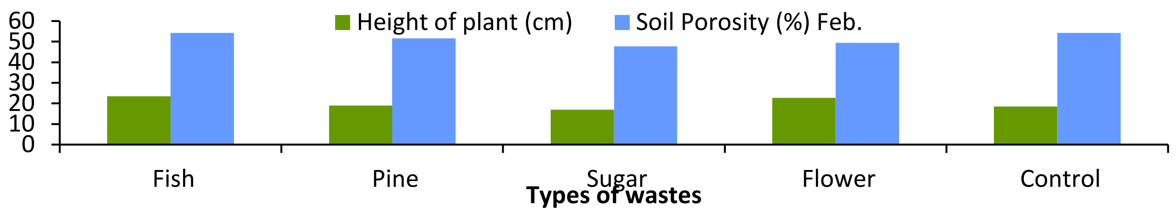


Fig.3.2: Graphical representation of no. of leaves with respect to soil porosity.

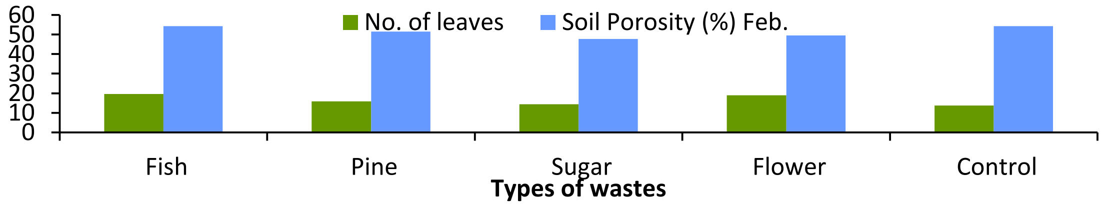


Fig.3.3: Graphical representation of root length with respect to soil porosity.

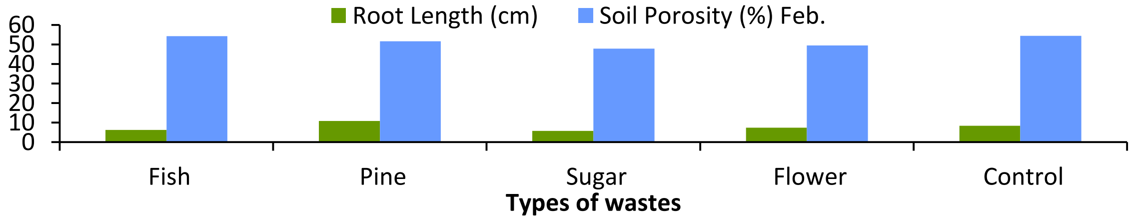
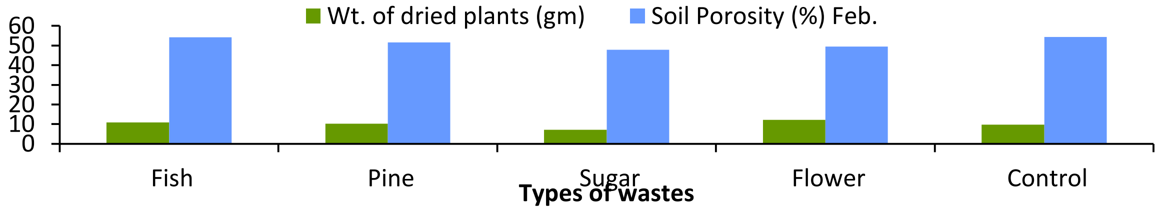


Fig.3.4: Graphical representation of biomass with respect to soil porosity.



The graphical representation of pH with reference to height, number of leaves, root length and biomass of cabbage were given in Figs. 4.1 to 4.4.

Fig.4.1: Graphical representation of height of plant with respect to pH.

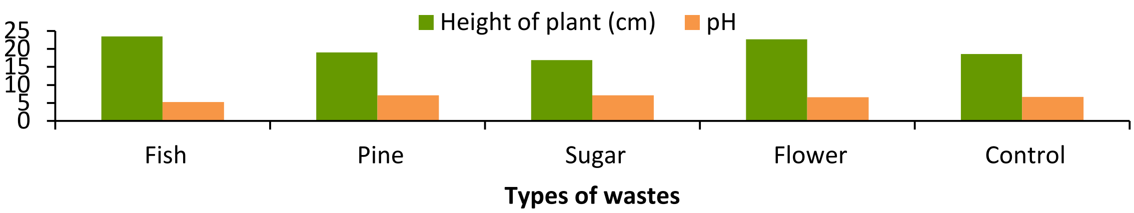


Fig.4.2: Graphical representation of no. of leaves with respect to pH.

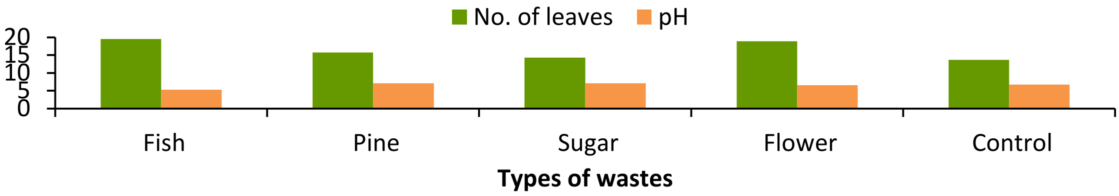


Fig.4.3: Graphical representation of root length with respect to pH.

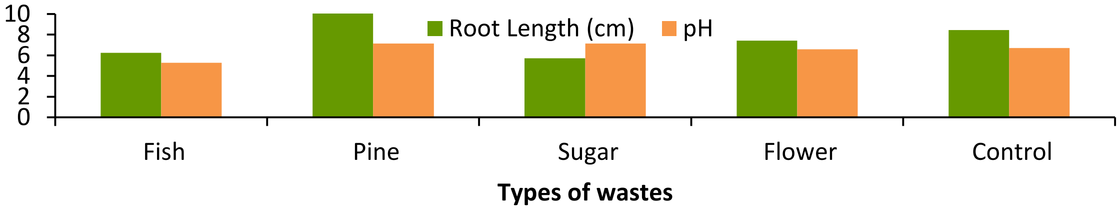
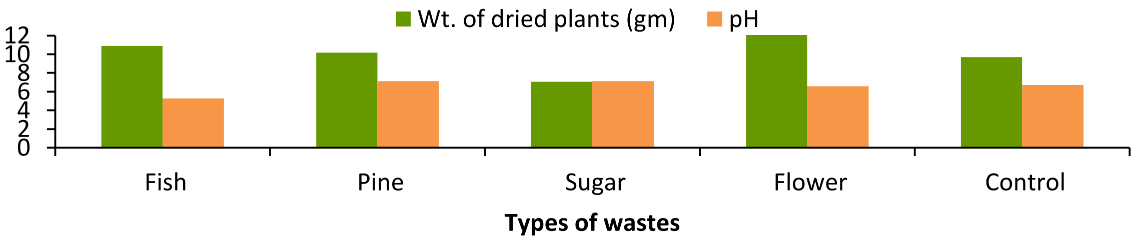


Fig.4.4: Graphical representation of biomass with respect to pH.



The graphical representation of organic C with reference to height, number of leaves, root length and biomass of cabbage were given in Figs. 5.1 to 5.4.

Fig.5.1: Graphical representation height of plant with respect to organic C.

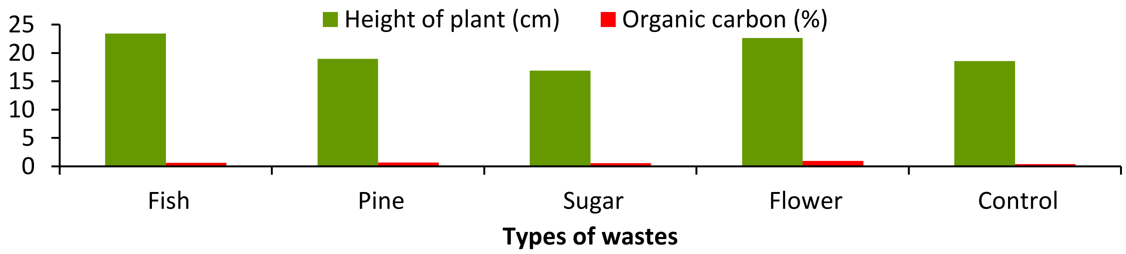


Fig.5.2: Graphical representation height of plant with respect to organic C.

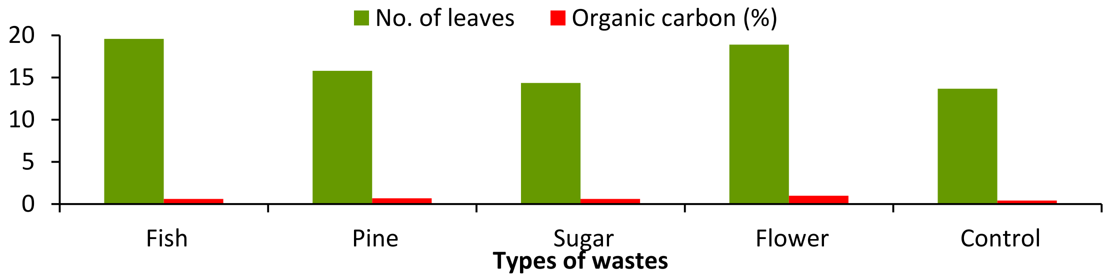


Fig.5.3: Graphical representation root length with respect to organic C.

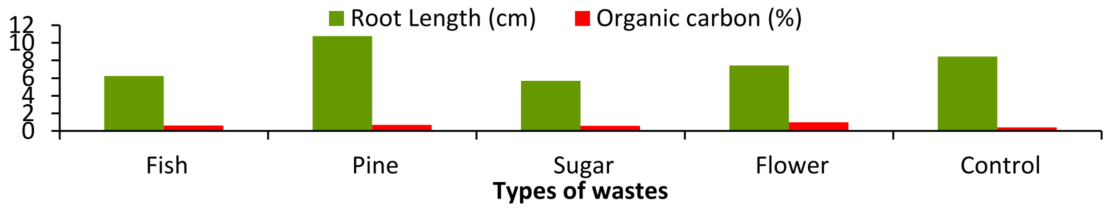
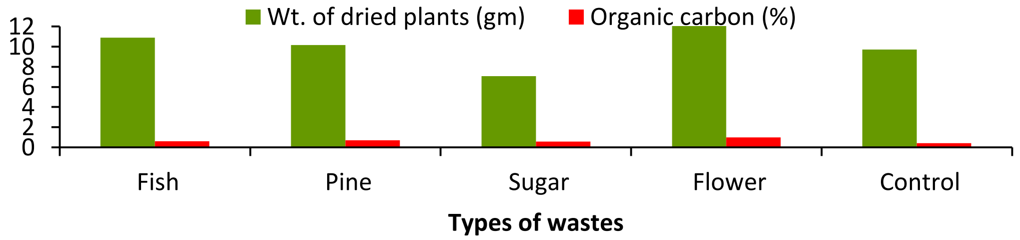


Fig.5.4: Graphical representation biomass with respect to organic C.



The graphical representation of total N with reference to height, number of leaves, root length and biomass of cabbage were given in Figs. 6.1 to 6.4.

Fig.6.1: Graphical representation height of plant with respect to total N.

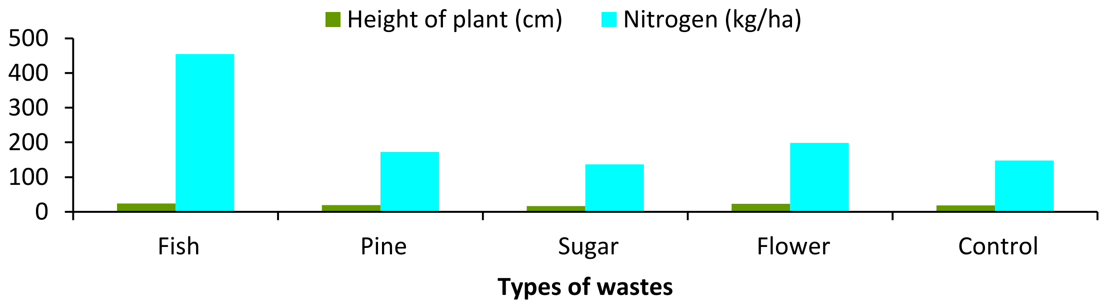


Fig.6.2: Graphical representation no. of leaves with respect to total N.

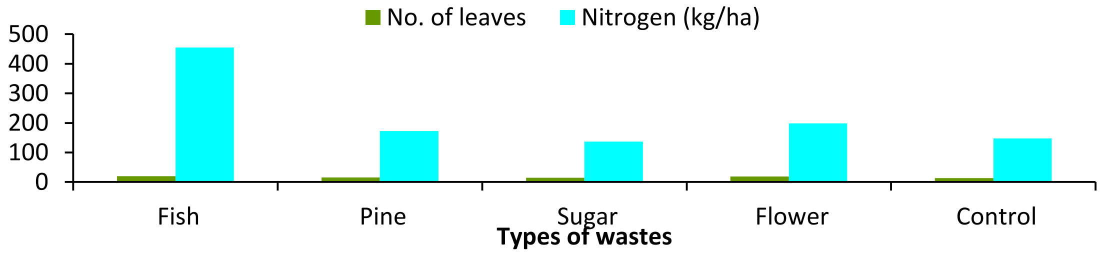


Fig.6.3: Graphical representation root length with respect to total N.

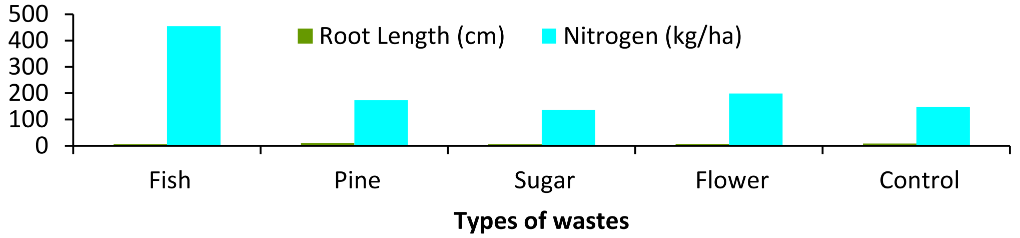
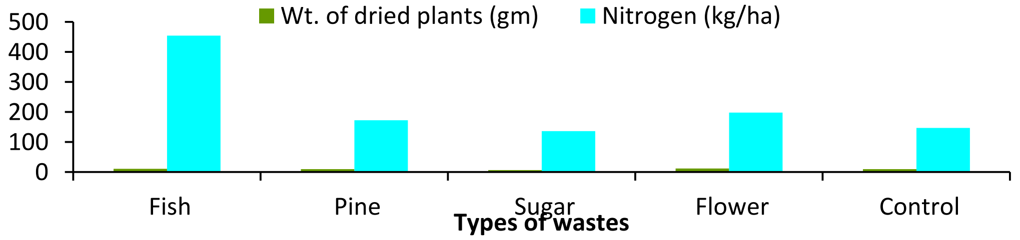


Fig.6.4: Graphical representation biomass with respect to total N.



The graphical representation of available P with reference to height, number of leaves, root length and biomass of cabbage were given in Figs. 7.1 to 7.4.

Fig.7.1: Graphical representation height of plant with respect to available P.

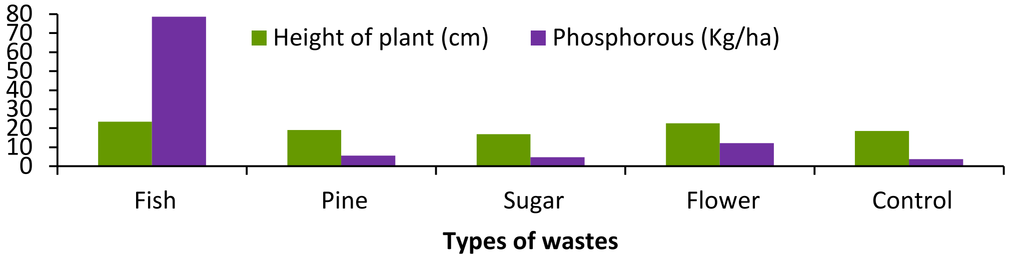


Fig.7.2: Graphical representation no. of leaves with respect to available P.

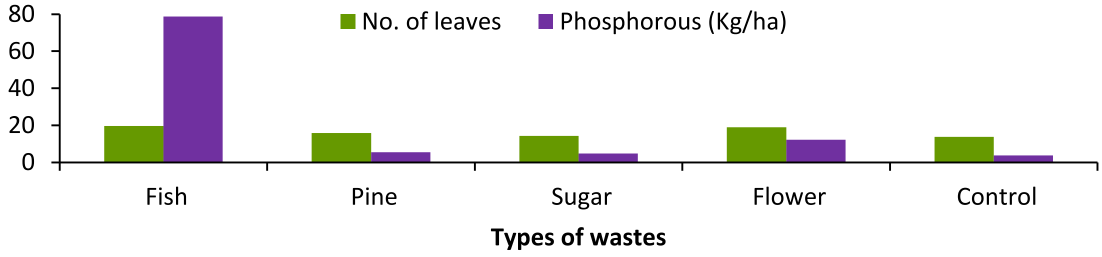


Fig.7.3: Graphical representation no. of leaves with respect to available P.

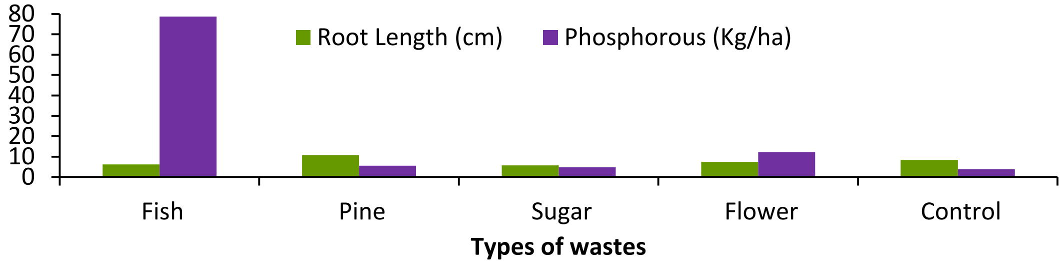
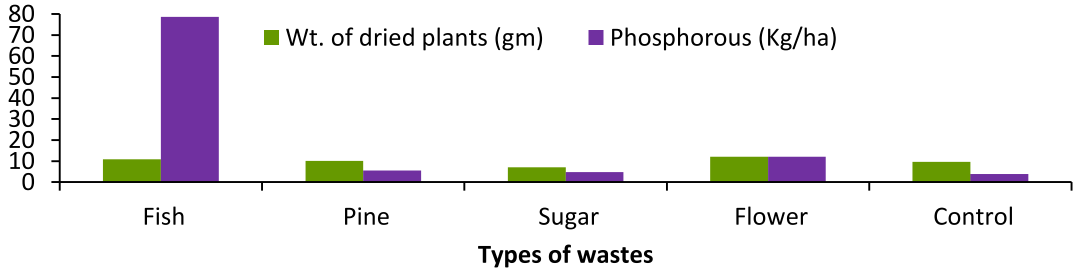


Fig.7.4: Graphical representation biomass with respect to available P.



The graphical representation of exchangeable K with reference to height, number of leaves, root length and biomass of cabbage were given in Figs. 8.1 to 8.4.

Fig.8.1: Graphical representation height of plant with respect to exchangeable K.

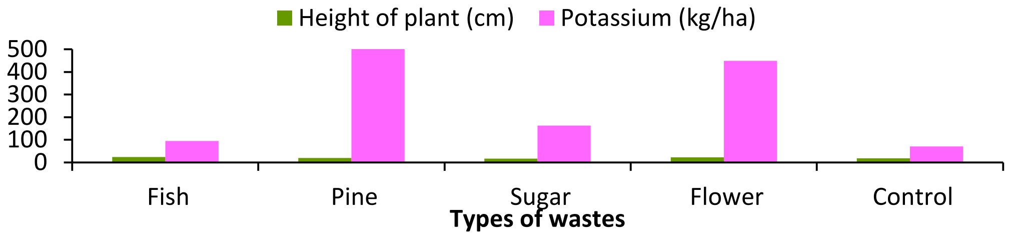


Fig.8.2: Graphical representation no. of leaves with respect to exchangeable K.

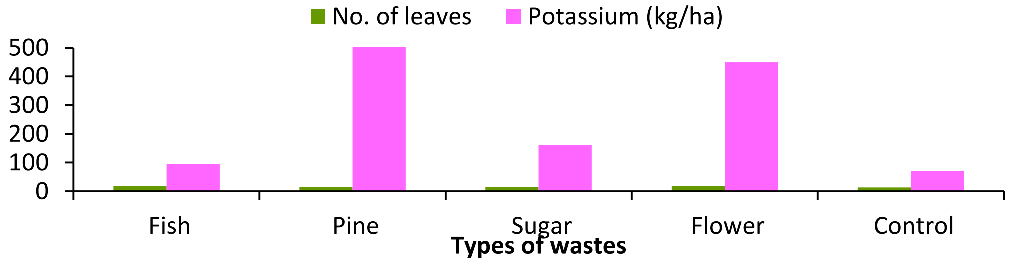


Fig.8.3: Graphical representation root length with respect to exchangeable K

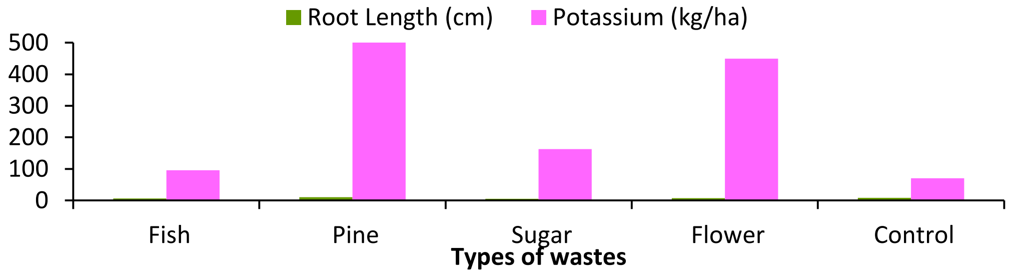
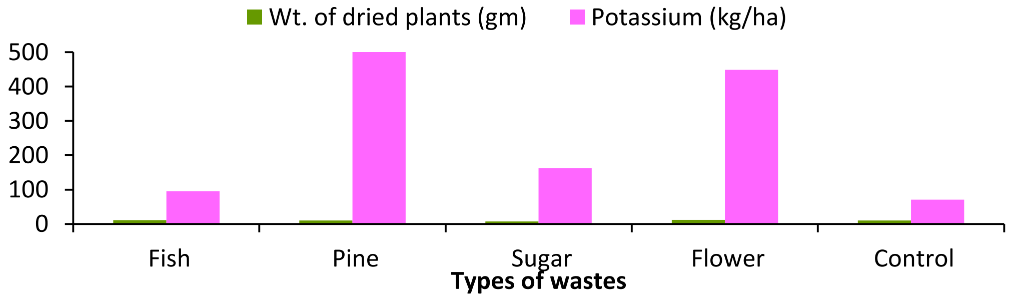


Fig.8.4: Graphical representation biomass with respect to exchangeable K.



4. A.4 Change in soil and crop characteristics

Maximum increase in the soil moisture was observed in the sugarcane waste amended pots (15.7%) and minimum in the fish waste amended pots (1.9%) (Table 8). Maximum increase in the bulk density was observed in sugarcane waste amended pots (0.17 g/cm^3) and a decrease in the fish waste amended pots (-0.01 g/cm^3).

Maximum increase in organic C was observed in the flower waste amended pots (0.58%) and minimum in the sugarcane waste amended pots (0.19%). Maximum increase in the total N was observed in the fish waste amended pots (301.5 kg/ha). Available P was found to increased maximum in the fish waste amended pots (74.86 kg/ha) and minimum in sugarcane waste amended pots (1.03 kg/ha). Maximum increase in exchangeable K was observed in the pineapple waste amended pots (447 kg/ha) and minimum in the fish waste amended pots (25 kg/ha).

Table 8. Physico-chemical characteristics of soil under control and amended pots. The figures within bracket indicates change due to amendment of wastes.

Type of waste	Soil moist. (%)	Bulk density (g/cm^3)	Soil porosity (%)	pH	C (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)
Control	15.16± 1.53	1.21± 0.03	54.34± 00	6.71± 0.01	0.4± 0.08	153± 14.61	3.79± 4.02	70± 30.40
Sugarcane	30.86± 2.01 (15.7)	1.38± 0.08 (0.17)	47.80± 3.64 (-6.54)	7.13± 0.02 (0.42)	0.59± 0.05 (0.19)	136.5± 14.61 (-16.5)	4.82± 0.94 (1.03)	162± 10.53 (92)
Fish	17.06± 2.31 (1.9)	1.22± 0.08 (0.01)	54.22± 0.50 (-0.12)	5.27± 0.01 (-1.44)	0.64± 0.12 (0.24)	454.5± 44.31 (301.5)	78.65± 6.5 (74.86)	95± 17.20 (25)
Flower	27.40± 6.00 (12.24)	1.34± 0.12 (0.13)	49.5± 2.33 (-4.84)	6.51± 0.03 (-0.2)	0.98± 0.12 (0.58)	198.5± 51.43 (45.5)	12.12± 2.16 (8.33)	449± 60.01 (379)
Pineapple	24.61± 2.20 (9.45)	1.29± 0.20 (0.08)	51.58± 1.38 (-2.76)	7.13± 0.01 (0.42)	0.69± 0.18 (0.29)	177.5± 29.70 (24.5)	5.53± 0.47 (1.74)	517± 10.07 (447)

Table 9. Growth pattern of cabbage under control and amended pots. The figures within bracket indicates the change due to amendment of wastes.

Types of wastes	Height(cm)	No of leaves	Root length(cm)	Biomass(g)
Control	22.67± 0.47	19± 0.94	7.87± 0.81	9.7± 0.12
Sugarcane	19.67± 1.41(-3)	19± 0.81(0)	5.7± 1.20(-2.17)	7.07± 0.16(-2.63)
Fish	31± 1.70(8.33)	24± 0.81(5)	6.23± 1.63(-1.64)	10.9± 0.26(1.2)
Flower	26.67± 3.70(4)	22± 4.50(3)	7.43± 3.55(-0.44)	12.1± 0.12(2.4)
Pineapple	23.33± 2.62(0.66)	22± 3.55(3)	10.77± 2.16(2.9)	10.17± 0.20(0.47)

Although amendment of sugarcane waste does not have significant increase in soil nutrient status, it was observed that retention of soil moisture was maximum. The result showed that sugarcane bagasse can be used for retention of moisture in dry and semi-arid soil.

Due to amendment of fish waste maximum increase in total N and available P were observed. Significant positive correlation with height of plant and no. of leaves with total N and available P in fish waste also showed that amendment of fish waste showed positive response in soil and crop.

Amendment of flower waste showed maximum increase in organic C. The significant correlation with organic C and crop characteristics also indicated that amendment of flower waste comes after fish waste by referring to soil and crop characteristics. The amendment of pineapple waste leads to maximum increase in exchangeable K which was positively correlated with root length.

The pineapple waste amended pots have high exchangeable K content, however there was no significant correlation observed with exchangeable K content in soil with growth parameters of crop except root length. Maftoun *et al.*, (2005) have found that combined use of municipal waste compost and poultry manure with P fertilization improve the growth and chemical composition of spinach. Chaturvedi *et al.*, (2009), also found increase in nutritional quality of tomato crop by using organic residue of tobacco waste. Batisda *et al.*, (2008) observed an average increase of 70% in organic matter content in soil after a single application of raw municipal solid waste in semi-arid conditions.

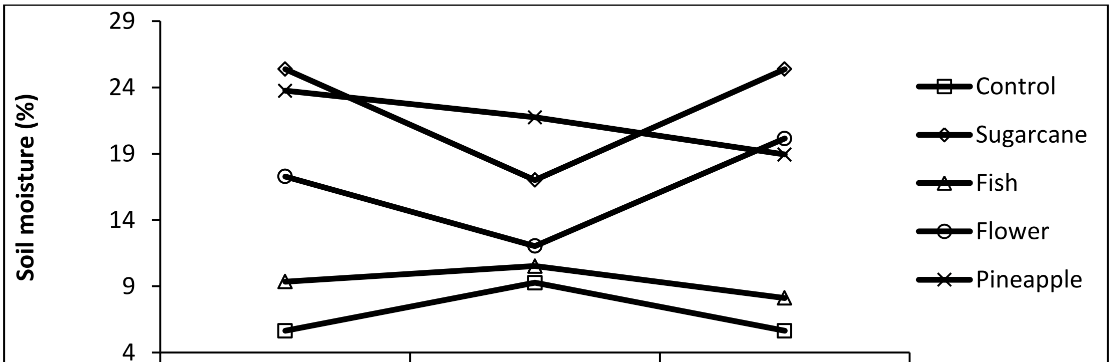
Therefore from all the observations, it can be concluded that the crop cabbage can grow successfully in fish and flower wastes amended soil. The performance of the wastes can be represented as fish>flower>pineapple>sugarcane.

4. B Chilli *(Capsicum annum)*

4. B.1 Monthly variation

The soil moisture in the control (Fig.9.1) ranged from 5.64% (June and August) to 9.27% (July). In the sugarcane waste amended pots, the range of the soil moisture was from 17.01% (July) to 25.38% (June and August). It ranged from 8.12% (August) to 10.53% (Jul) in the fish waste amended pots. It was observed that the soil moisture in the flower wastes amended pots ranged from 12.03% (July) to 20.14% (August). The soil moisture in the pineapple wastes amended pots ranged from 18.93% (August) to 23.75% (June). By comparing between control and wastes amendment, there was an overall increase in the level of soil moisture in the waste amended pots in all the three months.

Fig.9.1 Monthly variation of soil moisture in the control and different amendments for chilli.



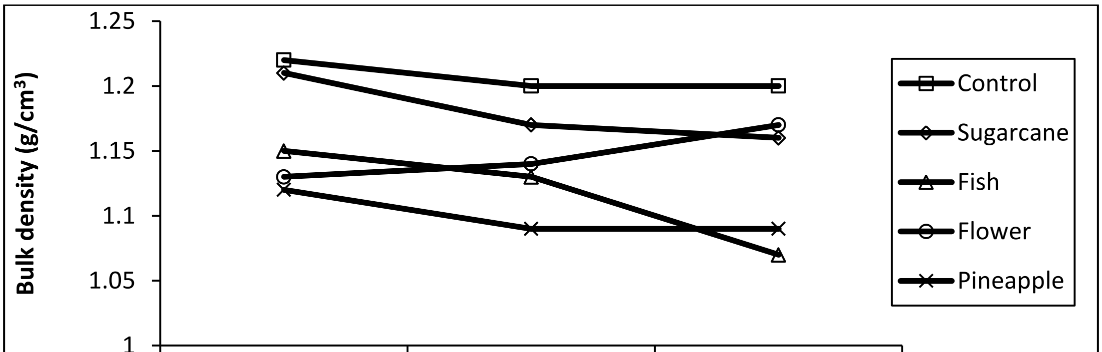
	June	July	August
Control	5.64	9.27	5.64
Sugarcane	25.38	17.01	25.38
Fish	9.35	10.53	8.12
Flower	17.28	12.03	20.14
Pineapple	23.75	21.74	18.93

Plate 6: Growth of chilli in first month.

Plate 7: Growth of chilli in second month.

Plate 8: Growth of chilli in third month.

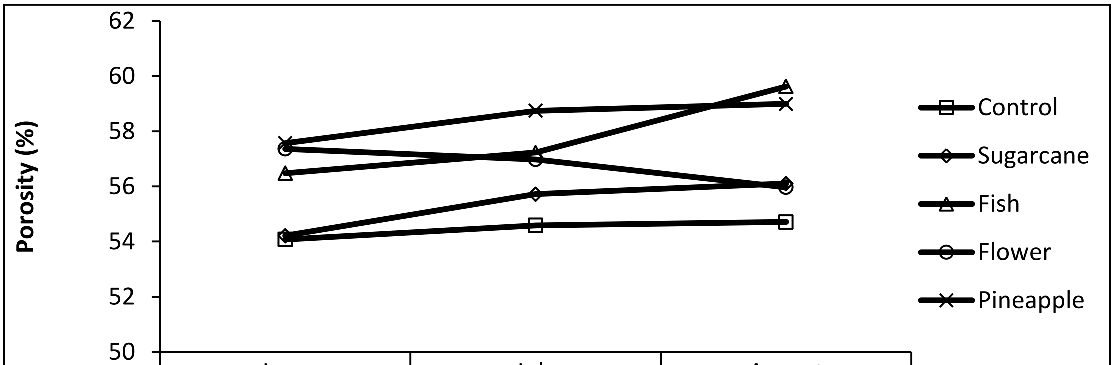
Fig. 9.2. Monthly variation of soil bulk density in the control and different amendments for chilli.



	June	July	August
Control	1.22	1.2	1.2
Sugarcane	1.21	1.17	1.16
Fish	1.15	1.13	1.07
Flower	1.13	1.14	1.17
Pineapple	1.12	1.09	1.09

Bulk density in control pots (Fig.9.2) were observed to range from 1.2 g/cm^3 (July and August) to 1.22 g/cm^3 (June). The bulk density in the sugarcane wastes amended pots ranged from 1.16 g/cm^3 (August) to 1.21 g/cm^3 (June). In the fish wastes amended pots, it was observed to range from 1.07 g/cm^3 (August) to 1.15 g/cm^3 (June). The bulk density in the flower waste amended pots ranged from 1.13 g/cm^3 (Jun) to 1.17 g/cm^3 (August). It was observed that the bulk density in pineapple wastes amended pots ranged from 1.09 g/cm^3 (July and August) to 1.12 g/cm^3 (June). In all the wastes amendments there was a decline in bulk density compared to control.

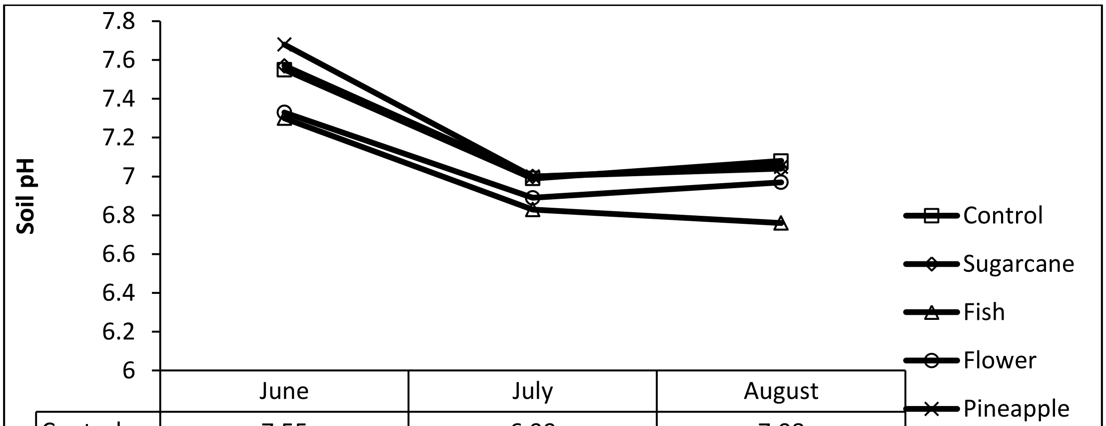
Fig. 9.3.Monthly variation of soil porosity in the control and different amendments for chilli.



	June	July	August
Control	54.08	54.59	54.71
Sugarcane	54.21	55.72	56.1
Fish	56.48	57.23	59.62
Flower	57.36	56.98	55.97
Pineapple	57.57	58.74	58.99

Soil porosity in the control pots (Fig.9.3) ranged from 54.08% (June) to 54.71% (August). The soil porosity in the sugarcane waste amended pots was found to ranged from 54.21% (June) to 56.1% (August). In the fish wastes amended pots, it ranged from 56.48% (June) to 59.62% (August). Soil porosity in the flower wastes amended pots ranged from 55.97% (August) to 57.36% (June). In the pineapple waste amended pots, soil porosity was observed to ranged from 57.57% (June) to 58.99% (August). In all the wastes amendment there was an increase in soil porosity by comparing with control.

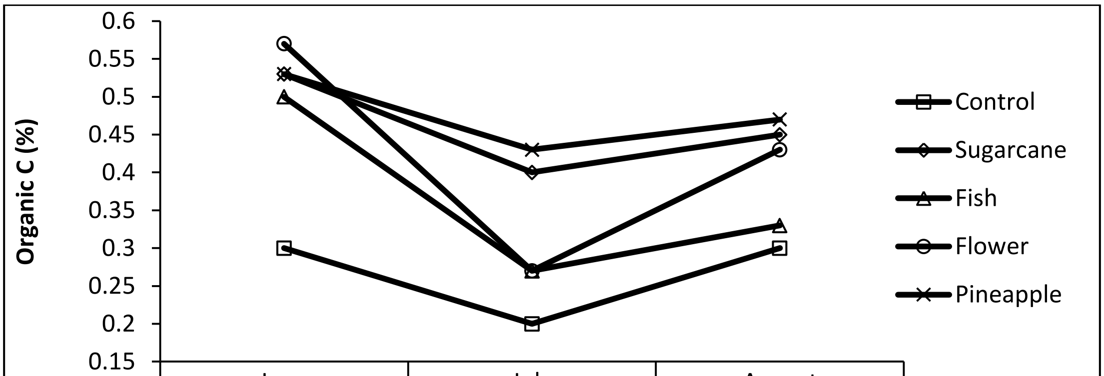
Fig.9.4. Monthly variation of soil pH in the control and different amendments for chilli.



	June	July	August
Control	7.55	6.99	7.08
Sugarcane	7.57	7	7.04
Fish	7.3	6.83	6.76
Flower	7.33	6.89	6.97
Pineapple	7.68	7	7.05

The soil pH in the control pots (Fig.9.4) ranged from 6.99 (July) to 7.55 (June). In sugarcane waste amended pots, the pH was observed to be ranged from 7.0 (July) to 7.57 (June). Soil pH in the fish wastes amended pots was recorded to ranged from 6.76 (August) to 7.3 (June). The pH in the flower wastes amended pots ranged from 6.89 (July) to 7.33 (June). In the pineapple waste amended pots, pH was observed to range from 7 (July) to 7.68 (June). The pH of soil range from 6.96 to 7.24. Change in soil pH does not follow a regular pattern in all the wastes amendments.

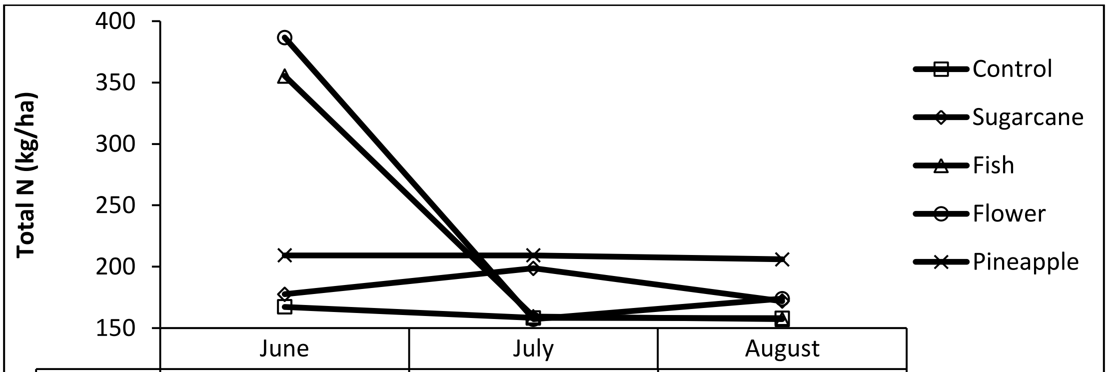
Fig. 9.5.Monthly variation of soil organic C in the control and different amendments for chilli.



	June	July	August
Control	0.3	0.2	0.3
Sugarcane	0.53	0.4	0.45
Fish	0.5	0.27	0.33
Flower	0.57	0.27	0.43
Pineapple	0.53	0.43	0.47

In the control pots, the organic C (Fig 9.5) was found to ranged from 0.2% (July) to 0.3% (June and August). In sugarcane waste amended pots it ranged from 0.4% (July) to 0.53% (June). Organic C in the fish wastes amended pots was observed to ranged from 0.27% (July) to 0.5% (June). In flower wastes amended pots the range of the organic C varied from 0.27% (July) to 0.57% (June). The organic C in the pineapple wastes amended pots was observed to range from 0.43% (July) to 0.53% (June). By comparing with control there was an overall increase in the organic C in all the wastes amended pots.

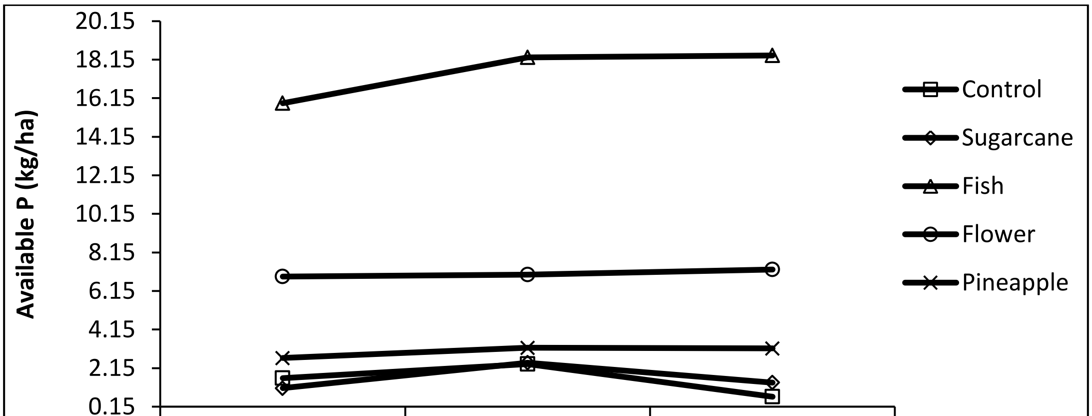
Fig. 9.6.Monthly variation of total soil N in the control and different amendments for chilli.



	June	July	August
Control	167.33	158.33	158
Sugarcane	177.67	198.67	172
Fish	355.33	159.33	157.33
Flower	386.67	157.33	174
Pineapple	209.33	209.33	206

The range of total soil N in the control pot (Fig.9.6) was observed to varied from 158 kg/ha (August) to 167.33 kg/ha (June). Total N in the sugarcane waste amended pots ranged from 172 kg/ha (August) to 198.67 kg/ha (July). It was observed that the total N in the fish waste amended pots ranged from 157.33 kg/ha (August) to 355.33 kg/ha (June). The range of total N in the flower wastes amended pots was from 157.33 kg/ha (July) to 386.67 kg/ha (June). Total N in the pineapple waste amended pots ranged from 206 kg/ha (August) to 209.33 kg/ha (June and July).There was an overall increase in the level of total N in all the wastes amended pots except in flower waste amended pots during July.

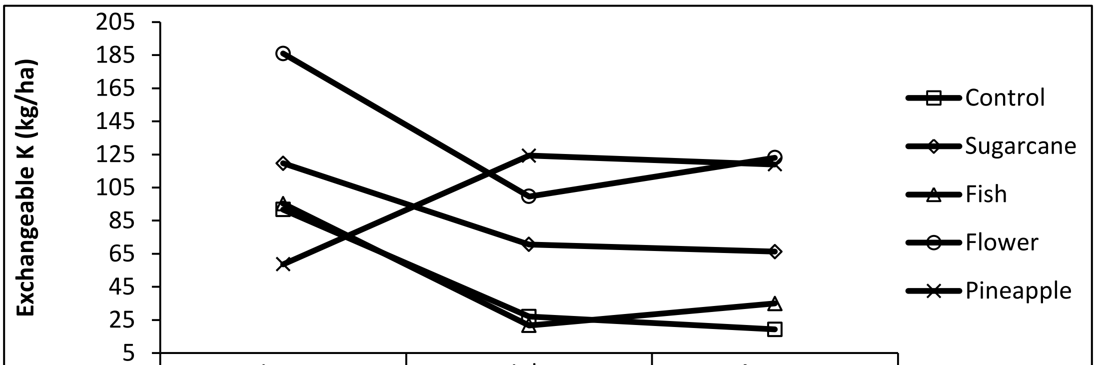
Fig.9.7. Monthly variation of soil available P in the control and different amendments for chilli.



	June	July	August
Control	1.63	2.36	0.67
Sugarcane	1.11	2.43	1.4
Fish	15.9	18.27	18.37
Flower	6.9	7	7.27
Pineapple	2.67	3.2	3.17

Available P (Fig.9.7) was observed to varied from 0.67 kg/ha (August) to 2.36 kg/ha (July) in the control pots. In the sugarcane waste amended pots, available P ranged from 1.11 kg/ha (June) to 2.43 kg/ha (July). Available P ranged from 15.9 kg/ha (June) to 18.37 kg/ha (August) in the fish wastes amended pots. In the flower wastes amended pots the range of the available P was from 6.9 kg/ha (June) to 7.27 kg/ha (August). The available P in the pineapple wastes amended pots ranged from 2.67 kg/ha (June) to 3.2 kg/ha (July). By comparing with control there was increase in all the amendments except in sugarcane wastes amendment during June.

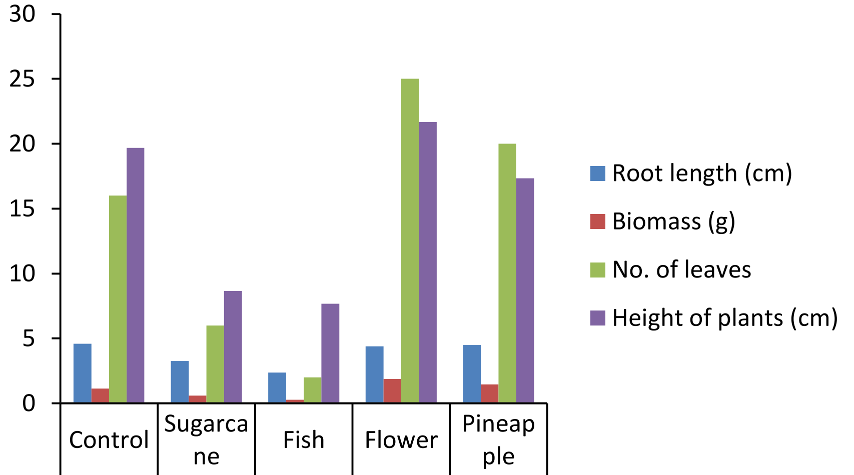
Fig.9.8. Monthly variation of soil exchangeable K in the control and different amendments for chilli.



	June	July	August
Control	91.67	27	19.33
Sugarcane	119.67	70.67	66.33
Fish	95.33	21.67	35
Flower	186	99.67	123
Pineapple	58.67	124.33	119

Exchangeable K in the control pots (Fig.9.8) ranged from 19.33 kg/ha (August) to 91.67 kg/ha (June). In sugarcane waste amended pots the exchangeable K ranged from 66.33 kg/ha (August) to 119.67 kg/ha (June). Exchangeable K in the fish waste amended pots ranged from 21.67 kg/ha (July) to 95.33 kg/ha (June). The range of exchangeable K in the flower waste amended pots was observed to range from 99.67 kg/ha (July) to 186 kg/ha (June). Exchangeable K in the pineapple waste amended pots ranged from 58.67 kg/ha (June) to 124.33 kg/ha (July). There was an overall increase in all amendments except in sugarcane wastes amendment during June and fish waste amendment during July.

Fig.9.9. Monthly variation in characteristics of chilli in the control and different amendments.



	Control	Sugarcane	Fish	Flower	Pineapple
Root length (cm)	4.6	3.27	2.37	4.4	4.5
Biomass (g)	1.13	0.6	0.27	1.87	1.47
No. of leaves	16	6	2	25	20
Height of plants (cm)	19.67	8.67	7.67	21.67	17.33

4. B.2 Anova

Analysis of variance of soil moisture for all the amendments showed significant variation in flower waste amended pots ($F=5.040$; $P<0.05$) and sugarcane waste amended pots ($F=5.640$; $P<0.05$)(Table 10.1 and 10.2).

Table 10: Anova for Soil Moisture in the different amendments for chilli.

Table 10.1: Sugarcane waste amendment.

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	139.77	2	69.89	5.64	P<0.05
Within Groups	74.34	6	12.39		
Total	214.12	8			

Table 10.2: Flower waste amendment.

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	55.125	2	27.563	5.040	P<0.05
Within Groups	32.815	6	5.469		
Total	87.940	8			

No significant variation of bulk density and porosity was observed in all of the wastes amended pots.

Analysis of variance in soil pH was observed to be significant between all the treatments (Table 11.1 to 11.5).

Table 11: Anova for soil pH in the control and different amendments for chilli.

Table11.1: Control

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.54	2	0.27	13.82	P<0.01
Within Groups	0.12	6	0.02		
Total	0.66	8			

Table 11.2: Sugarcane waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.62	2	0.31	15.69	P<0.01
Within Groups	0.12	6	0.02		
Total	0.73	8			

Table 11.3 Fish waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.51	2	0.25	10.39	P<0.01
Within Groups	0.15	6	0.02		
Total	0.66	8			

Table 11.4: Flower waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.32	2	0.16	33.85	P<0.01
Within Groups	0.02	6	0.005		
Total	0.35	8			

Table 11.5: Pineapple waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.85	2	0.42	22.14	P<0.01
Within Groups	0.11	6	0.02		
Total	0.97	8			

Significant variation of organic C was observed in control, fish and flower wastes amended pots (Table 12.1 to 12.3).

Table 12: Anova for organic C in the control and different amendments for chilli.

Table 12.1: Control

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.02	2	0.01	3.00	P<0.1
Within Groups	0.02	6	0.003		
Total	0.04	8			

Table 12.2: Fish waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.087	2	0.043	7.80	P<0.05
Within Groups	0.033	6	0.006		
Total	0.120	8			

Table 12.3: Flower waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.136	2	0.068	5.083	P<0.05
Within Groups	0.080	6	0.013		
Total	0.216	8			

Significant variation of total N was observed only in the flower waste amended pots (F=58.33 ; P<0.05) and fish waste amended pots (F=90.191 ; P<0.05) (Table 13.1 and 13.2.

Table 13: Anova for total N in the different amendments for chilli.

Table 13.1: Fish waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	77624.00	2	38812.00	90.19	P<0.01
Within Groups	2582.00	6	430.33		
Total	80206.00	8			

Table 13.2: Flower waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	98098.66	2	49049.33	58.33	P<0.01
Within Groups	5045.33	6	840.88		
Total	103144.00	8			

Significant variation of the available P was observed in sugarcane waste amended pots ($F=3.496$; $P<0.05$) and the control ($F=65.433$; $P<0.05$) (Table 14.1 and 14.2)

Table 14: Anova for available P in the control and different amendments for chilli.

Table 14.1: Control

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	4.36	2	2.18	65.43	P<0.01
Within Groups	0.20	6	0.03		
Total	4.56	8			

Table 14.2: Sugarcane waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	1.80	2	0.90	3.49	P<0.05
Within Groups	1.54	6	0.25		
Total	3.34	8			

Significant variation of exchangeable K was observed in all the wastes amended pots (Table 15.1 to 15.5).

Table 15: Anova for exchangeable K in the control and different amendments for chilli.

Table 15.1: Control

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	9472.66	2	4736.33	42.20	P<0.01
Within Groups	673.33	6	112.22		
Total	10146.00	8			

Table 15.2: Sugarcane waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	5264.22	2	2632.11	6.13	P<0.05
Within Groups	2574.00	6	429.00		
Total	7838.22	8			

Table 15.3: Fish waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	9244.66	2	4622.33	70.51	P<0.01
Within Groups	393.33	6	65.55		
Total	9638.00	8			

Table 15.4: Flower waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	11966.88	2	5983.44	22.23	P<0.01
Within Groups	1614.66	6	269.11		
Total	13581.55	8			

Table 15.5: Pineapple waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	9290.66	2	4645.33	43.45	P<0.01
Within Groups	641.33	6	106.88		
Total	9932.00	8			

Significant variation was observed in height of plant in flower waste amendment (Table 16.1). Significant variation was also observed in number of leaves in control (Table 17.1).

Table 16: Anova for plant height in the different amendments for chilli.

Table 16.1: Flower waste amendment.

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	88.66	2	44.33	19.95	P<0.01
Within Groups	13.33	6	2.22		
Total	102.00	8			

Table 17: Anova for number of leaves in the control for chilli.

Table 17.1: Control

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	86.22	2	43.11	6.69	P<0.05
Within Groups	38.66	6	6.44		
Total	124.88	8			

4. B. 3 Correlation

There was no significant correlation between soil moisture and crop characteristics. However, significant correlation was observed between all the crop characteristics (Table 18). Soil pH was observed to be significantly correlated with no. of leaves and root length (Table 19). Regression lines were shown in Figs. l and m. No significant correlation was found between organic C and total N with crop characteristics.

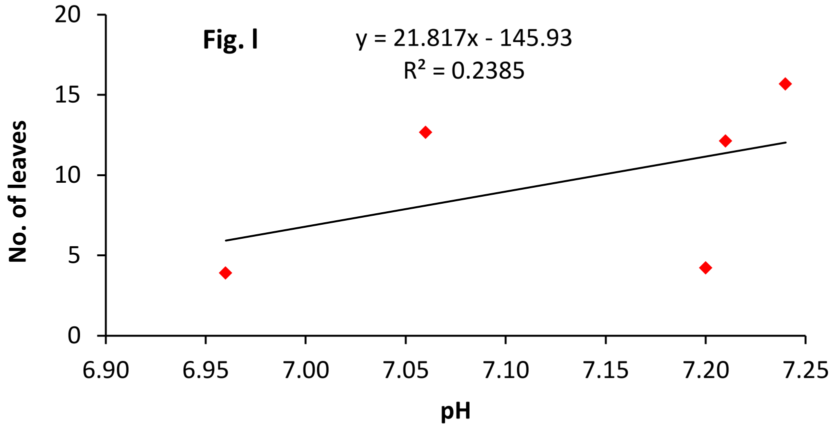
Available P was found to be significantly and negatively correlated with the no. of leaves root length and biomass of the plants (Table 20). Regression lines were shown in Fig. n, o and p. Exchangeable K was found to be positively and significantly correlated with all the characteristics of the plants except the height of the plants (Table 21). Regressive lines were shown in Figs. q, r and s.

Table 18: Correlation (r, n=5) between soil moisture and characteristics of chilli.

	Soil moisture (%)	Height of plants (cm)	No. of leaves	Root length (cm)
Soil moisture (%)	1	-	-	-
Height of plants (cm)	-0.17	1	-	-
No. of leaves	0.17	0.83	1	-
Root length (cm)	-0.20	0.89	0.91	1
Wt. of dried plants (g)	0.09	0.92	0.88	0.87

Table 19: Correlation between pH and characteristics of the crop chilli along with regression lines (Figs. l and m).

	pH
pH	1
Height of plants (cm)	0.25
No. of leaves	0.48
Root length (cm)	0.65
Wt. of dried plants (g)	0.31



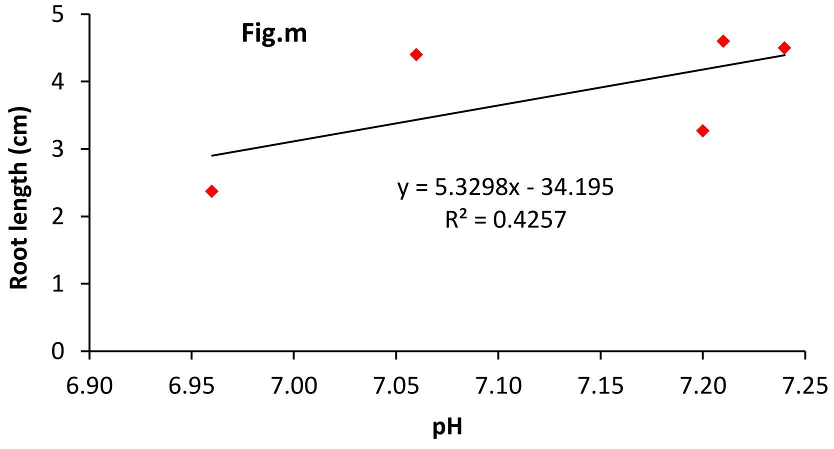
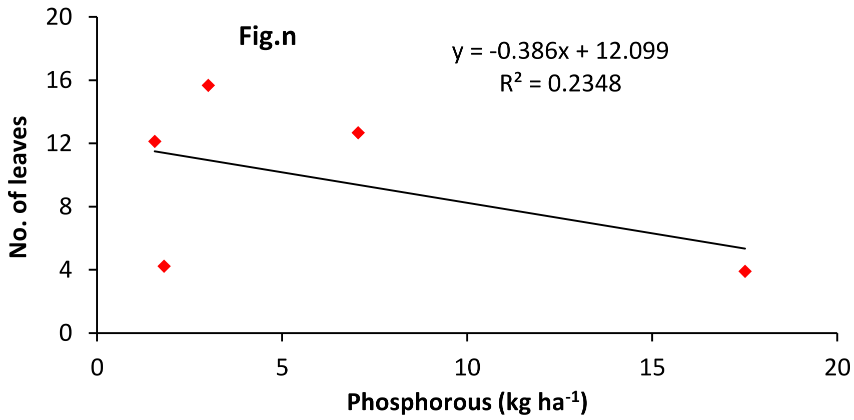
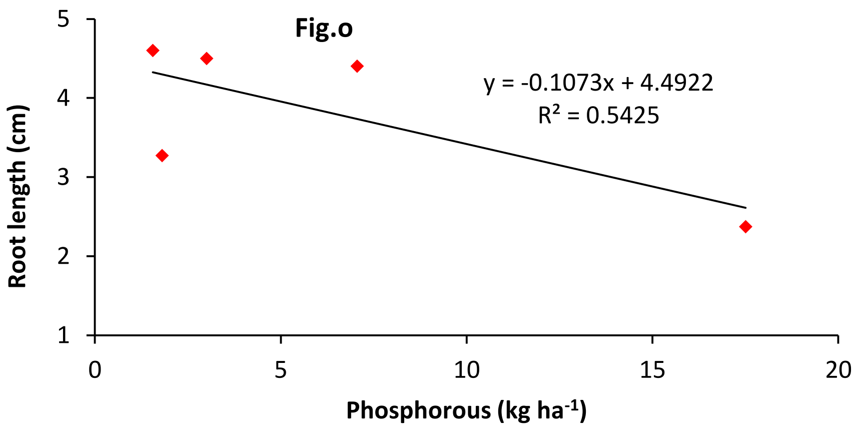


Table 20: Correlation (r, n=5) between available P and characteristics of chilli along with regression lines (Figs. n, o and p).

	Available P (kg/ha)
Available P (kg/ha)	1
Height of plants	-0.42
No. of leaves	-0.48
Root length (cm)	-0.73
Wt. of dried plants (g)	-0.45





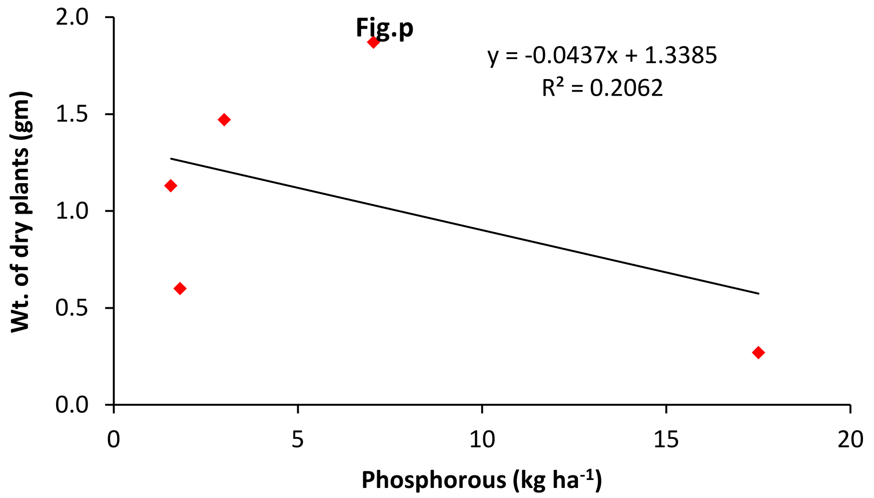


Table 21: Correlation (r, n=5) between exchangeable K and characteristics of the crop chilli along with regression lines (Figs. q, r and s).

	Exchangeable K (kg/ha)
Exc. K (kg/ha)	1
Height of plants	0.43
No. of leaves	0.61
Root length (cm)	0.49
Wt. of dried plants (g)	0.75

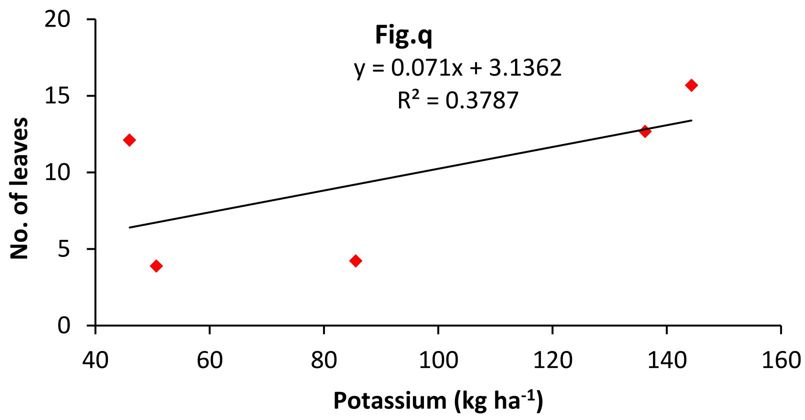


Fig.q
y = 0.071x + 3.1362
R² = 0.3787
No. of leaves
Potassium (kg ha-1)
0
5
10
15
20
40
60
80
100
120
140
160

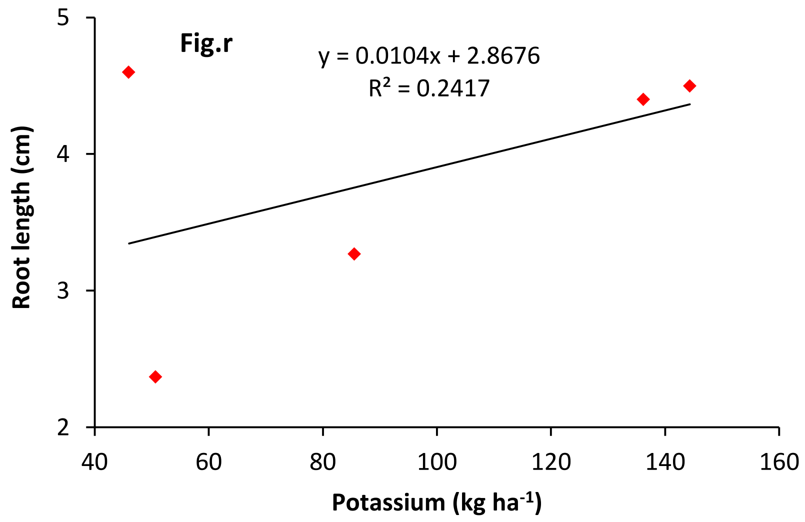


Fig.r
y = 0.0104x + 2.8676
R² = 0.2417
Root length (cm)
Potassium (kg ha-1)
2
3
4
5
40
60
80
100
120
140
160

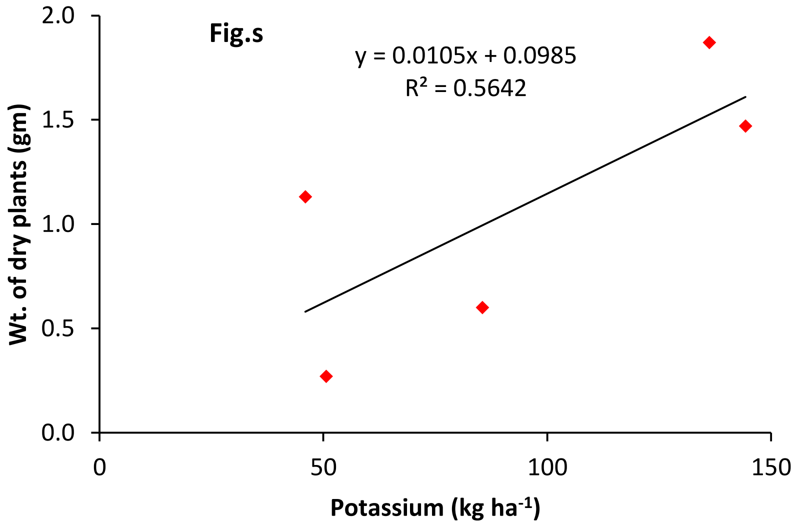


Fig.s
y = 0.0105x + 0.0985
R² = 0.5642
Wt. of dry plants (gm)
Potassium (kg ha-1)
0.0
0.5
1.0
1.5
2.0
0
50
100
150

The graphical representation of soil moisture with respect to crop characteristic of chilli were shown in Figs.10.1 to 10.4.

Fig. 10.1: Graphical representation of height of chilli with respect to soil moisture.

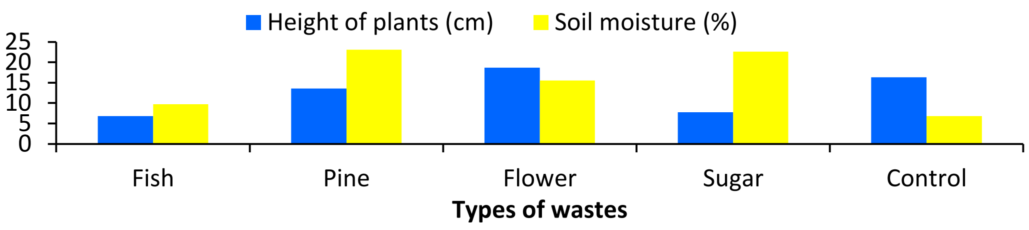


Fig.10.2: Graphical representation of no. of leaves of chilli with respect to soil moisture.

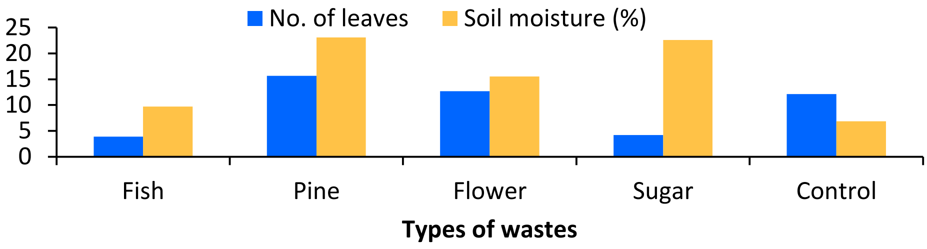


Fig.10.3: Graphical representation of root length of chilli with respect to soil moisture.

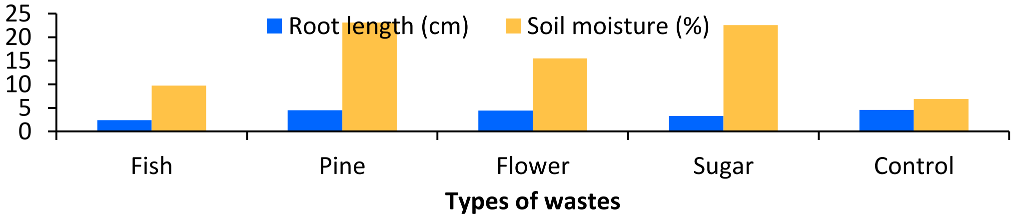
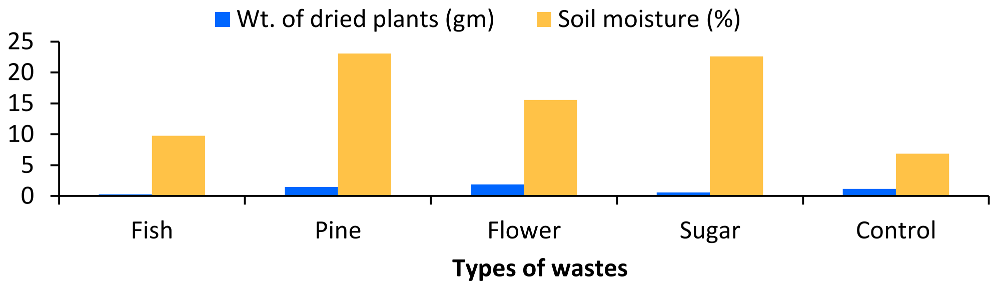


Fig.10.4: Graphical representation of biomass of chilli with respect to soil moisture.



The graphical representation of bulk density with respect to crop characteristic of chilli were shown in Figs 11.1 to 11.4.

Fig.11.1: Graphical representation of height of plant (cm) of chilli with respect to soil bulk density (g/cm^3).

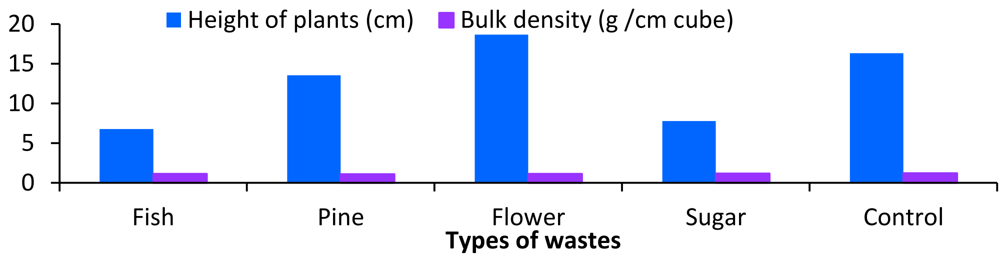


Fig.11.2: Graphical representation of no. of leaves of chilli with respect to bulk density (g/cm^3).

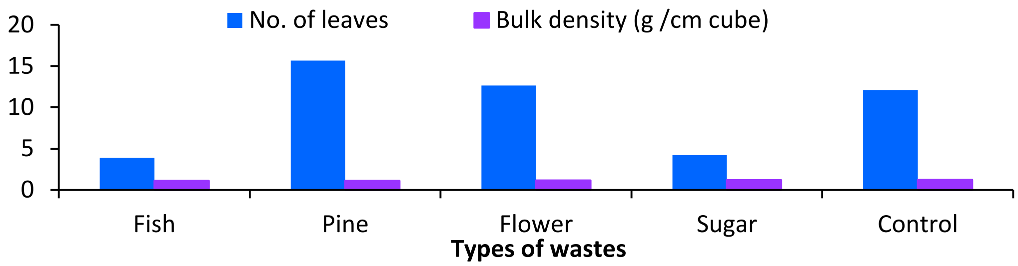


Fig.11.3: Graphical representation of root length (cm) with respect to bulk density (g/cm^3).

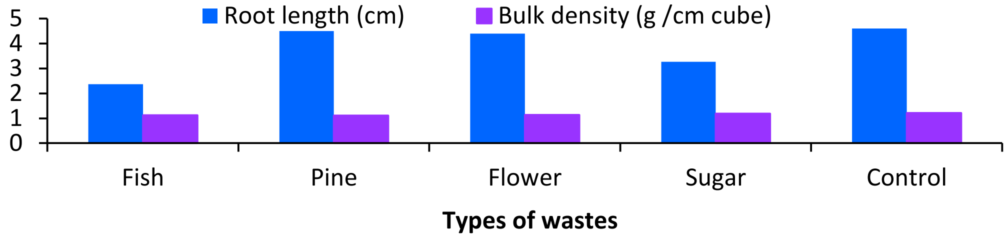
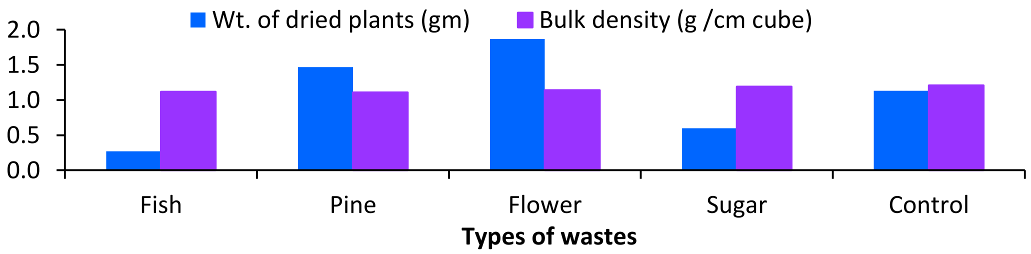


Fig.11.4: Graphical representation of biomass (g) with respect to bulk density (g/cm^3).



The graphical representation of soil pH with respect to crop characteristic of chilli were shown in Figs.12.1 to 12.2 and 13.1 to 13.2.

Fig.12.1: Graphical representation of height of plant with respect to pH.

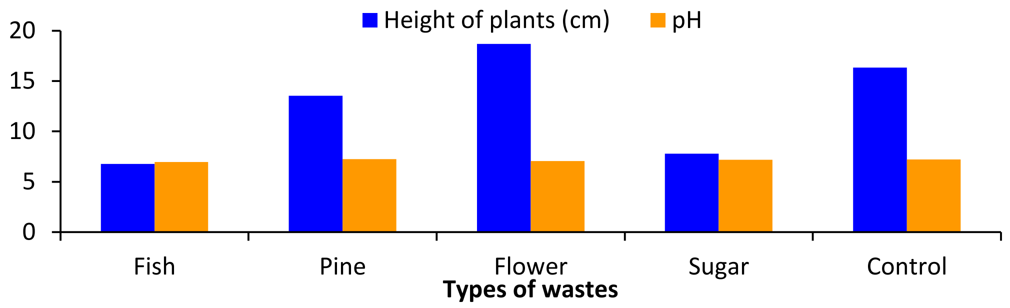


Fig.12.2: Graphical representation of no. of leaves with respect to pH.

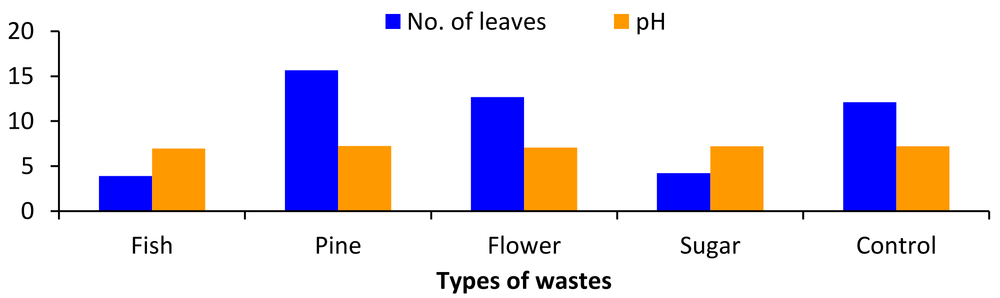


Fig.13.1: Graphical representation of root length with respect to pH.

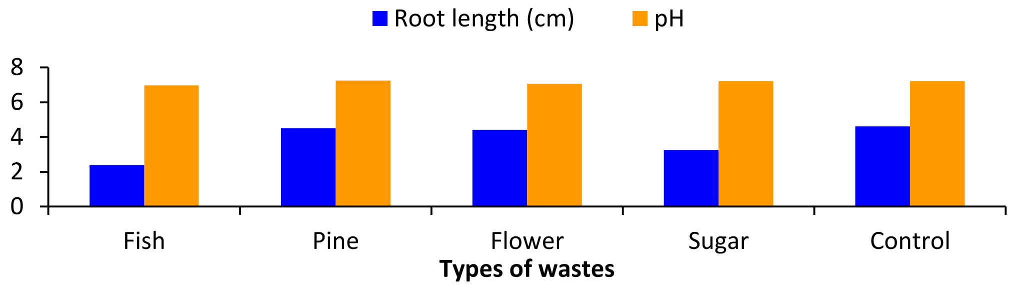
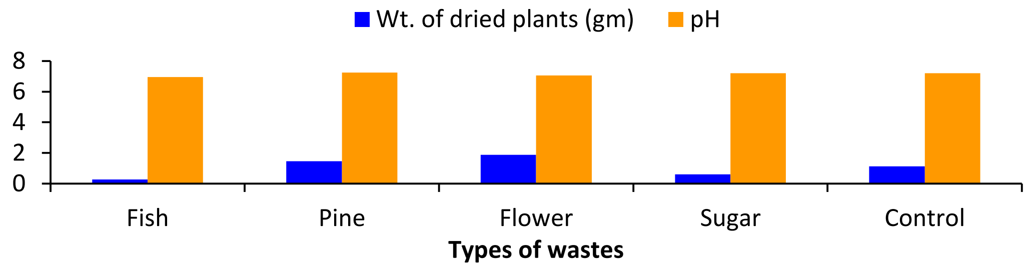


Fig.13.2: Graphical representation of biomass with respect to pH.



The graphical representation of organic C with respect to crop characteristic of chilli were shown in Figs.14.1 to 14.4.

Fig.14.1: Graphical representation height of plant with respect to organic C.

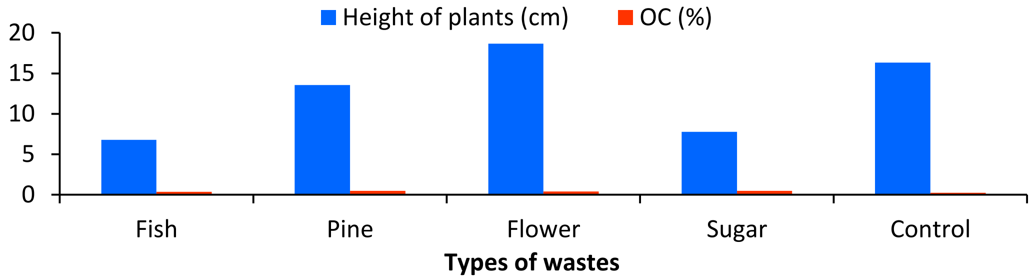


Fig.14.2: Graphical representation no. of leaves with respect to organic C.

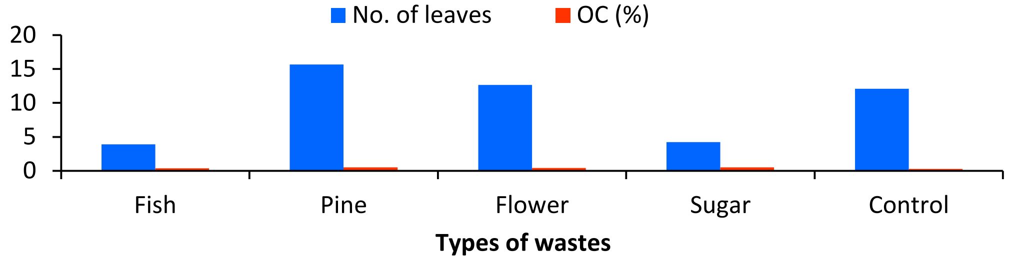


Fig.14.3: Graphical representation root length with respect to organic C.

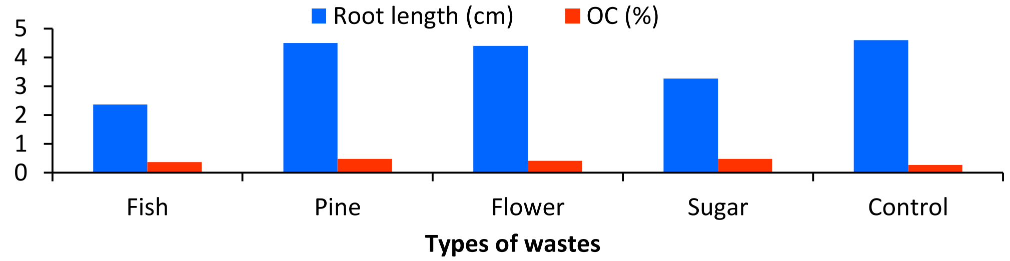
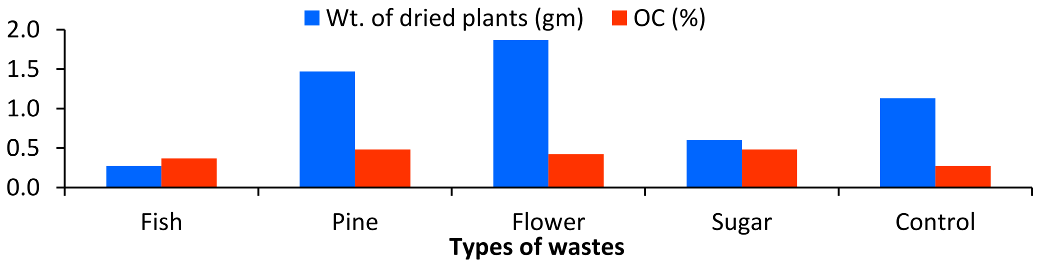


Fig.14.4: Graphical representation biomass with respect to organic C.



The graphical representation of total N with respect to crop characteristic of chilli were shown in Figs.15.1 to 15.4.

Fig.15.1: Graphical representation height of plant with respect to total N.

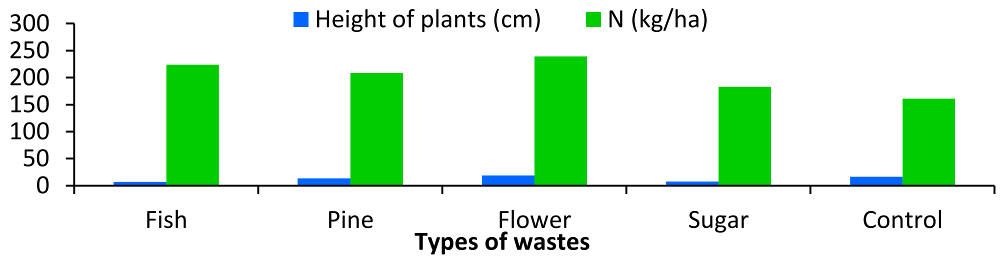


Fig.15.2: Graphical representation no. of leaves with respect to total N.

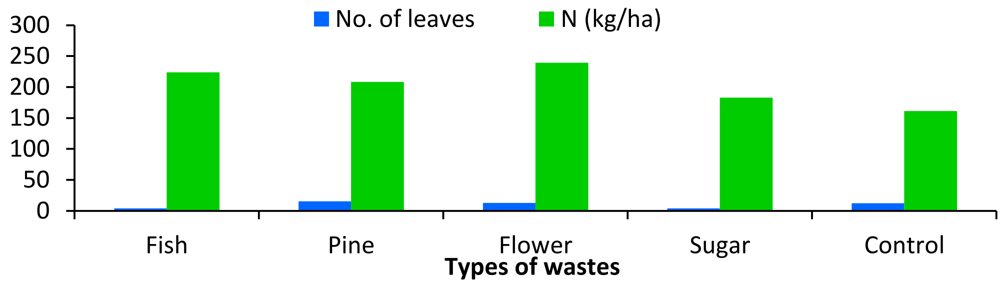


Fig.15.3: Graphical representation root length with respect to total N.

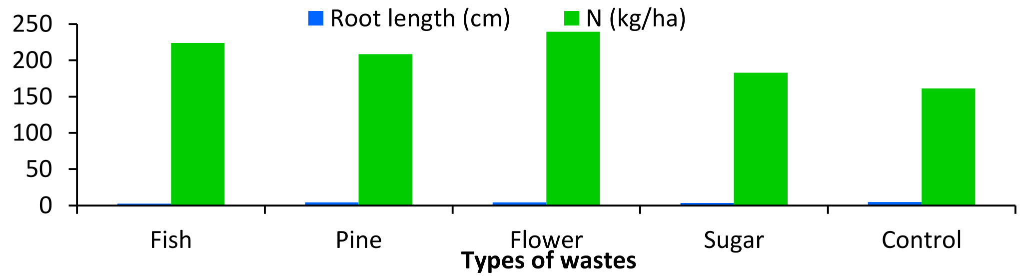
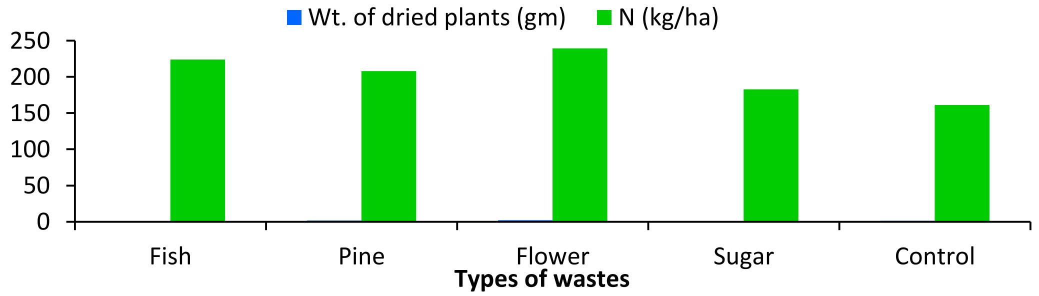


Fig.15.4: Graphical representation biomass with respect to total N.



The graphical representation of available P with respect to crop characteristic of chilli were shown in Figs.16.1 to 16.4.

Fig.16.1: Graphical representation height of plant with respect to available P.

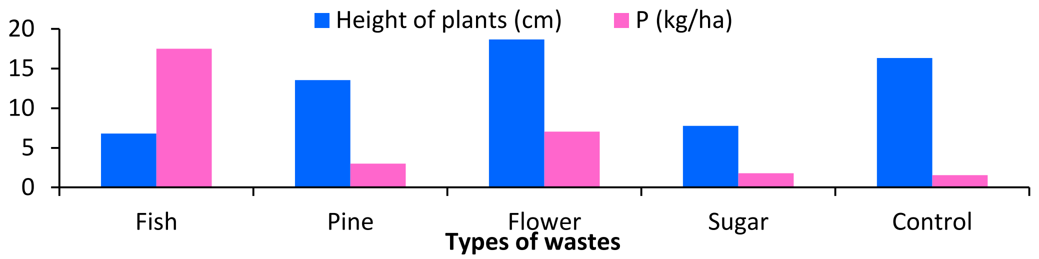


Fig.16.2: Graphical representation no. of leaves with respect to available P.

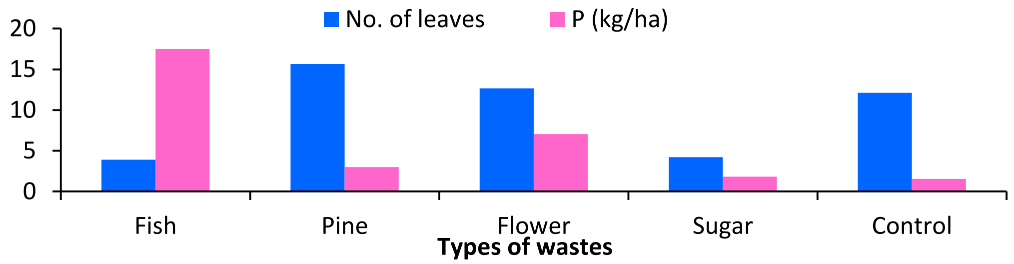


Fig.16.3: Graphical representation root length with respect to available P.

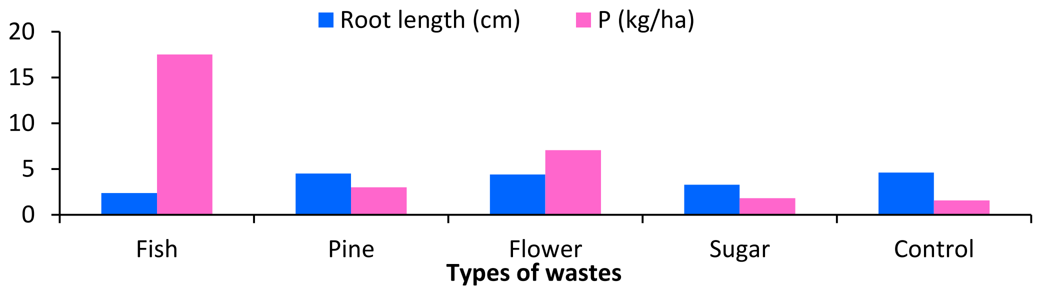
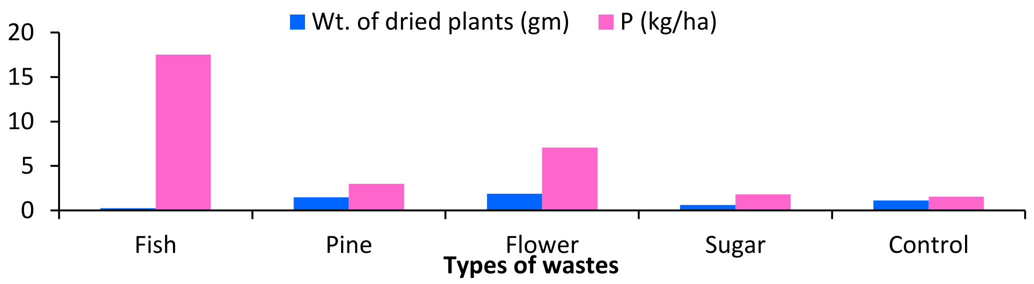


Fig.16.4: Graphical representation biomass with respect to available P.



The graphical representation of exchangeable K with respect to crop characteristic of chilli were shown in Figs.17.1 to 17.3

Fig.17.1: Graphical representation height of plant with respect to exchangeable K.

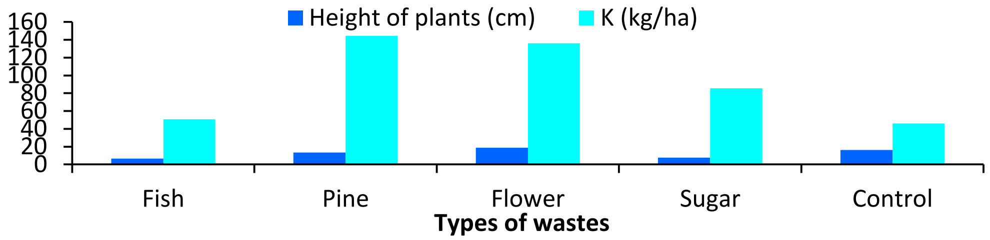


Fig.17.2: Graphical representation no. of leaves with respect to exchangeable K.

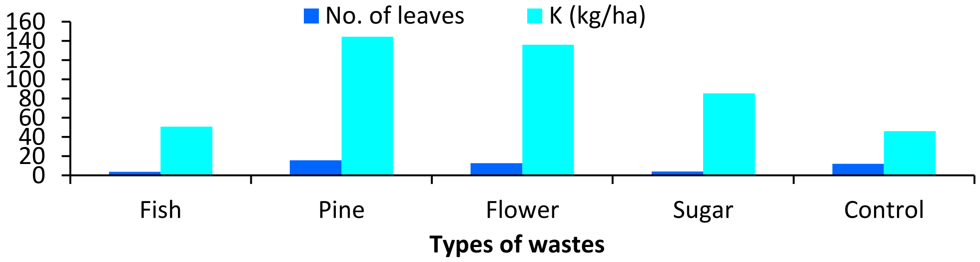
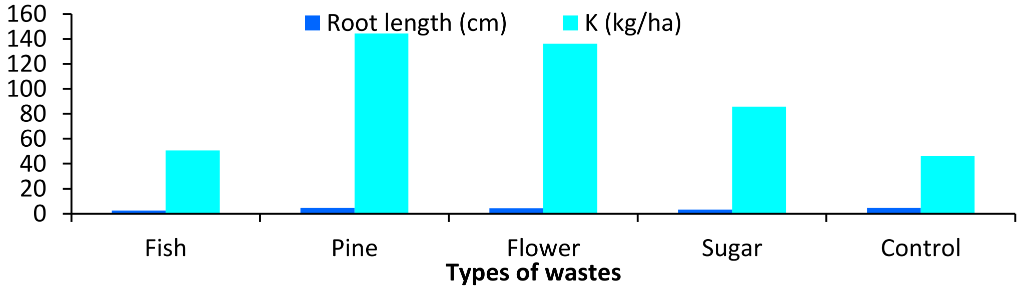


Fig.17.3: Graphical representation root length with respect to exchangeable K



4. B.4. Change in soil and crop characteristics

Maximum increase in the soil moisture was observed in the sugarcane waste amended pots (15.74%) and minimum in the fish waste amended pots (2.48%) (Table 22). Maximum decrease in the bulk density was observed in pineapple waste amended pots (-0.11 g/cm^3) and a minimum decrease in the sugarcane waste amended pots (-0.03 g/cm^3). Maximum increase in the soil porosity was observed in the pineapple wastes amended pots (3.97%) and minimum decrease was found in the sugarcane wastes amended pots (0.88%).

Maximum increase in acidity was observed in the pineapple waste amended pots (0.03) and minimum decrease in the fish waste amended pots (-0.25). There was an overall decrease in pH in all the wastes amendment except in pineapple waste amended pots when compared to control. Related to change in pH definite pattern was not observed which makes the reason to be complicated. Maximum increase in organic C was observed in the pineapple waste amended pots (0.21%) and minimum increase in the fish waste amended pots (0.13%). Maximum increase in the total N was observed in the flower waste amended pots (78.11 Kg/ha) and minimum in the sugarcane waste amended pots (21.56 Kg/ha).

Available P was found to increased maximum in the fish wastes amended pots (15.96 kg/ha) and minimum in sugarcane waste amended pots (0.1 kg/ha). Maximum increase in exchangeable K was observed in the flower waste amended pots (90.22 kg/ha) and minimum decrease in the fish waste amended pots (4.67 kg/ha) (Table 22).The crop chilli showed an increase in height of the plants, no. of leaves and biomass in flower and pineapple wastes amended pots.

Table 22. Physico-chemical characteristics of soil under control and amended pots. The figures within bracket indicates change due to amendment of wastes.

waste	Soil moisture (%)	Bulk density (g/cm^3)	Soil porosity (%)	pH	C (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)
Control	6.85± 1.53	1.21± 0.03	54.46± 0.27	7.21± 0.01	0.27± 0.08	161.22± 14.61	1.55± 4.02	46± 30.40
Sugar cane	22.59± 2.01 (15.74)	1.18± 0.08 (-0.03)	55.34± 0.81 (0.88)	7.20± 0.02 (-0.01)	0.46± 0.05 (0.19)	182.78± 14.61 (21.56)	1.65± 0.94 (0.1)	85.56± 10.53 (39.56)
Fish	9.33± 2.31 (2.48)	1.12± 0.08 (-0.09)	57.78± 1.33 (3.32)	6.96± 0.01 (-0.25)	0.4± 0.12 (0.13)	224± 44.31 (62.78)	17.51± 6.50 (15.96)	50.67± 17.20 (4.67)
Flower	16.48± 6.00 (9.63)	1.15± 0.12 (-0.06)	56.77± 0.58 (2.31)	7.06± 0.03 (-0.15)	0.42± 0.12 (0.15)	239.33± 51.43 (78.11)	7.06± 2.16 (5.51)	136.22± 60.01 (90.22)
Pine apple	21.47± 2.20 (14.62)	1.1± 0.20 (-0.11)	58.43± 0.61 (3.97)	7.24± 0.01 (0.03)	0.48± 0.18 (0.21)	208.22± 29.70 (47)	3.01± 0.47 (1.46)	100.67± 10.07 (54.67)

Table 23. Growth pattern of chilli under control and amended pots. The figures within bracket indicates the change due to amendment of wastes.

Types of wastes	Height(cm)	No of leaves	Root length(cm)	Biomass(g)
Control	19.67±0.47	16±0.94	4.6±0.81	1.13±0.12
Sugarcane	8.67±1.41(-11)	6±0.81(-10)	3.27±1.20(-1.33)	0.6±0.16(-0.53)
Fish	7.67±1.70(-12)	2±0.81(-14)	2.37±1.63(-2.23)	0.27±0.26(-0.86)
Flower	21.67±3.70(2)	25±4.50(9)	4.4±3.55(-0.2)	1.87±0.12(0.74)
Pineapple	17.33±2.62(-2.3)	20±3.55(4)	4.5±2.16(0.1)	1.47±0.20(0.34)

The increase in soil moisture was maximum in the amendment of sugarcane bagasse. The same result was also obtained in cabbage grown pots. The result indicates that these wastes can protect the soil from loss of moisture.

Significant positive correlation of no. of leaves, root length and biomass with exchangeable K showed that amendment of flower wastes was more beneficial for the growth of chilli. Moreover, response of chilli to flower waste was positive in height, no. of leaves and biomass.

Research on the effect of different doses of raw municipal solid waste in Mediterranean semi-arid conditions, ranging between 65 and 260 t/ha demonstrated that 17 years after a single application of the organic amendment there was an average increase of 70% in organic matter content (Batisda *et al*., 2008). Although there was no significant correlation with the crop and soil organic C the role of the wastes in increasing organic C content of soil is an important aspect. Soil organic material applications increased the organic C stock and therefore increased the cation exchange capacity. This effect was due to the high negative charge of organic matter. This is important for retaining nutrients and making available to plants (Ross *et. al*., 2006; Kaur *et. al.*, 2008). Soil rich in organic matter are less prone to erosion than soils with low content, such as those which predominate in arid and semi-arid areas (Duran *et. al*., 2008). Several long lasting application of organic amendments can enhance soil available P, exchangeable K and particularly organic C (Diacono *et. al.*, 2010).

In the short period of three months and limited area of the earthen pots, treatment of flower waste on the crop *Capsicum annum* have profound influence on its productivity. The response of the crop to other types of wastes may not be significant as limited root spread of chilli or brinjal will not be able to take the advantage of the slow release of nutrients from organic sources which diffuses gradually and moves slowly to different layers (Pradeepkumar *et. al.,* 2017).

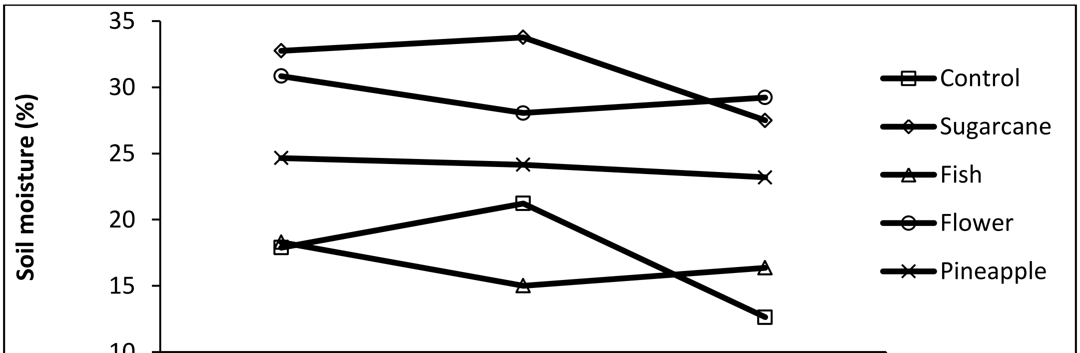
Therefore, out of the four types of wastes amendments flower waste was beneficial for the growth of chilli.

4. C Brinjal *(Solanum melongena)*

4. C.1 Monthly variation

Soil moisture in the control (Fig.18.1) ranged from 12.63% (May,) to 21.22% (April). In sugarcane waste amended pots, the soil moisture ranged from 27.5% (May) to 33.77% (April). Soil moisture in fish waste amended pots ranged from 15.01% (April) to 18.3% (March). In flower waste amended pots, soil moisture ranged from 28.05% (April) to 30.84% (March). The soil moisture in pineapple waste amended pots ranged from 23.2% (May) to 24.66% (March). By comparing with control, the amendment of wastes leads to increase in soil moisture in all types except during April, in fish waste amended pots.

Fig. 18.1.Monthly variation of soil moisture in the control and different amendments for brinjal.



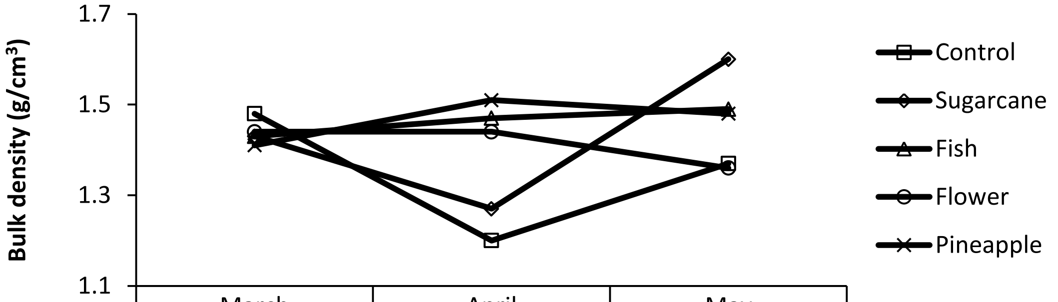
	March	April	May
Control	17.89	21.22	12.63
Sugarcane	32.76	33.77	27.5
Fish	18.3	15.01	16.37
Flower	30.84	28.05	29.23
Pineapple	24.66	24.15	23.2

Plate 9: Growth of brinjal during first month.

Plate 10: Growth of brinjal during second month.

Plate 11: Growth of brinjal during third month.

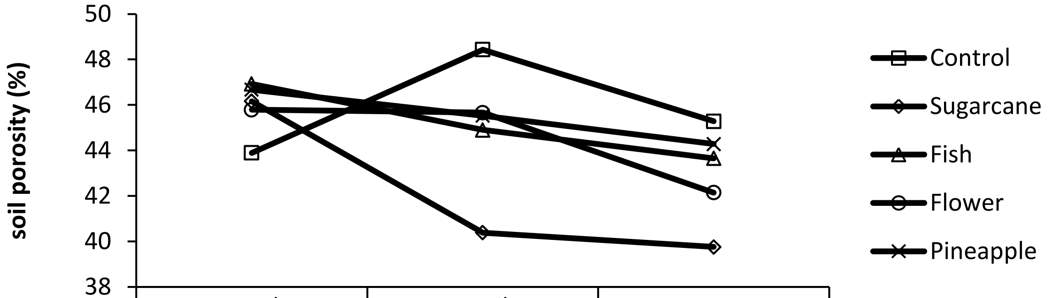
Fig. 18.2.Monthly variation of bulk density in the control and different amendments for brinjal



	March	April	May
Control	1.48	1.2	1.37
Sugarcane	1.43	1.27	1.6
Fish	1.43	1.47	1.49
Flower	1.44	1.44	1.36
Pineapple	1.41	1.51	1.48

It was observed that the bulk density (Fig.18.2) in control pots ranged from 1.2 g/cm^3 (April) to 1.48 g/cm^3 (March). The bulk density ranged from 1.27 g/cm^3 (March) to 1.60 g/cm^3 in sugarcane wastes amended pots. In fish wastes amended pots, it was observed to varied from 1.43 g/cm^3 (April) to 1.49 g/cm^3 (May). The soil bulk density of the flower wastes amended pots ranged from 1.36 g/cm^3 (May) to 1.44 g/cm^3 (March and April). The range of bulk density in pineapple wastes amended pots was from 1.41 g/cm^3 (March) to 1.51 g/cm^3 (March and April).

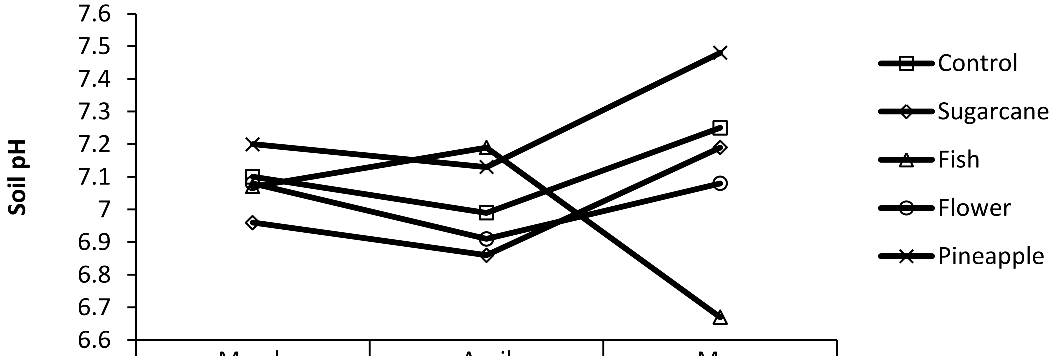
Fig.18.3.Monthly variation of soil porosity in the control and different amendments for brinjal.



	March	April	May
Control	43.89	48.43	45.28
Sugarcane	46.16	40.38	39.75
Fish	46.92	44.9	43.65
Flower	45.79	45.66	42.14
Pineapple	46.67	45.53	44.28

Soil porosity in the control pots (Fig.18.3) was observed to range from 43.89% (May) to 48.43% (April). In sugarcane wastes amended pots, the soil porosity ranged from 39.75% (May) to 46.16% (March). Soil porosity in the fish wastes amended pots ranged from 43.65% (May) to 46.92% (March). It was also observed that the soil porosity of the flower wastes amended pots ranged from 42.14% (May) to 45.79% (March). The porosity of soil ranged from 44.28% (May) to 46.67% (March) in the pineapple wastes amended pots.

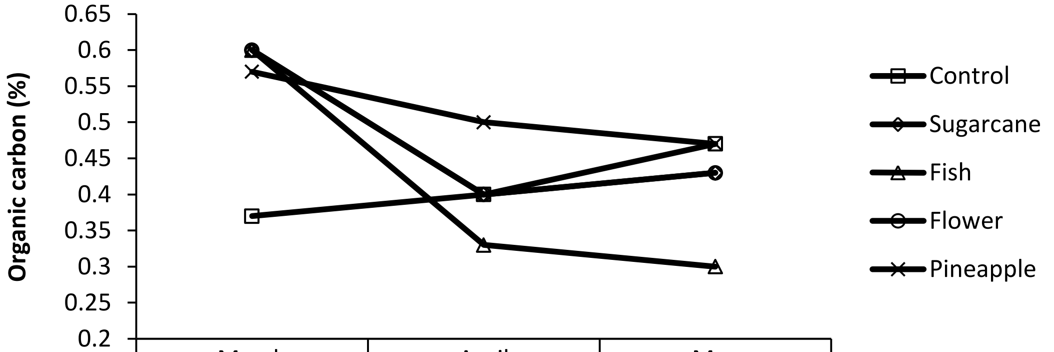
Fig.18.4. Monthly variation of soil pH in the control and different amendments for brinjal.



	March	April	May
Control	7.1	6.99	7.25
Sugarcane	6.96	6.86	7.19
Fish	7.07	7.19	6.67
Flower	7.08	6.91	7.08
Pineapple	7.2	7.13	7.48

The pH in the control pots (Fig. 18.4) ranged from 6.99 (April) to 7.25 (May). In sugarcane wastes amended pots, the pH was observed to range from 6.86 (April) to 7.19 (May). Soil pH in the fish wastes amended pots was recorded to ranged from 6.67 (May) to 7.19 (April). The pH in the flower wastes amended pots ranged from 6.91 (April) to 7.08 (March and May). In the pineapple wastes amended pots, the pH was observed to ranged from 7.13 (April) to 7.48 (May). The soil was overall acidic having a range of 6.67 to 7.48.

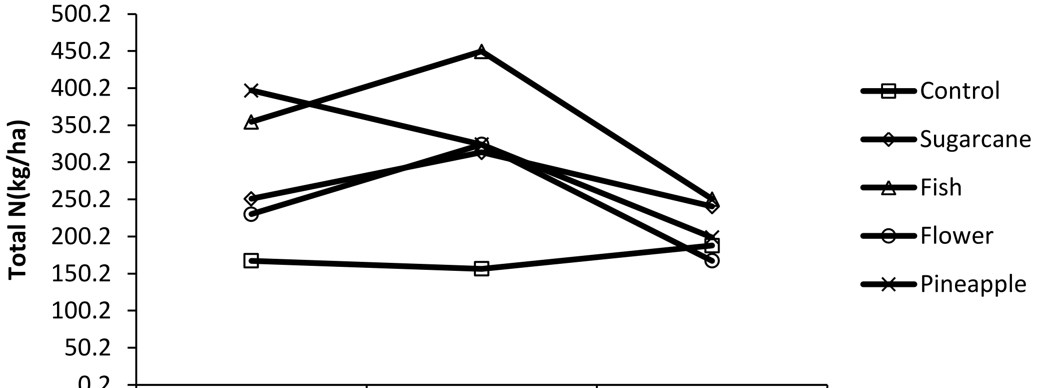
Fig.18.5. Monthly variation of organic C in the control and different amendments for brinjal.



	March	April	May
Control	0.37	0.4	0.47
Sugarcane	0.6	0.4	0.43
Fish	0.6	0.33	0.3
Flower	0.6	0.4	0.43
Pineapple	0.57	0.5	0.47

In the control pots, the organic C (Fig. 18.5) was found to ranged from 0.37% (March) to 0.47% (May). Organic C in sugarcane wastes amended pots ranged from 0.4% (April) to 0.6% (March). Organic C in the fish wastes amended pots was observed to ranged from 0.3% (May) to 0.6% (March). In flower wastes amended pots the range of the organic C was from 0.4% (April) to 0.6% (March). The organic C in the pineapple wastes amended pots was observed to ranged from 0.47% (May) to 0.57% (March). During the month of March there was an overall increase in all the waste amendments compared to the control. However during April in fish waste amendment there was decrease in organic C. During the month of May there was a decline except in pineapple waste amendment.

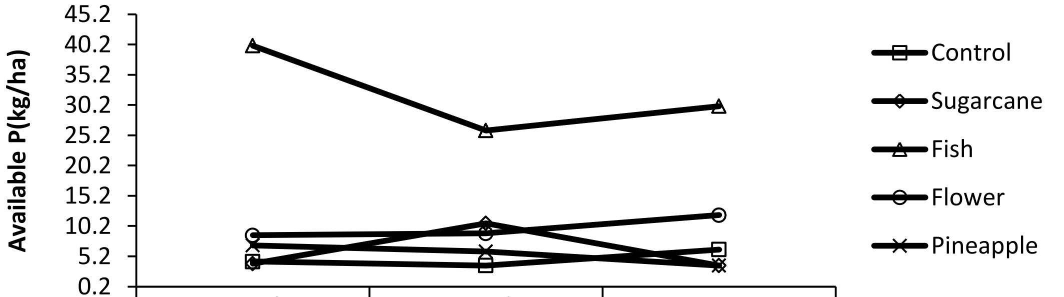
Fig. 18.6.Monthly variation of total N in the control and different amendments for brinjal.



	March	April	May
Control	167.33	156.67	188
Sugarcane	251	313.67	240.67
Fish	354.67	449.67	250.67
Flower	230.33	324.33	167.33
Pineapple	397	324.33	199

The range of the total N in the control pot (Fig. 18.6) was observed to ranged from 156.67 kg/ha (April) to 188 kg/ha (May).Total N in the sugarcane wastes amended pots ranged from 240.67 kg/ha (May) to 313.67 kg/ha (April). It was observed that in the fish waste amended pots it ranged from 250.67 Kg/ha (May) to 449.67 kg/ha (April). The range of total N in the flower wastes amended pots ranged from 167.33 kg/ha to 324.33 kg/ha (April). In the pineapple wastes amended pots it ranged from 199 kg/ha to 397 kg/ha (March). By comparing with control overall increase was observed in all the amendments except in flower waste amendment during May.

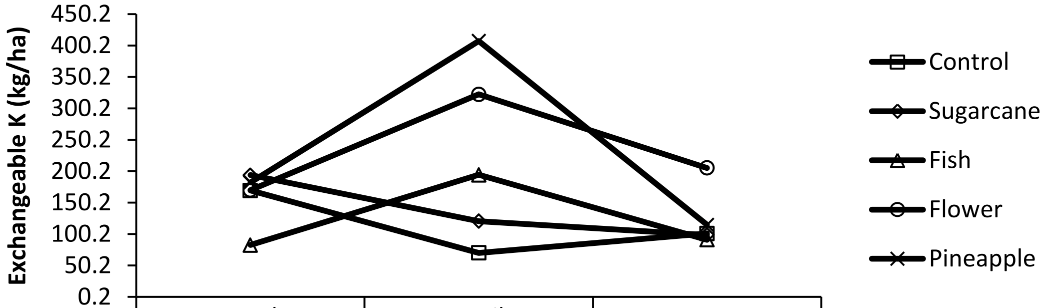
Fig.18.7. Monthly variation of available P in the control and different amendments for brinjal.



	March	April	May
Control	4.33	3.67	6.33
Sugarcane	4	10.67	3.67
Fish	40	26	30
Flower	8.67	9	12
Pineapple	7	6	3.67

Available P was observed to range from 3.67 kg/ha (April) to 6.33 kg/ha (May) in the control pots (Fig. 18.7). In the sugarcane wastes amended pots, available P ranged from 3.67 kg/ha (May) to 10.67 kg/ha (April). It ranged from 26 kg/ha (April) to 40 kg/ha (March) in the fish wastes amended pots. In the flower waste amended pots the range of the available P was from 8.67 kg/ha (March) to 12.0 kg/ha (May). The available P in the pineapple wastes amended pots ranged from 3.67 kg/ha (May) to 7.0 kg/ha (March). There was an increase in all the amendments except in sugarcane waste amendment during March and May, and during May in pineapple waste amendment.

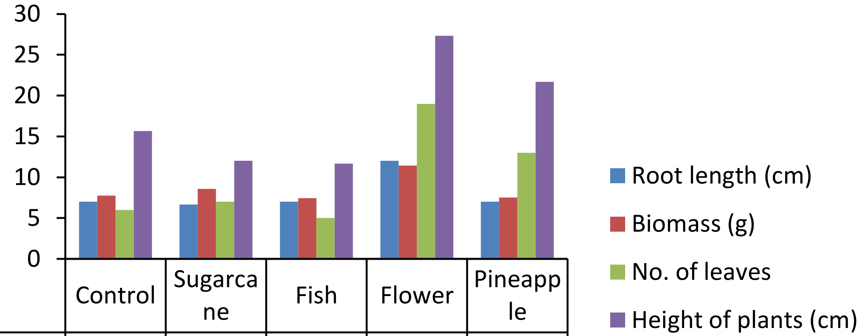
Fig.18.8. Monthly variation of exchangeable K in the control and different amendments for brinjal.



	March	April	May
Control	169.33	70	101
Sugarcane	193.67	120.67	98.67
Fish	82.67	194.33	91
Flower	170	322.33	205.33
Pineapple	182	407.33	114.67

Exchangeable K in the control pots (Fig. 18.8) ranged from 70 kg/ha (April) to 169.33 kg/ha (March). In sugarcane wastes amended pots the exchangeable K ranged from 98.67 kg/ha (May) to 193.67 kg/ha (March). In the fish wastes amended pots it ranged from 82.67 kg/ha (March) to 194.33 kg/ha (April). The range of exchangeable K in the flower waste amended pots was observed from 170 kg/ha (March) to 322.33 kg/ha (April). In the pineapple waste amended pots it ranged from 114.67 kg/ha (May) to 407.33 kg/ha (April). There was an increase in all the amendments compared to control except in fish waste amendment during March and May and in sugarcane waste amendment during May.

Fig.18.9. Monthly variation in characteristics of brinjal in the control and different amendments.



	Control	Sugarcane	Fish	Flower	Pineapple
Root length (cm)	7	6.67	7	12	7
Biomass (g)	7.77	8.57	7.43	11.43	7.5
No. of leaves	6	7	5	19	13
Height of plants (cm)	15.67	12	11.67	27.33	21.67

4. C.2 Anova

Analysis of variance for soil moisture for control and wastes amendments showed significant variation except in fish wastes amended pots (Table 24.1 to 24.2 and 25.1 to 25.2).

Table 24: Anova for Soil Moisture in the control and different amendments for brinjal.

Table 24.1: Control

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	110.62	2	55.31	31.82	P<0.01
Within Groups	10.42	6	1.73		
Total	121.05	8			

Table 24.2: Sugarcane waste amendment.

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	543.34	2	271.67	39.27	P<0.01
Within Groups	41.50	6	6.91		
Total	584.84	8			

Table 25.1: Flower waste amendment.

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	358.81	2	179.40	9.66	P<0.01
Within Groups	111.32	6	18.55		
Total	470.14	8			

Table 25.2: Pineapple waste amendment.

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	117.88	2	58.94	14.37	P<0.01
Within Groups	24.60	6	4.10		
Total	142.48	8			

Significant variation of soil bulk density was observed only in sugarcane waste amended pots ($F=15.913$; $P<0.05$) (Table 26.1).

Table 26: Anova for bulk density in the different amendments for brinjal.

Table 26.1: Sugarcane waste amendment.

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.053	2	0.026	15.91	P<0.01
Within Groups	0.010	6	0.002		
Total	0.063	8			

Significant variation of the soil porosity was observed (Table 27.1) only in the sugarcane wastes amended pots (F=15.914; P<0.05).

Table 27: Anova for porosity in the different amendments for brinjal.

Table 27.1: Sugarcane waste amendment.

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	75.05	2	37.52	15.91	P<0.01
Within Groups	14.14	6	2.35		
Total	89.20	8			

Significant variation of soil pH was observed (Table 28.1 to 28.4) among all the wastes amended pots except in the fish waste amended pots.

Table 28: Anova for pH in the control and different amendments for brinjal.

Table 28.1: Control

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.102	2	0.051	2.95	P<0.1
Within Groups	0.104	6	0.017		
Total	0.206	8			

Table 28.2: Sugarcane waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.43	2	0.21	5.21	P<0.05
Within Groups	0.25	6	0.04		
Total	0.68	8			

Table 28.3: Flower waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.388	2	0.194	4.942	P<0.05
Within Groups	0.235	6	0.039		
Total	0.623	8			

Table 28.4 Pineapple waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.199	2	0.099	5.551	P<0.05
Within Groups	0.108	6	0.018		
Total	0.306	8			

Significant variation of organic C was observed in the fish waste amended pots ($F=8.375$; $P<0.05$) and sugarcane waste amended pots ($F=4.429$; $P<0.1$) (Table 29.1 and 29.2).

Table 29: Anova for organic C in the different amendments for brinjal.

Table 29.1: Sugarcane waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.07	2	0.03	4.43	P<0.05
Within Groups	0.05	6	0.008		
Total	0.12	8			

Table 29.2: Fish waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	0.15	2	0.07	8.37	P<0.01
Within Groups	0.05	6	0.01		
Total	0.20	8			

Significant variation of total N was observed in the pineapple waste amended pots (F=3.193; P<0.1) and flower waste amended pots (F=4.420 ; P<0.1) (Table 30.1 and 30.2).

Table 30: Anova for total N in the different amendments for brinjal.

Table 30.1: Flower waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	37454.00	2	18727.00	4.42	P<0.05
Within Groups	25422.00	6	4237.00		
Total	62876.00	8			

Table 30.2: Pineapple waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	24416.88	2	12208.44	3.19	P<0.1
Within Groups	22943.33	6	3823.88		
Total	47360.22	8			

No significant variation of available P was found in control and wastes amended pots. Significant variation of exchangeable K was found in pineapple waste amended pots (F=7.724 ; P<0.05) and flower waste amended pots (F=3.809 ; P<0.1) (Table 31.1and 31.2).

Table 31: Anova for exchangeable K in the different amendments for brinjal.

Table 31.1. Flower waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	41822.88	2	20911.44	3.81	P<0.1
Within Groups	32938.66	6	5489.77		
Total	74761.55	8			

Table 31.2 Pineapple waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	140962.66	2	70481.33	7.72	P<0.05
Within Groups	54751.33	6	9125.22		
Total	195714.00	8			

Significant variation of crop height was observed in the control and different amendments (Table 32.1 to 32.5)

Table 32: Anova for plant height in the control and different amendments of brinjal.

Table 32.1: Control

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	56.88	2	28.44	9.48	P<0.01
Within Groups	18.00	6	3.00		
Total	74.88	8			

Table 32.2: Sugarcane waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	29.55	2	14.77	10.23	P<0.01
Within Groups	8.66	6	1.44		
Total	38.22	8			

Table 32.3: Fish waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	64.88	2	32.44	12.16	P<0.01
Within Groups	16.00	6	2.66		
Total	80.88	8			

Table 32.4: Flower waste amendment.

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	214.88	2	107.44	10.51	P<0.01
Within Groups	61.33	6	10.22		
Total	276.22	8			

Table 32.5: Pineapple waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	116.66	2	58.33	8.07	P<0.01
Within Groups	43.33	6	7.22		
Total	160.00	8			

Significant variation of number of leaves was observed in control and waste amendments (Table 33.1 to 33.5)

Table 33: Anova for number of leaves in the control different amendments for brinjal.

Table 33.1: Control

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	56.88	2	28.44	9.48	P<0.01
Within Groups	18.00	6	3.00		
Total	74.88	8			

Table33.2: Sugarcane waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	29.55	2	14.77	10.23	P<0.01
Within Groups	8.66	6	1.44		
Total	38.22	8			

Table 33.3: Fish waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	64.88	2	32.44	12.16	P<0.01
Within Groups	16.00	6	2.66		
Total	80.88	8			

Table 33.4: Flower waste amendment

Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	214.88	2	107.44	10.51	P<0.01
Within Groups	61.33	6	10.22		
Total	276.22	8			

Table 33.5: Pineapple waste amendment

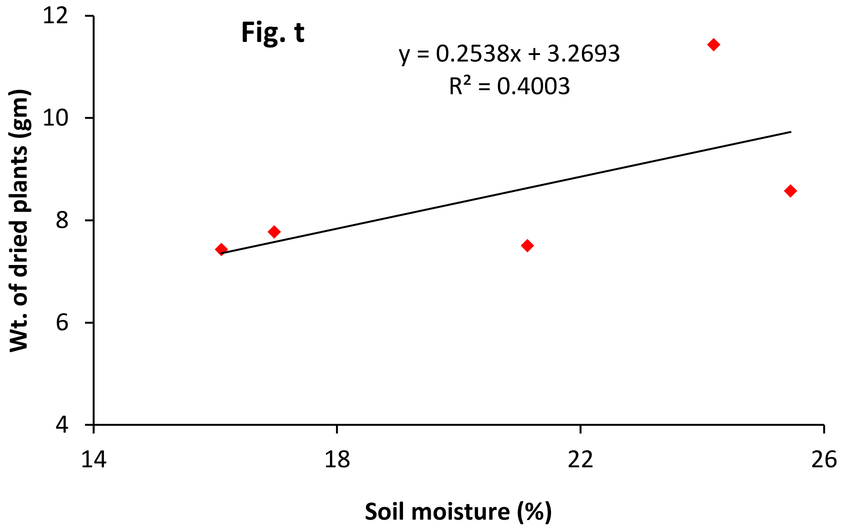
Source of variation	Sum of Squares	df	Mean Square	F	P
Between Groups	116.66	2	58.33	8.07	P<0.01
Within Groups	43.33	6	7.22		
Total	160.00	8			

4. C.3 Correlation

Soil moisture was found to be positively and significantly correlated with biomass (Table 34.1) of the plant (r=0.63). The regression line was shown in Fig. t. All the characteristics of the crop, height, no of leaves, root length and the biomass of the plant have significant correlation between them.

Table 34.1: Correlation (r, n=5) between soil moisture and characteristics of brinjal along with the regression chart (Fig.t).

	Soil moisture (%)	Heights of the plants (cm)	No. of leaves	Root length (cm)
Soil moisture (%)	1	-	-	-
Heights of the plants (cm)	0.42	1	-	-
No. of leaves	0.37	0.90	1	-
Root length (cm)	0.40	0.74	0.95	1
Biomass (g)	0.63	0.65	0.85	0.94



It was observed that the height of the plants, no. of leaves and root length were significantly and negatively correlated with the bulk density (Table 34.2). The regression lines were shown in Figs. u, v and w.

Table 34.2: Correlation (r, n=5) between bulk density and characteristics of brinjal along with the regression charts (Figs. u, v and w).

	Bulk density (g/cm^3)
Bulk density (g/cm^3)	1
Heights of the plants(cm)	-0.55
No. of leaves	-0.60
Root length (cm)	-0.48
Biomass (g)	-0.21

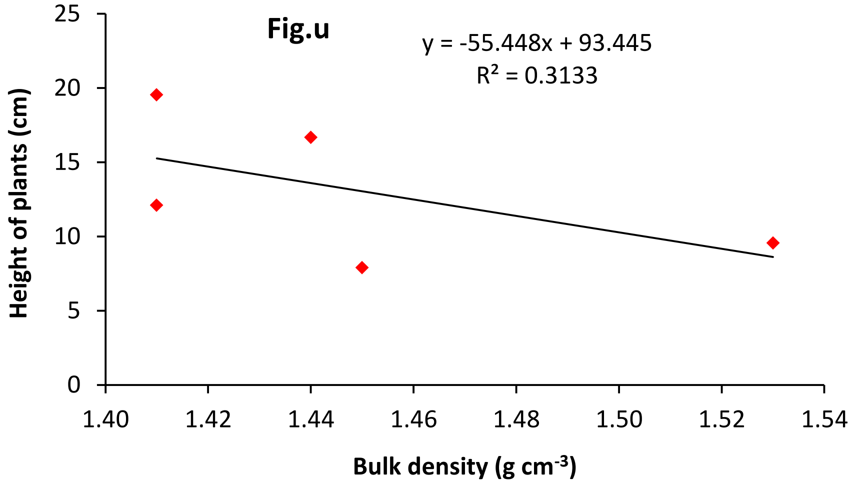


Fig.u
y = -55.448x + 93.445
R² = 0.3133
Height of plants (cm)
25
20
15
10
5
0
1.40
1.42
1.44
1.46
1.48
1.50
1.52
1.54
Bulk density (g cm-3)

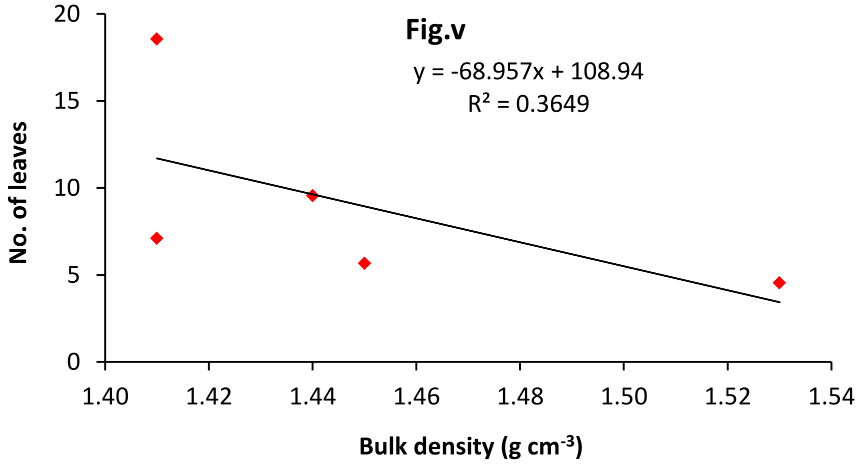


Fig.v
y = -68.957x + 108.94
R² = 0.3649
No. of leaves
20
15
10
5
0
1.40
1.42
1.44
1.46
1.48
1.50
1.52
1.54
Bulk density (g cm-3)

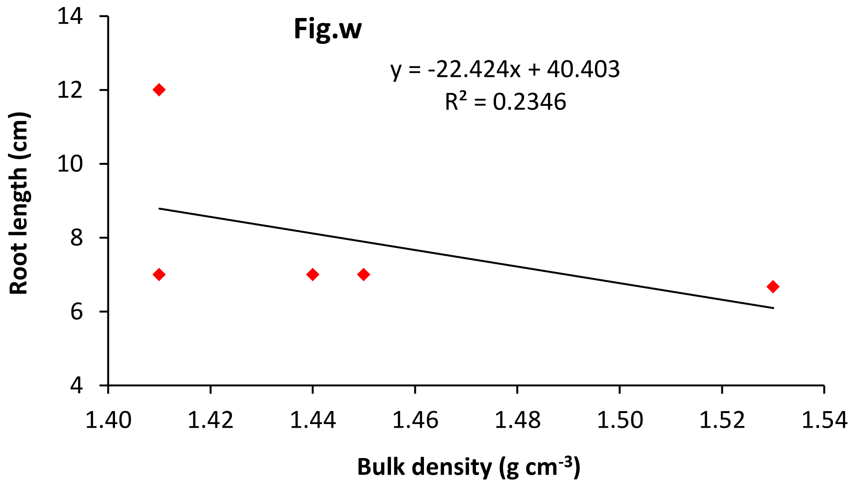
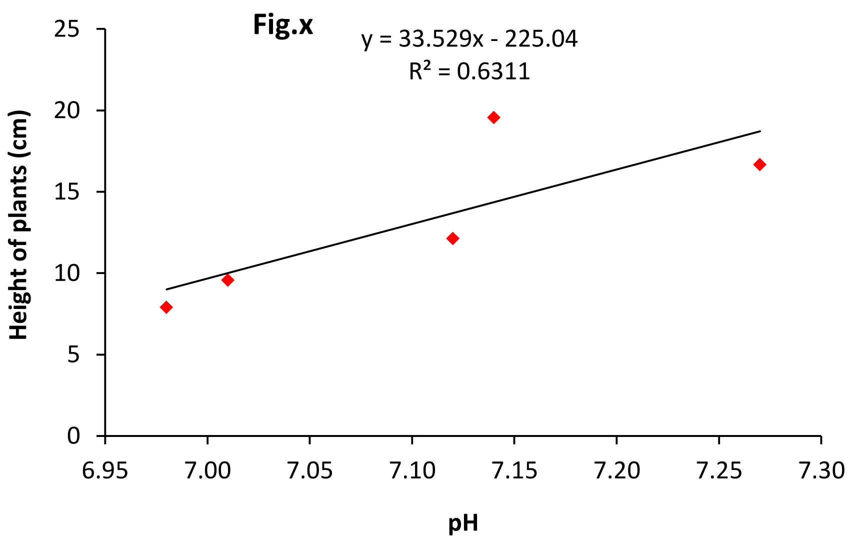


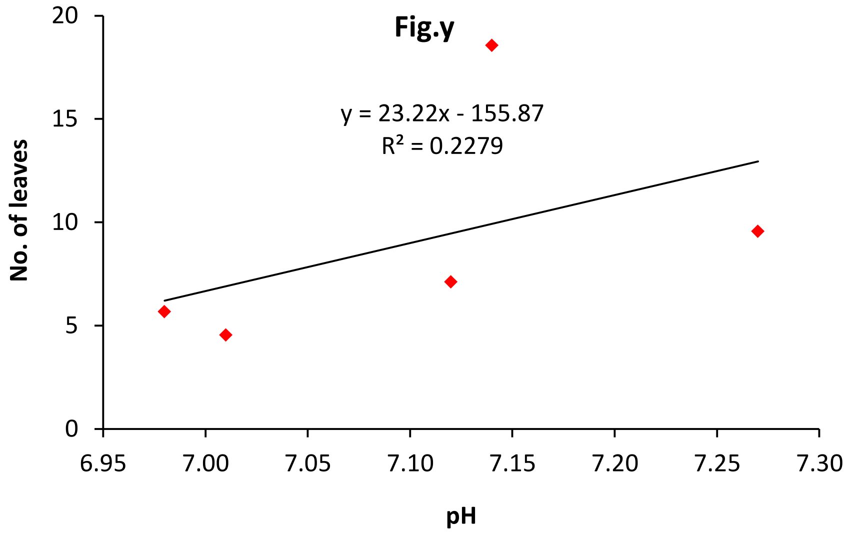
Fig.w
y = -22.424x + 40.403
R² = 0.2346
Root length (cm)
14
12
10
8
6
4
1.40
1.42
1.44
1.46
1.48
1.50
1.52
1.54
Bulk density (g cm-3)

Soil pH was found was found to be significantly and positively correlated with the heights of the plants (r=0.79) and the no. of leaves (r=0.48) (Table 34.4). The regression lines were shown in Figs. x and y.

Table.34.3: Correlation (r, n=5) between pH and characteristics of brinjal along with the regression charts (Figs. x and y).

	pH
pH	1
Heights of the plants (cm)	0.79
No. of leaves	0.47
Root length (cm)	0.20
Wt. of dried plants (g)	0.06

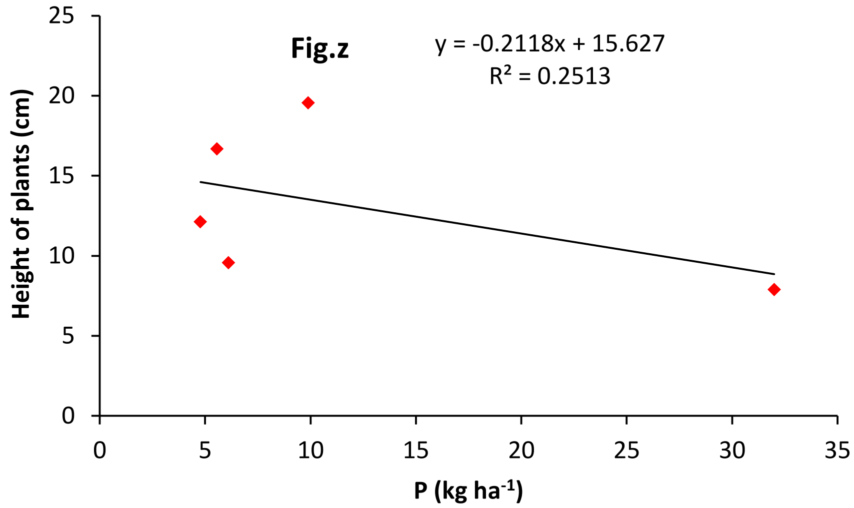




Significant correlation was not observed for organic C and total N with crop characteristics. Available P was not correlated with the heights of the plants (Table 34.4). The regression line was shown in Fig. z.

Table 34.4: Correlation (r, n=5) between available P and characteristics of brinjal along with the regression chart (Fig. z).

	Available P (kg/ha)
Available P (kg/ha)	1
Heights of the plants	-0.50
No. of leaves	-0.19
Root length (cm)	-0.06
Biomass (g)	-0.2



Exchangeable K was found to be positively and significantly correlated with all the characteristics of the crop (Table 34.5). The regression lines were shown in Figs. aa, ab, ac and ad.

Table 34.5: Correlation (r, n=5) between exchangeable K and characteristics of brinjal along with the regression charts (Fig aa, ab, ac and ad).

	Exchangeable K (kg/ha)
Exc. K (kg/ha)	1
Heights of the plants (cm)	0.93
No. of leaves	0.76
Root length (cm)	0.59
Biomass (g)	0.54

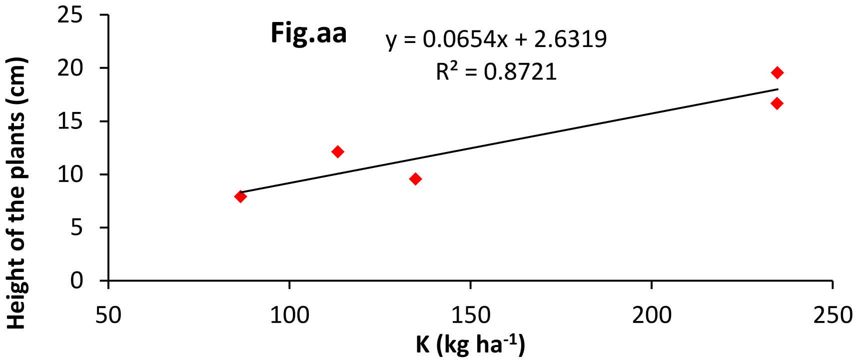


Fig.aa
y = 0.0654x + 2.6319
R² = 0.8721
Height of the plants (cm)
0
5
10
15
20
25
50
100
150
200
250
K (kg ha-1)

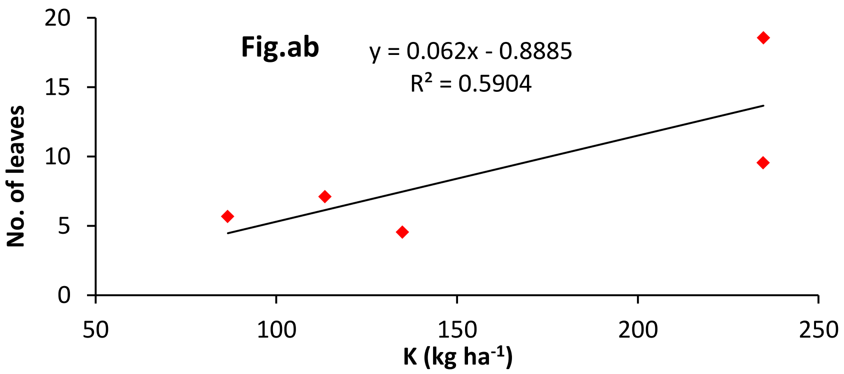


Fig.ab
y = 0.062x - 0.8885
R² = 0.5904
No. of leaves
0
5
10
15
20
50
100
150
200
250
K (kg ha-1)

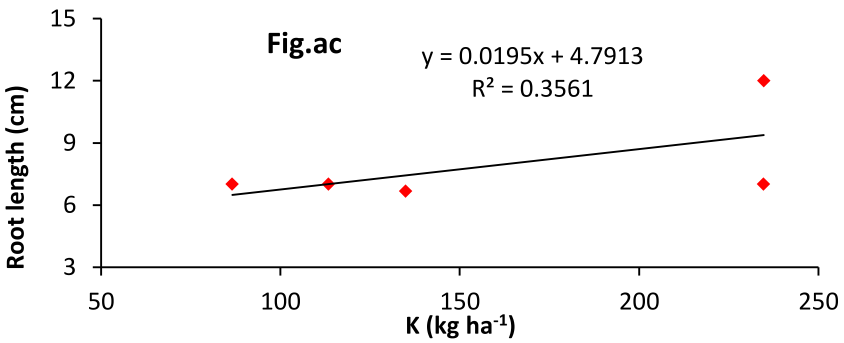


Fig.ac
y = 0.0195x + 4.7913
R² = 0.3561
Root length (cm)
3
6
9
12
15
50
100
150
200
250
K (kg ha-1)

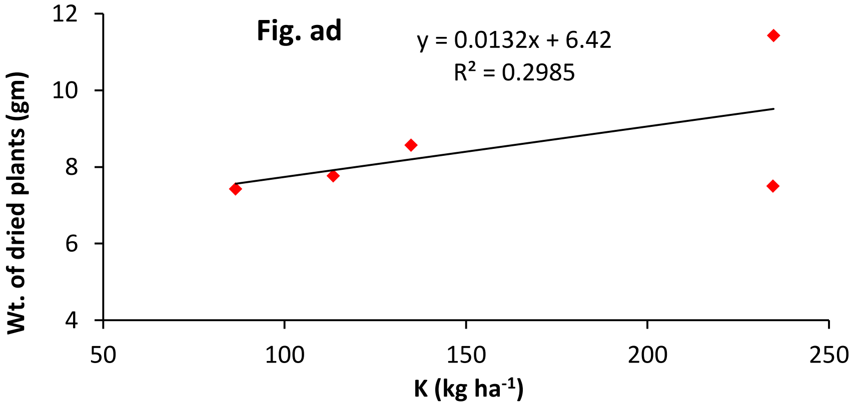


Fig. ad
y = 0.0132x + 6.42
R² = 0.2985
Wt. of dried plants (gm)
4
6
8
10
12
50
100
150
200
250
K (kg ha-1)

Graphical representation of soil moisture with respect to different crop characteristics of brinjal were shown in Figs. 35.1 to 35.4.

Fig.35.1: Graphical representation of height of brinjal with respect to soil moisture.

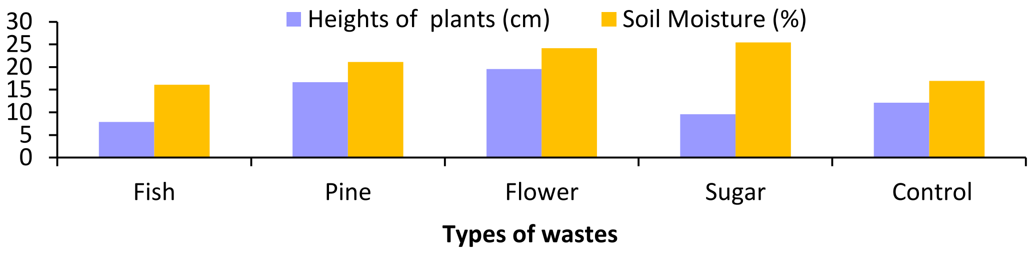


Fig.35.2: Graphical representation of no. of leaves of brinjal with respect to soil moisture.

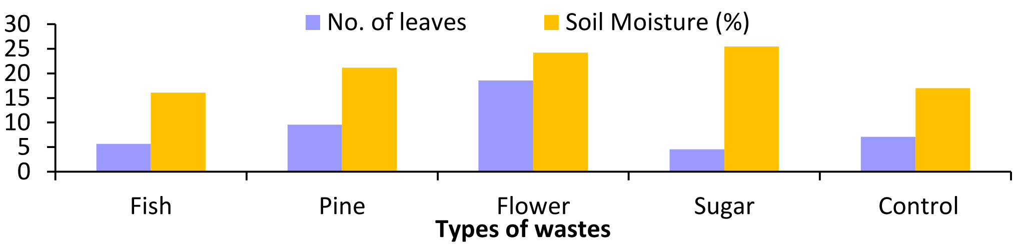


Fig.35.3: Graphical representation of root length of brinjal with respect to soil moisture.

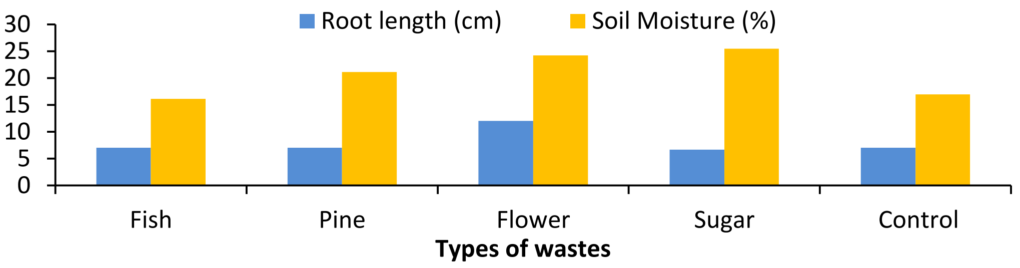
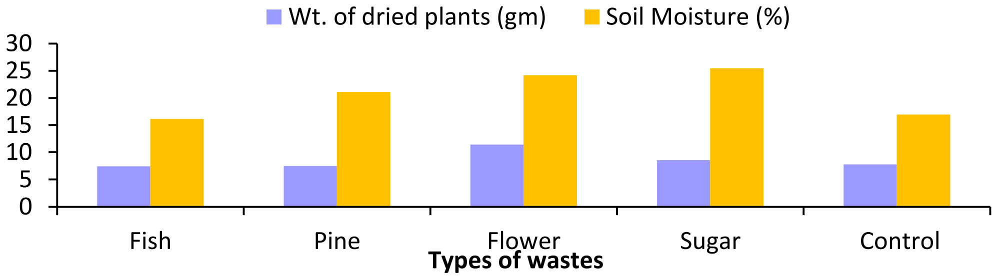


Fig.35.4: Graphical representation of biomass of brinjal with respect to soil moisture.



Graphical representation of porosity with respect to different crop characteristics of brinjal were shown in Figs. 36.1 to 36.4.

Fig.36.1: Graphical representation of height of plant of brinjal with respect to porosity.

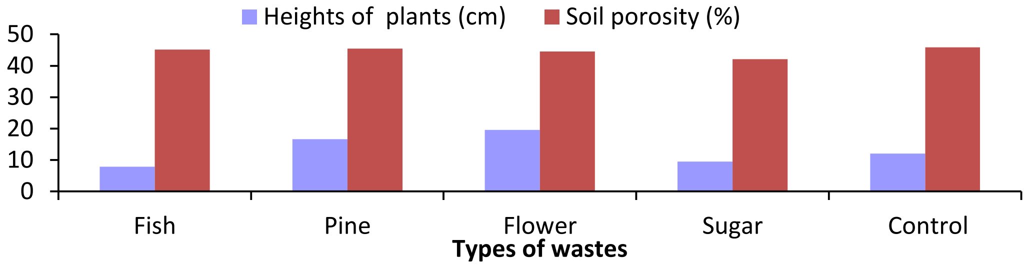


Fig.36.2: Graphical representation of no. of leaves of brinjal with respect to porosity.

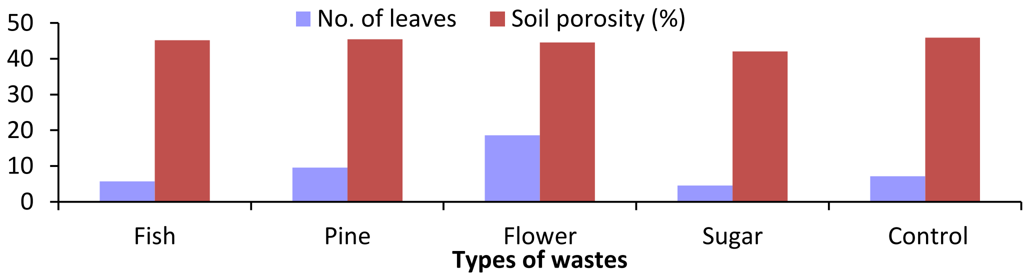


Fig.36.3: Graphical representation of root length with respect to porosity.

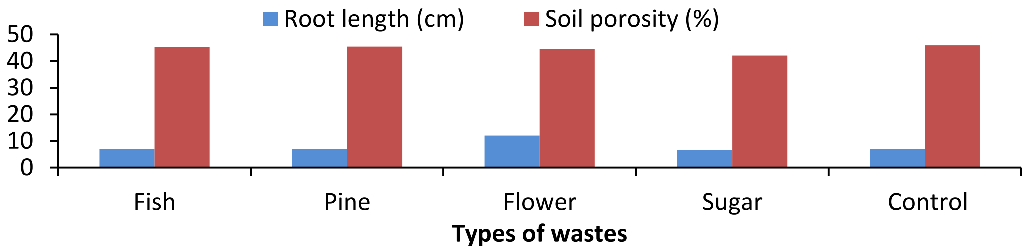
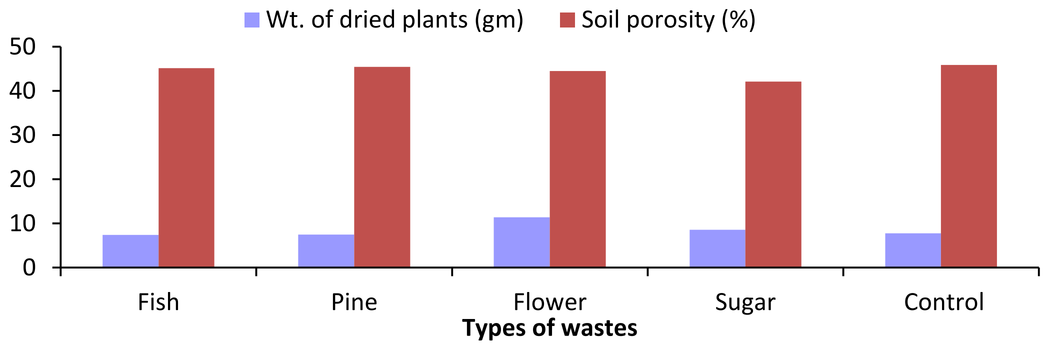


Fig.36.4: Graphical representation of biomass with respect to porosity.



Graphical representation of pH with respect to different crop characteristics of brinjal were shown in Figs. 37.1 to 37.4.

Fig.37.1: Graphical representation of height of plant with respect to pH.

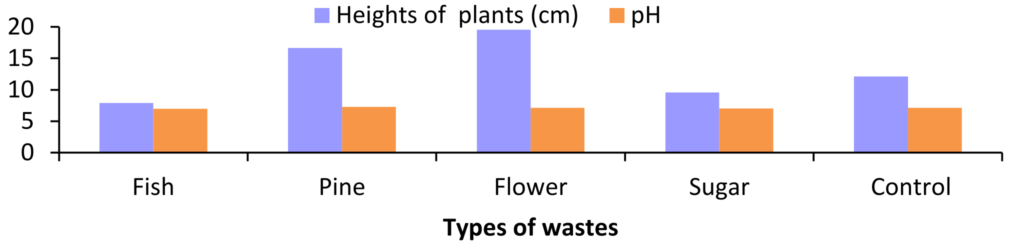


Fig.37.2: Graphical representation of no. of leaves with respect to pH.

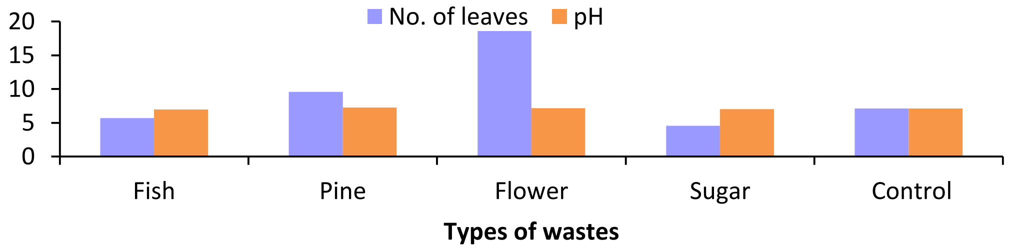


Fig.37.3: Graphical representation of root length with respect to pH.

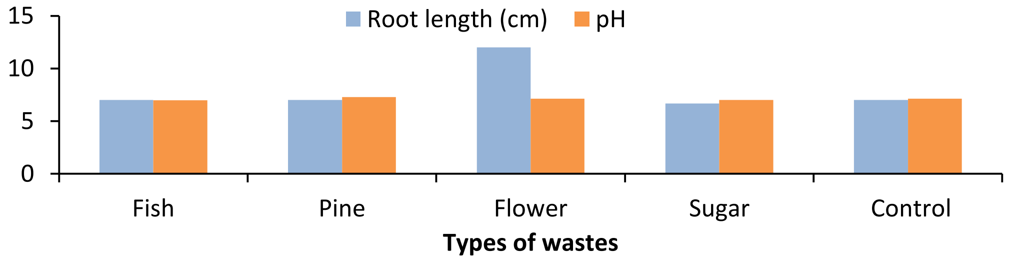
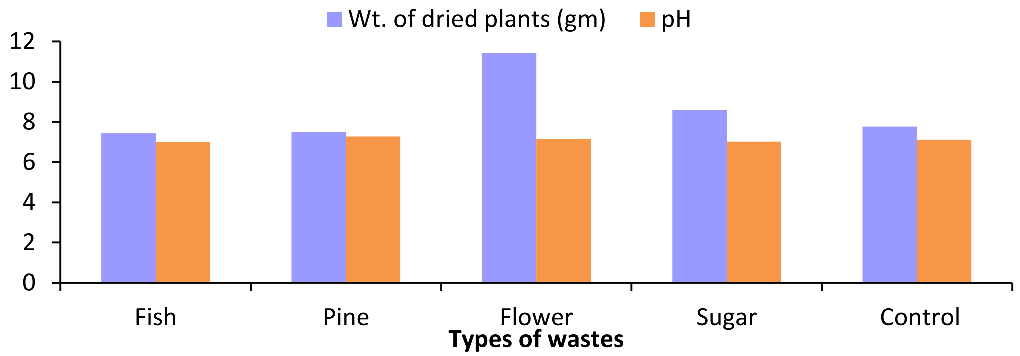


Fig.37.4: Graphical representation of biomass with respect to pH.



Graphical representation of organic C with respect to different crop characteristics of brinjal were shown in Figs. 38.1 to 38.4.

Fig.38.1: Graphical representation height of plant with respect to organic C.

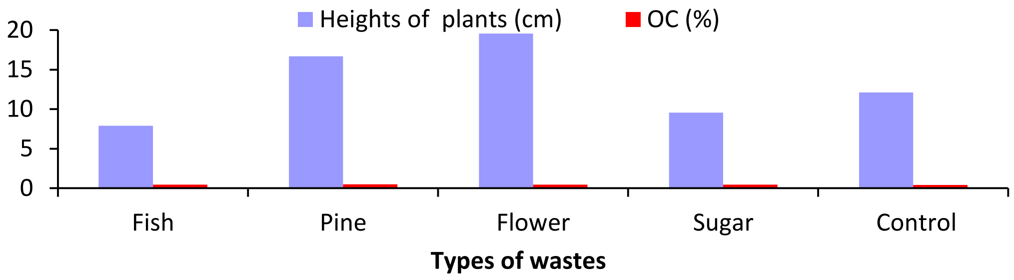


Fig.38.2: Graphical representation no. of leaves with respect to organic C.

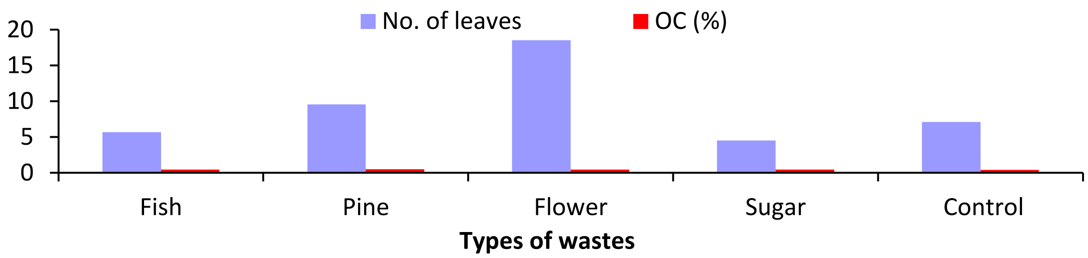


Fig.38.3: Graphical representation root length with respect to organic C.

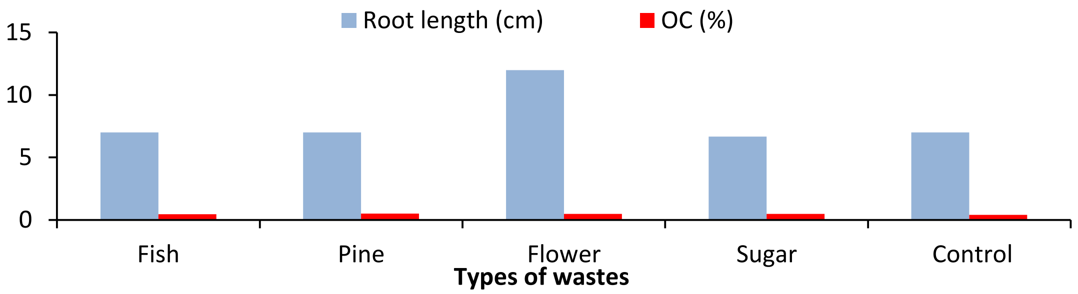
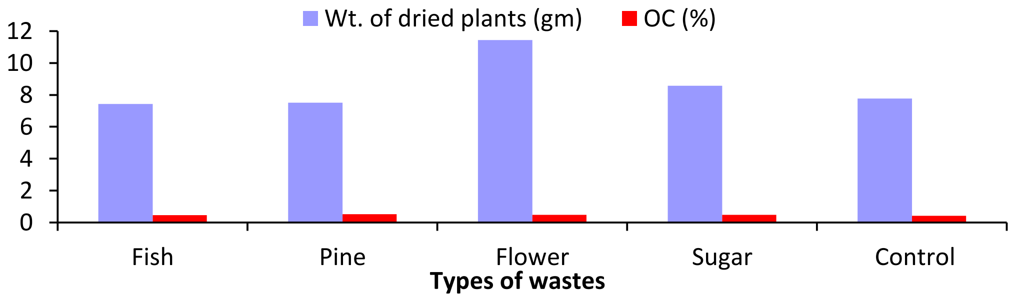


Fig.38.4: Graphical representation biomass with respect to organic C.



Graphical representation of total N with respect to different crop characteristics of brinjal were shown in Figs. 39.1 to 39.4.

Fig.39.1: Graphical representation height of plant with respect to total N.

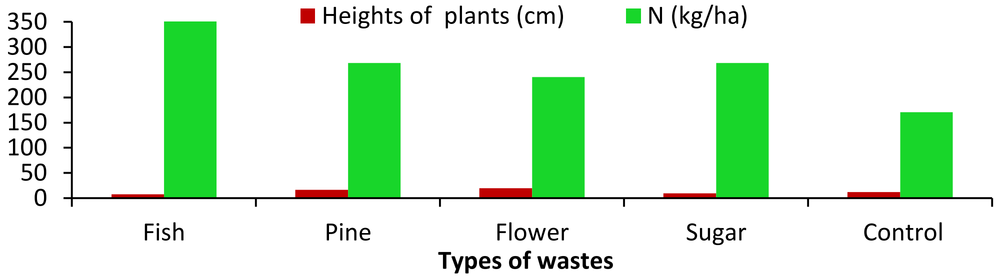


Fig.39.2: Graphical representation no. of leaves with respect to total N.

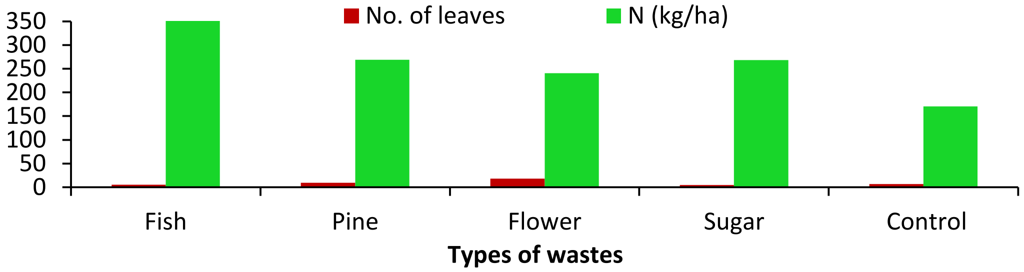


Fig.39.3: Graphical representation root length with respect to total N.

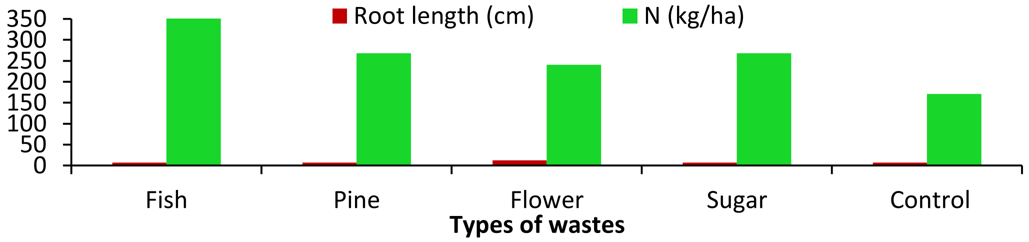
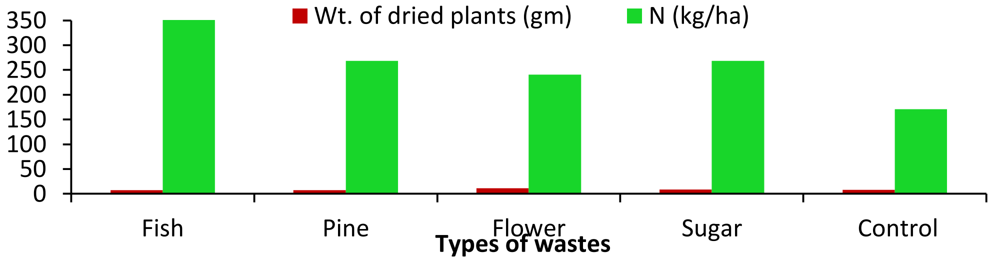


Fig.39.4: Graphical representation biomass with respect to total N.



Graphical representation of available P with respect to different crop characteristics of brinjal were shown in Figs. 40.1 to 40.4.

Fig.40.1: Graphical representation height of plant with respect to available P.

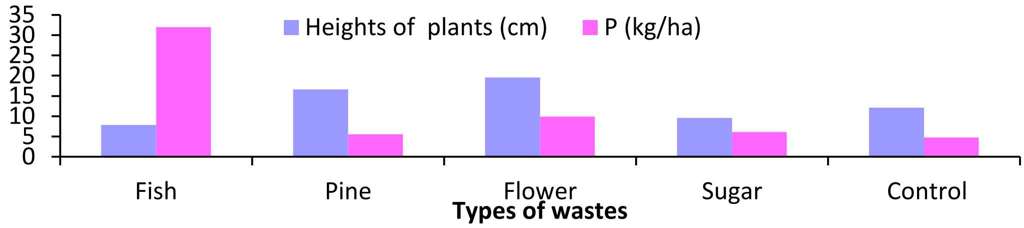


Fig.40.2: Graphical representation no. of leaves with respect to available P.

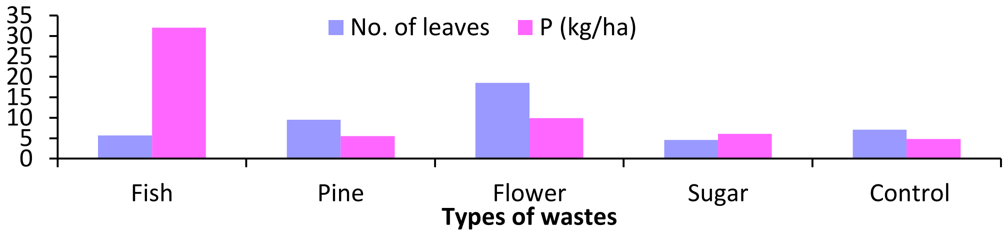


Fig.40.3: Graphical representation root length with respect to available P.

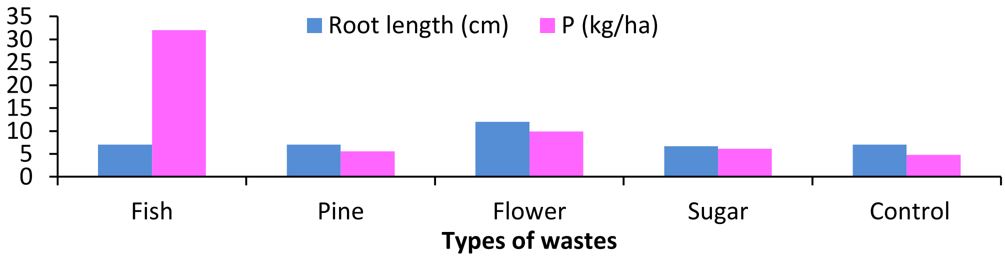
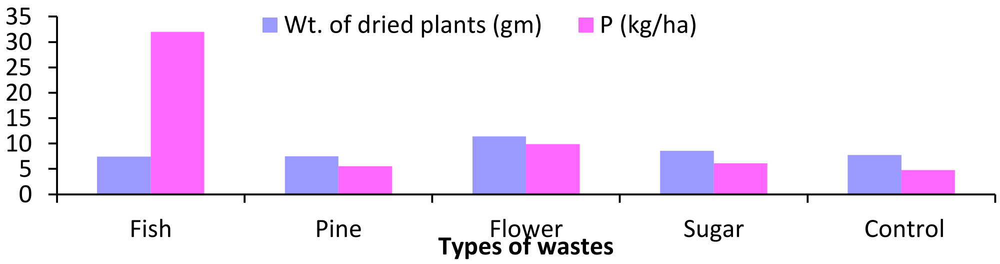


Fig.40.4: Graphical representation biomass with respect to available P.



Graphical representation of exchangeable K with respect to different crop characteristics of brinjal were shown in Figs. 41.1 to 41.4.

Fig.41.1: Graphical representation height of plant with respect to exchangeable K.

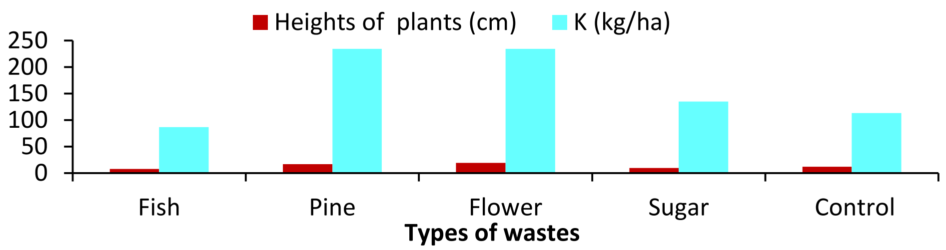


Fig.40.2: Graphical representation no. of leaves with respect to exchangeable K.

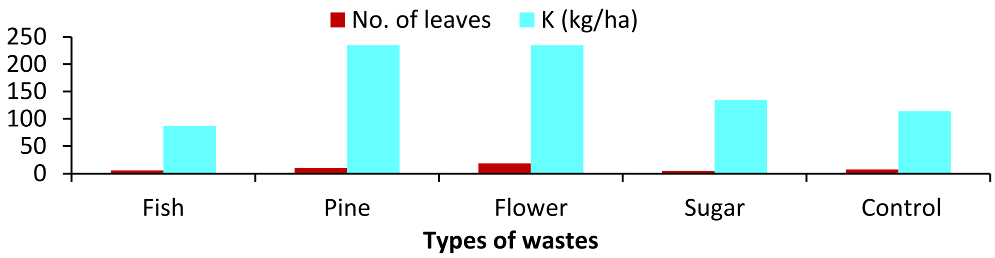


Fig.40.3: Graphical representation root length with respect to exchangeable K

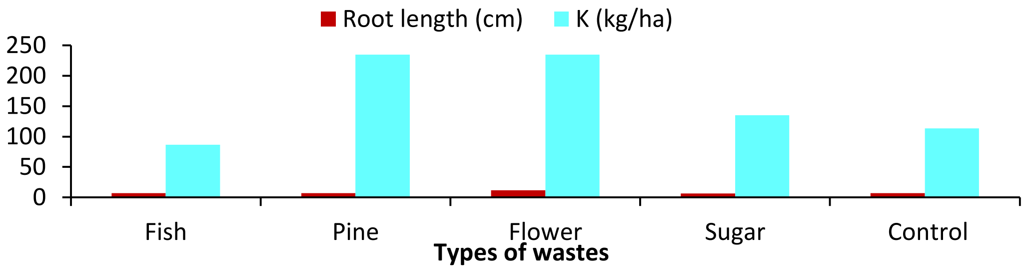
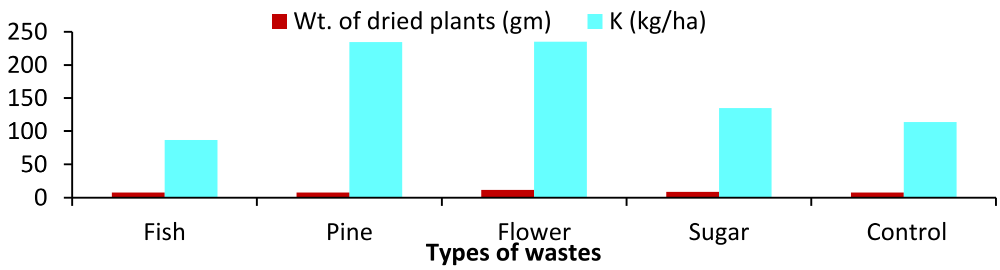


Fig.40.4: Graphical representation biomass with respect to exchangeable K.



4. C. 4. Change in soil and crop characteristics

Soil moisture was found to increase in all the wastes amended pots except in the fish wastes amended pots when compared with the control pot. Maximum increase in soil moisture was observed in sugarcane waste amended pots (14.10%) (Table 35). Increase in bulk density was maximum in pineapple waste amended pots (0.12g/cm^3) and minimum in the flower waste amended pots (0.06g/cm^3). Decrease in soil porosity was found to be maximum in pineapple waste amended pots (-0.38%) and minimum in sugarcane waste amended pots (-3.77%).

Increase in organic C was observed to be maximum in the pineapple waste amended pots (0.10%) and no increase in fish waste amendment (Table 35). Total N was found to increase in all the treated pots. Maximum increase was observed in the fish waste amended pots (181.00 kg/ha) and minimum in the flower waste amended pots (69.99kg/ha). Available P was found to increased maximum in the fish waste amended pots (27.22 kg/ha) and minimum in pineapple waste amended pots (0.78 kg/ha). Maximum increase in exchangeable K was observed in pineapple waste amended pots (121.23 kg/ha) and minimum in fish waste amended pots (9.23 kg/ha).

Table 35. Physico-chemical characteristics of soil under control and amended pots. The figures within bracket indicates change due to amendment of wastes.

Type of waste	Soil moisture (%)	Bulk density (g/cm^3)	Soil porosity (%)	pH	C (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)
Control	17.24± 1.53	1.35± 0.03	45.87± 1.89	7.11± 0.01	0.41± 0.08	170.67± 14.61	4.78± 4.02	113.44± 30.40
Sugarcane	31.34± 2.01 (14.10)	1.43± 0.08 (0.08)	42.10± 2.88 (-3.77)	7.00± 0.02 (-0.11)	0.47± 0.05 (0.07)	268.45± 14.61 (97.78)	6.11± 0.94 (1.33)	137.67± 10.53 (24.23)
Fish	16.56± 2.31 (-0.68)	1.46± 0.08 (0.11)	45.16± 1.34 (-0.71)	6.98± 0.01 (-0.13)	0.41± 0.12 (0.00)	351.67± 44.31 (181)	32± 6.5 (27.22)	122.67± 17.20 (9.23)
Flower	29.37± 6.00 (12.13)	1.41± 0.12 (0.06)	44.53± 1.69 (-1.34)	7.02± 0.03 (-0.09)	0.48± 0.12 (0.07)	240.66± 51.43 (69.99)	9.89± 2.16 (5.11)	232.55± 60.01 (119.11)
Pineapple	24.00± 2.20 (6.76)	1.47± 0.20 (0.12)	44.28± 0.97 (-0.38)	7.27± 0.01 (0.16)	0.51± 0.18 (0.10)	306.78± 29.70 (136.11)	5.56± 0.47 (0.78)	234.67± 10.07 (121.23)

Table 36. Growth pattern of Brinjal under control and amended pots. The figures within bracket indicates the change due to amendment of wastes.

Types of wastes	Height (cm)	No of leaves	Root length (cm)	Biomass (g)
Control	15.6±0.47	6±0.94	7.0±0.81	7.7±0.12
Sugarcane	12.0±1.41(-3.6)	7±0.81(1)	6.6±1.20(-0.4)	8.5±0.16(0.8)
Fish	11.6±1.70(-4.0)	5±0.81(-1)	7.0±1.63(0)	7.4±0.26(-0.3)
Flower	27.3±3.70(11.7)	19±4.50(13)	12.0±3.55(5)	11.4±0.12(3.7)
Pineapple	21.6±2.62(6.0)	13±3.55(7)	7.0±2.16(0)	7.5±0.20(-0.2)

The increase in soil moisture was also observed to be maximum in sugarcane waste amended pots. Recommendation of sugarcane bagasse can be done for retention of soil moisture in degraded lands, arid and semi-arid soils.

By referring to the response of the crop brinjal to different amendments, flower wastes amendment showed maximum positive influence, however significant correlation was observed only with exchangeable K of soil. Amendment of pineapple waste was showing maximum increase in exchangeable K, moreover analysis of variance was significant in exchangeable K in all amendments. Therefore growth of brinjal was more in respect of pineapple waste. Amendment of flower waste comes next to pineapple waste amendment in increasing level of exchangeable K. Therefore, pineapple waste and flower waste amendments can be considered to have positive influence in the soil and the crop brinjal.

5. GENERAL DISCUSSION AND CONCLUSION

In the present study, the wastes collected for amendment in soil were chopped into small pieces having sizes of 1 to 2cm. After amendment with soil they were stabilized for one month. Through visual observation it was found that the wastes have decomposed in the soil by 90%. Fine textured compost had greater effect on growth of crop and soil properties compared to coarse textured composting. The reason was due to higher surface area to volume ratio of the former. Larger surface area increase the contact area with water, thereby the salts and nutrients are leached from the compost layer to the soil providing accessibility of soil and compost microbes (Duong *et al*., 2012).

The soil moisture was found to increased maximum in the sugarcane waste amendment. During the growth of the crop Cabbage the soil moisture does not showed significant variation in sugarcane as well as other waste amendments. However during the growth of the crops Chilli and Brinjal, there was significant variation of soil moisture in the sugarcane waste amendments. The results indicate that due to amendment of sugarcane waste maximum amount of soil moisture was retained in soil. Although the amendment of sugarcane waste does not showed positive impact on the characteristics of growth pattern of the crops based upon the non -significant correlations, these type of waste have profound impact on soil moisture. Therefore recommendation of sugarcane waste amendment can be made for protecting the soil from loss of moisture, especially in arid and semiarid regions.

Increase in soil organic C, total N, available P and exchangeable K were observed in all the amendments, however response of different crops due to the changes were different. Moreover, variation of all the soil properties were not always significant in the different amendments. Therefore, the results can be discussed based upon the response of the three types of crops separately.

During the growth of Cabbage there was maximum increase of organic C in flower waste amendment (0.58%). In fish waste amendment maximum increase in total N (301.5kg/ha) and available P (74.86kg/ha) was found. There was significant correlation of organic C, total N and available P with the majority of crop characteristics. However significant variation was found in available P and organic C in fish waste amendment only. Therefore from the statistical observations it can be stated that the growth of the crop cabbage responds maximum in the fish waste amendment. The maximum increase in available P was the important factor in the growth of cabbage in fish waste amendment.

During the growth of the crop chilli maximum increase of total N and exchangeable K were found in flower waste amendment : 78.11kg/ha and 15.96kg/ha respectively. Available P increased maximum in fish waste amendment (90.22kg/ha). However, there was significant positive correlation only with exchangeable K and crop characteristics. There was negative correlation of available P with crop characteristics. Moreover, analysis of variance showed significant variation of exchangeable K only in flower waste amendment. The results indicate that the crop Chilli responds positively and significantly only in the flower waste amendment due to the maximum increase in the amount of soil exchangeable K.

The response of Chilli in available P was negative , whereas in cabbage it was positive. Maximum increase in available P was found in fish waste amendment in both types of crop growth.

During the time when the crop Brinjal was grown, maximum increase of organic C was found in pineapple waste amendment (0.10kg/ha), total N available P in fish waste amendment : 181 kg/ha and 27.22kg/ha respectively. Exchangeable K increased maximum in pineapple waste amendment (121.23kg/ha). By comparing with growing stage of Cabbage and Chilli, during the growth of Brinjal there was also maximum increase in available P in fish waste amendment, indicating that this type of waste have high content of available P.

The response of the crop Brinjal towards available P was negative as there was negative correlation with crop characteristics. Significant variations of total N and exchangeable K were found in flower waste and pineapple waste amendments. However significant positive correlation was observed only with exchangeable K and the crop characteristics. The results indicate that exchangeable K plays an important role in the growth of brinjal. As there was maximum increase in level of exchangeable K in pineapple waste amendment followed by flower waste amendment, it can be stated that these wastes have positive impact on growth of brinjal.

Many studies reported positive response of different types of crop towards organic waste amendment either in the form of raw waste on in the form of compost. The microflora of the soils treated with organic fertilizers made from market refuse consist of different population offering more favorable conditions for growth of sunflower crop and protects the soil from harmful microorganisms (Marchesine *et* *al*.,1988). Poultry manure contained high amount of P which leads to higher storability of the crop tomato (Ghorlani *et al.,* 2008). Food wastes were rich in cellulose, hemicellulose, lignin and other functional groups which aid in retaining metals to these substrates (Hashem *et al.,* 2007). The yield and quality of honeydew melon significantly and positively correlated with applied spent mushroom substrate (Wang, 2016) and municipal solid waste compost (Wenliang *et al.,* 2008). Usage of fish waste compost increase root length of lettuce (Busato *et al*., 2017). Yield of alfalfa increased by 1.2 times higher in amendment of municipal solid waste compost (Mbarki *et al.,* 2008). Plant uptake of P increased by addition of municipal solid waste in tomato, strawberry, spinach and potato (Zheljazkov *et al*., 2005)

Significant variation in physical characteristics as well as some of the chemical soil characteristics was not observed in the present study. The reason could be attributed to the short period of the study. The amendment of the waste in the pots could be kept for longer duration of at least one year, so that significant variations could be observed. However in the short period of the present study important findings were observed and stated above. After twelve weeks of incubation, pineapple residue treatments showed an increasing trend in mineral N content in soil whereas sugarcane trash did not (Asghar and Kinehiro, 1976).

In all the amendments although significant variation was not observed in all conditions, increase in organic C in soil was observed. Many studies have reported such type results (Leogrande *et al.,* 2013; Yazdanpanah *et al.,* 2016). Application of low cost agricultural byproducts of wheat straw, composted bagasse, farmyard manure, bio-humus, chicken manure, municipal solid wastes and tobacco wastes increased concentration of organic matter in soil. The application also leads to significant increase in structural stability, total porosity, infiltration rate, water content and decrease bulk density (Barzegar *et al.*, 2002; Shukla *et al.*,2008; Mamedov *et al.*, 2014; Scotti *et al*., 2016; Cercioglu *et al.*, 2017). Supply of 15t/ha of compost was able to restore soil C-mineralization reducing hazards of high release of nitrates in soil caused by high dose of compost (Morra *et al*., 2010). Amendment of manure increase level of N (Acjiba et al., 2010) and available P in soil (Yan *et al*.,2016).

The increase in soil as well as crop characteristics due to amendment of solid waste were mainly due to increase in the level of soil micro flora and micro fauna. Addition of manure increased the population of nitrifying and ammonifying bacteria in soil (Shukla *et al.*, 2008). Population of bacteria and fungi increased by 16% in soil treated with biowaste (Ceuvas, 2009). Microbial respiration increase in soil amended municipal solid waste (Yazdanpanah *et al.*, 2016)

Limitations are also associated with amendment of municipal solid waste in soil and growing of crop therein. Decomposition of wastes in soil led to increase in soil salinity due to direct solubilization of ions releasing soluble minerals which may be harmful to crop and soil (Scotti *et al.*, 2016). Various types of heavy metals were released into soil and plants due to addition of municipal solid waste (Debiase *et al.*, 2016). Therefore selection of non-polluted bio waste should be undertaken for converting into compost as well as direct amendment in soil.

Finally it can be conclude that sugarcane bagasse have the potential to control loss of soil moisture. Addition of fish waste leads to significant increase in the level of available P in soil which was beneficial for the growth of the crop cabbage. The response of the growth pattern of the crops chilli and brinjal was negative towards available P, however, they respond to the amendment of flower and pineapple wastes respectively due to enhancement of exchangeable K in soil.

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10. List of papers presented in conferences and seminars

Sl. No.	Title of Paper	Conference and Seminar
1.	Change in soil physico-chemical properties due to treatment of organic wastes	The 105th Indian Science Congress M.U. March 16-20, 2018.
2.	Impact of Soil Amendment with Organic Wastes on Growth Pattern of Chilli	National Seminar on Ethnobiology and Traditional Knowledge in Biodiversity Conservation- Approaches and Dimensions. Assam University,Silchar. February 2 and 3, 2017.

11. List of papers published

Sl. No.	Authors	Title of paper	Name of journal
1.	**Yaiphabi Akoijam,** Angom Sarjubala Devi and Elangbam Jadu Singh	Impact of Solid Wastes Treatment on Growth Pattern of *Capsicum annum* and soil properties.	Environment&Ecology 35(4E):3813-3816, October-December 2017. ISSN 0970-0420.
2.	**Yaiphabi Akoijam**, Angom Sarjubala Devi and Elangbam Jadu Singh	Effect of solid wastes amendment on growth and yield of *Solanum melongena.*	Indian J. Agric. Res., 52(4) 2018:409-413 Print ISSN:0367-8245

1. Paper published in Book

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