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Research Article

EFFICACY OF BANANA (*Musa paradisiaca*) AND SWEET LIME (*Citrus limetta*) PEELS AS NATURAL FERTILIZER IN HERBS

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Abstract- This investigation was elucidated to check the efficacy of banana (*Musa paradisiaca*) and sweet lime (*Citrus limetta*) peel as natural fertilizer in herbs *i.e*., coriander and mint. One way of using natural fertilizer is composting. Composting practice is an alternative sustainable waste management practice to transform organic waste into valuable commodity benefiting the environment because manure nutrients are converted to more stable forms, are less likely to reach groundwater or move in surface runoff. Compost is valued for its organic matter content and is typically used as a soil amendment to enhance the chemical, physical and biological properties of soil. The fruit peels were used in various combinations using backyard composting and their effect on plant growth and soil composition was observed. Results showed that plant sample containing a combination of both the fruit peels showed the best growth and coriander showed a faster rate of growth as compared to mint concluding that soil sample having a neutral pH gave the best results.

Keywords- Natural fertilizer, sweet lime peel, banana peel, backyard composting

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Introduction

Over the last century, the global population has quadrupled. Earlier, in 1915, the world population was 1.8 billion. Today according to the most recent estimate by the United Nations, there are 7.3 billion people - and may reach 9.7 billion by 2050. This increase in the population as well as the income rising in developing countries is also causing an increase in demand for food. With such rampant increase in population, industrialization and in order to meet such high demand of food, the farmers have to produce more and more food. This can be achieved by increasing the area of agricultural land required to grow crops or enhancing the productivity of the agricultural land available by using chemical fertilizers, irrigation and new methods of farming. To be able to produce more food and therefore be more productive, farmers have been more dependent on synthetic fertilizers [1].

The widespread use of chemical fertilizers has contributed to environmental degradation especially on soil fertility by reducing the natural nutrients on the soil surface. Though intensive use of chemical fertilizers in agriculture increases the crop production but at the same time it causes negative impact on land, air, water and on environmental health. In order to combine hydrogen and nitrogen gases to make fertilizer, chemists use a process that submits both elements under enormous pressure and heat in presence of a catalyst. To supply the process with the needed energy a great amount of electricity is needed and electricity is mostly produced by burning fossil fuels which is the leading cause of global warming and other environmental problems. Furthermore, the hydrogen used in the process is provided by oil, coal or natural gas making the process even more dependent on non-renewable resources as well as environmentally polluting. Moreover, the constant use of synthetic fertilizer does not improve the quality of the soil rather they cause nutrient imbalances in soil and it is a considerable expense for farmers in developed countries and most of the time a non- viable option for farmers in developing countries. In addition, excess fertilizer from agricultural lands and residential areas are a non-point pollution contaminant that can cause severe damage to soil, ground waters, rivers, lakes and coastal zones. Also, addition of chemical nitrogenous fertilizers makes the plant susceptible to disease [2].

Also, with increasing population and demand for food, agricultural waste is also increasing. India is principally an agricultural country. In India, nearly 700 million tons of organic waste is generated annually, leading to challenges for its safe disposal, with the waste being usually either burned or land filled. India faces major environmental challenges associated with waste generation and inadequate waste collection, transport, treatment and disposal thus causing negative impact on environment and public health. Food waste is an important component of all municipal waste generated and its disposal in landfills has critical environmental effects [3].

In order to solve these issues, better alternative techniques have been gaining quite some importance. Instead of using inorganic/ synthetic fertilizers farmers can use organic/natural fertilizer. Organic fertilizers include substances such as dried blood or seaweed derivatives, which are of animal and plant origin respectively [2]. One way of using organic fertilizer is composting. The composting process does not bum fossil fuels and the use of compost as soil amendment does not pollute our waters. Composting practice is an alternative sustainable waste management practice to transform organic waste into valuable commodity. Composting benefits the environment because manure nutrients are converted to more stable forms and are less likely to reach groundwater or move in surface runoff. Compost is valued for its organic matter content and is typically used as a soil amendment to enhance the chemical, physical and biological properties of soil [4].

Materials and Methods

The objective of this study was aimed to study the efficacy of fruit peel *i.e*., banana and sweet lime peel as natural fertilizers in herbs *i.e*., coriander and mint, as well as their effect on plant growth and soil composition. The materials required

(Banana, sweet lime, coriander seeds, mint saplings, soil and earthen pots) were bought from the market and cleaned properly before further use.

Treatments and Experimental designs

The fruit peels were washed, dried (shade dried) and ground to a coarse powder. Backyard composting was used as a method of composting. 3 formulations and a control were prepared for both coriander and mint. Formulation 1 comprised of soil containing sweet lime peel, Formulation 2 comprised of soil containing banana peel and Formulation 3 comprised of a combination of banana and sweet lime peel in a ratio of 1:1. The powdered peels were mixed with soil in a ration of 1:10 (50gms of ground fruit peel was mixed to 500gms of soil). The mixtures were kept in open containers for 15 days and turned manually daily for proper aeration. Control comprised of soil without any fruit peel. It contained 550gms of soil which was kept separately in polythene bags to prevent them from drying. After 15 days the formulations were ready for planting.

One batch of all 3 formulations and control was kept separately. These batches were later sent to the laboratory to determine the changes in the soil parameters (pH, total nitrogen, potassium, phosphorus and total carbon). The changes in the soil parameters were used to determine the effect of fruit peels in soil as compared to the soil prior to formulation (control sample).

Sowing of coriander seeds – Empty earthen flower pots were taken. 1st pot was filled with Formulation 1 and labelled as C_1, 2nd pot was filled with Formulation 2 and labelled C_2, 3rd pot was filled with Formulation 3 and labelled as C_3, and the 4th pot was filled with the Control and labelled as C_4. Coriander seeds were sown in all the four pots. The soil was watered and monitored for growth daily.

Planting of mint saplings – Empty earthen flower pots were taken. 1st pot was filled with Formulation 1 and labelled as M_1, 2nd pot was filled with Formulation 2 and labelled M_2, 3rd pot was filled with Formulation 3 and labelled as M_3, and the 4th pot was filled with the Control and labelled as M_4. Mint saplings were planted in all the four pots. The soil was watered and monitored for growth daily.

Studied Characteristics

The following parameters were studied:

Soil pH: The pH of the soil was determined by shaking 10 g of the soil in 100ml of distilled water (1:10) for 30 minutes. The pH was measured by pH meter.

Nutrient levels in soil: After 2 months of preparation of the soil formulations, 1 batch of each of the formulation (*i.e.*, Formulation 1,2,3) and 1 batch of control was sent to laboratory for analysis of total nitrogen, phosphorus, potassium and total carbon levels in the soil. The procedure that were followed for the soil analysis were as follows:

a. For testing the total nitrogen levels in the soil – IS 14684 (1999) test method given by the Bureau of Indian Standards was used.
b. For testing phosphorus levels in the soil – method proposed by Shio Kou given in the Methods of Soil Analysis (Soil Science Society for America) was used.
c. For testing potassium levels in the soil – method proposed by Roger S. Swift given in the Methods of Soil Analysis (Soil Science Society for America) was used.
d. For testing total carbon levels in the soil – IS 2720(Part 22) 1972 test method given by the Bureau of Indian Standards was used.

Rate of plant growth: Plant growth was regularly monitored to determine which formulation was best suited for the plants.

Plant length: The plants were randomly selected and the lengths between the tip of the shoot to the tip of the root were measured. An average was taken. The mean value was calculated and expressed in centimetres.

Results and discussion

pH of the soil samples: The pH value of the control soil sample was 7.28 (neutral). It was seen that pH value of soil decreased after addition of sweet lime peel 6.03 (acidic), increased on addition of banana peel 8.46 (basic/ alkaline), whereas it remained neutral *i.e.*, 7.26 after addition of a mixture of both sweet lime and banana peel.

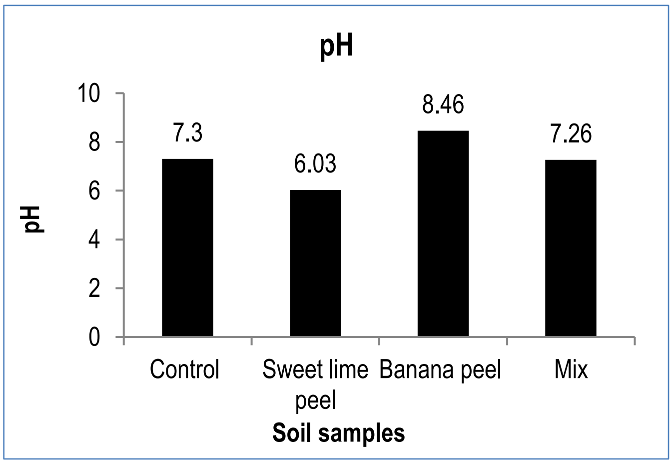

Fig-1 pH of soil samples

Sweet lime peels contain organic acids such as citric acid, malic acid. Thus, a decrease in pH of the soil after addition of sweet lime peel may be due to the acid content of the fruit peel. Banana peels contain potassium in large amounts which is alkaline in nature. Thus, an increase in pH of the soil after addition of banana peel may be seen because of the alkaline nature of the peel. It was also seen that when a combination of both the peels was added in the soil the pH of the soil was neutral signifying that addition of both acidic and alkaline fruit peel balanced the pH of the soil making it neutral hence, concluding that a combination of both the peels can be used to maintain the pH of the soil. Generally, soil from a slightly acidic pH of 6.5 to slightly alkaline pH of 7.5 is acceptable for most plants as most nutrients become available in this pH range. Soil pH is important because it affects the availability of nutrients to plants also this range of pH is generally very compatible to plant root growth. Nitrogen, phosphorus, and potassium are the primary nutrients needed in fairly large quantities. Calcium, magnesium, and sulphur are secondary nutrients required by the plant in lesser quantities. Zinc and manganese are micronutrients required by the plant in very small amounts. Most secondary and micronutrient deficiencies are easily corrected by keeping the soil at the optimum pH value [5].

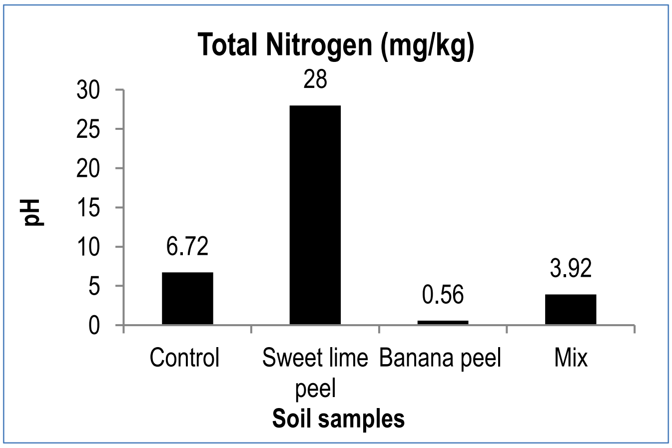

Fig-2 Total nitrogen content of soil samples

Nutrient levels of soil samples: After 2 months total nitrogen, phosphorus, potassium and total carbon levels were estimated in the soil samples. These parameters are essential to understand the effect of fruit peel as a fertilizer in soil.

(i) Total nitrogen content: The nitrogen content of the soil greatly increased in the sample containing sweet lime peel, whereas, it decreased in the sample containing banana peel and sample containing a mixture of both the peels. The huge increase in total nitrogen content of the soil on addition of sweet lime peel in the soil may be seen due to the presence of by non-symbiotic nitrogen fixing bacteria. Studies suggest that organic material incorporated in soil markedly accelerates the nitrogen fixation process and also the presence of organic acids prevents the growth of pathogenic organisms in the soil. The activity of bacteria (particularly nitrogen fixing bacteria) that decompose organic matter may have increased which may have resulted in huge amounts of nutrients especially, nitrogen in the soil [6].

Whereas, a decrease in the total nitrogen content of soil on addition of banana peel may be seen due to alkaline pH of the soil. Soil pH also plays an important role in volatization losses. Nitrogen is present in soil in the form of ammonium and ammonia gas. Ammonium and ammonia gas exist in equilibrium in the soil. The equilibrium is strongly pH dependent. The difference between NH_3 and NH_4+ is a H+. There is higher loss of ammonium gas seen at a higher pH. As soon as a molecule of NH_3 escapes the soil, a molecule of NH_4+ converts to NH_3 to maintain the equilibrium [9]. Hence, addition of banana peel made the soil more alkaline causing an increase in the release of ammonia gas and thus a reduction in nitrogen content of the soil. Even though a decrease in the nitrogen content in the soil containing a combination of sweet lime and banana peel was seen, but it showed best plant growth. This may be due to the neutral pH of the soil sample. Studies have shown that a neutral pH is the best environment for plant growth as the nutrients become readily available in soil which have a neutral pH [6].

(ii) Phosphorus content: The phosphorus content showed a decrease in all soil samples. Phosphorus is directly affected. There was a larger decrease seen on addition of sweet lime peel as at acidic pH values, as the H_2PO_4- phosphate ions react with aluminium and iron to form less soluble compounds. Hence, causing a decrease in the amount of phosphorus that should be available for the plants to grow [6].

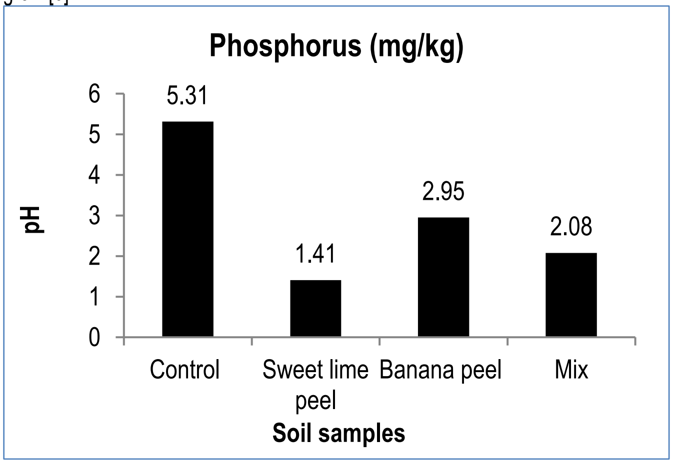

Fig-3 Phosphorus content in soil samples

Whereas, at alkaline pH values, greater than pH 7.5, the HPO_4 2- phosphate ions tend to react quickly with calcium and magnesium to form less soluble compounds [6]. Hence, causing a decrease in the amount of phosphorus that should be available for the plants to grow.

(iii) Potassium content: The potassium content of the soil slightly increased in the sample containing sweet lime peel, and greatly increased in the sample containing banana peel and soil sample containing a mixture of both the peels. The slight increase in potassium content of the soil containing sweet lime peel may be due to the fixation of potassium and entrapment at specific sites between clay layers tends to be lower under acid conditions. This situation is thought to be due to the presence of soluble aluminium that occupies the binding sites. Hence, a reduced fixation of potassium may be seen in acidic soils which may cause loss of potassium through leaching [6]. Whereas, the potassium content in the soil containing banana peel increased to a larger extent. This may be due to the high levels of potassium that is present in the banana peel which causes an increase in potassium levels in the soil after being acted upon by micro-organisms converting the organic form to the inorganic form making it available to the soil [6].

A combination of both the peels also showed significant amount of increase in the potassium levels, which may be seen due to high levels of potassium in banana peels as well as neutrality in pH of the soil. The potassium content is enough for proper growth of the plants making it suitable for plant growth.

(iv) Total carbon content: Organic wastes have also shown to increase the reduced carbon pools. Carbon serves primarily as an energy source for the microorganisms, while a small fraction of the carbon is incorporated to the microbial cells [5].

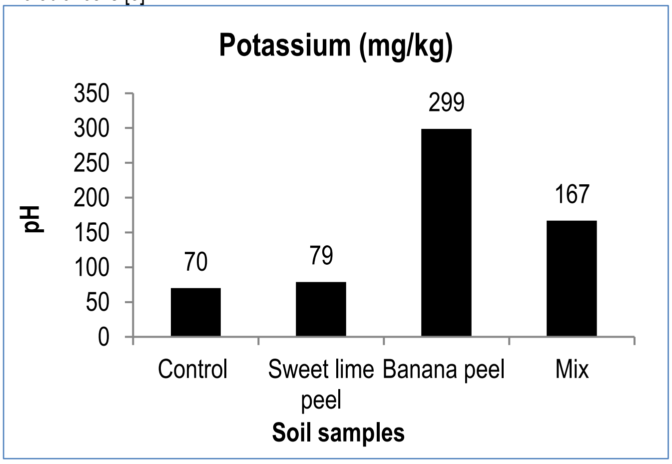

Fig-4 Potassium content in soil samples

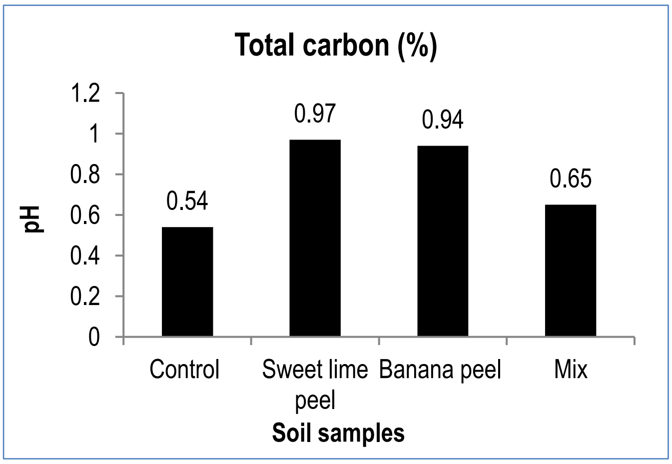

Fig-5 Total carbon content of soil samples

It was seen that there was an increase in percentage of carbon content in all the soil when compared to the control. Studies have shown that CO_2 (Carbon Dioxide), CH_4 (methane) are the main carbon-based atmospheric gases, that microbes synthesize from organic material. Organic materials are a rich source of simple and complex sugars and dietary fibres, hence making them a good food source for the microbes. Organic materials are decomposed into the soil by microbes, leading to carbon inputs into the soil [6]. Hence, addition of fruit peels caused and increase in the total carbon levels in the soil.

Rate of plant growth: Highest growth rate was observed in formulation 3 *i.e.*, soil with a combination of banana and sweet lime peel followed by the control samples. The growth rate seen in formulation 1 and 2 were quite low and the saplings died after a period of time, though the nutrients were available in the soil they were not being utilized by the plant due the unfavourable pH of the soil. Coriander leaves showed the best growth. Coriander showed a faster rate of growth, the size of the leaves as well as length of the plants, were bigger as compared to mint. Thus, it can be said that the unproductiveness of acid and alkali soils is very often due to the lack of available plant nutrients. In acid soils (low pH), the availability of some of the nutrients such as phosphorus, potassium *etc.*, are reduced to starvation level (become unavailable). The same is the case at high pH (alkaline conditions), plant growth suffers due to the unavailability of nutrients like nitrogen, phosphorus and some minor elements (example, iron, manganese, boron etc). Another indirect effect occurs through the activity of microorganisms. Most microorganisms function at their best within a pH range 6.5 to 7.5. If soil reaction is changed beyond this range, the microorganisms become functionless.

Consequently, the supply of some of the essential plant nutrients like nitrogen is considerably reduced. It is also seen that some plants grow well over a wide pH range, whilst others are very sensitive to small variations in acidity or alkalinity. Studies have shown that coriander and mint plants require a neutral pH for proper growth. Too much acidity or too much alkalinity may be detrimental to these plants [5].

Plant length: C_3 *i.e*., coriander plant containing a combination of both the fruit peels in its soil showed best plant growth, also the plants were taller and sturdier, followed by C_4 *i.e*., coriander plant in control soil sample. The average plant length seen in C_3 was 15.3 cm whereas the average plant length seen in C_4 was 9.8 cm.

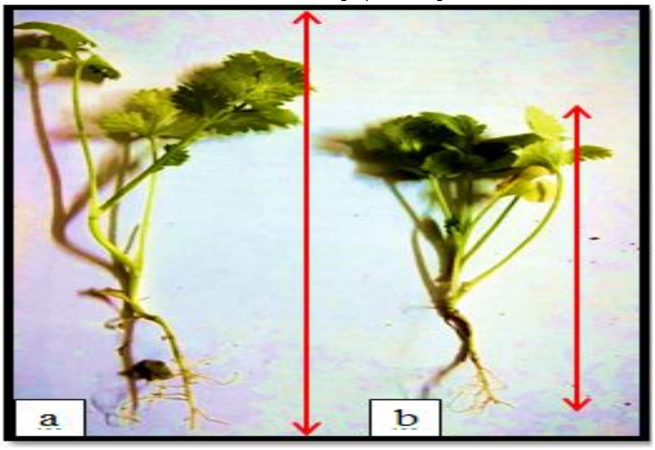

Fig-6-Plant growth was higher in (a) coriander plant in soil sample containing a combination of both the fruit peels than (b) coriander plant in the control sample

Similarly, M_3 *i.e*., mint plant containing a combination of both the fruit peels in its soil showed best plant growth, followed by M_4 *i.e*., mint plant in control sample. The average plant length seen in M_3 was 10.1 cm whereas the average plant length seen in C_4 was 7.8 cm.

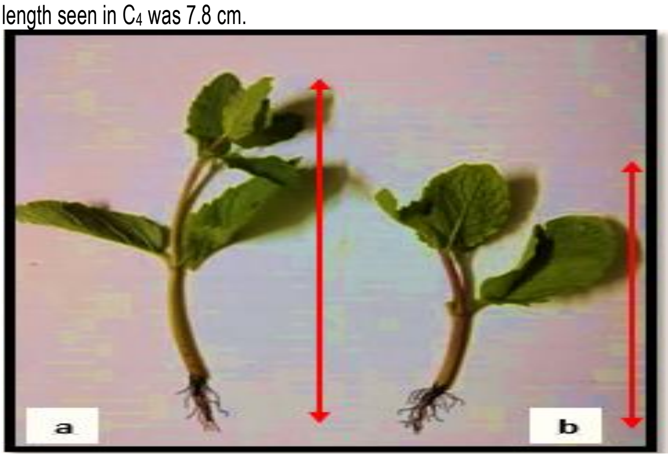

Fig-7 Plant growth was higher in (a) mint plant with soil sample containing a combination of both the fruit peels than (b) mint plant in control sample

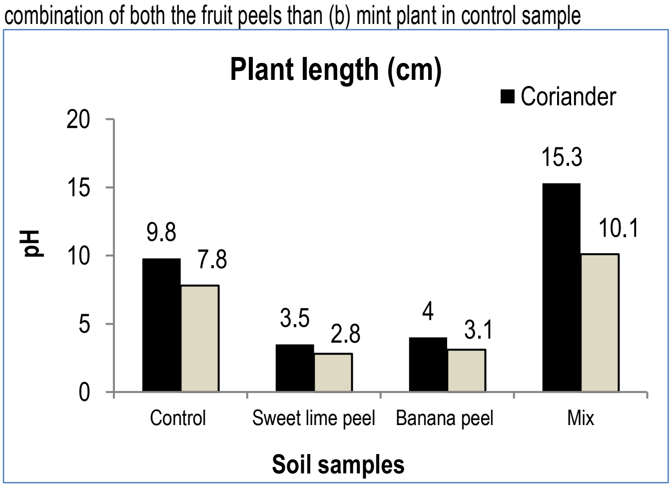

Fig-8 Plant length

Conclusion

Plant sample containing a combination of both the fruit peels showed the best growth followed by the control sample whereas sample containing only banana or sweet lime peel showed the least growth, though the nutrients were available in the soil they were not being utilized by the plant due to unfavourable pH of the soil. Hence, concluding that soil pH plays a major role in plant growth.

Application of research

This research can be applied by farmers for growing crops. This study shows that organic wastes can be used as a natural fertilizer by farmers for agriculture purposes.

Research Category: Natural fertilizer

Abbreviations:

gms: grams
ml: millilitre
H_2PO_4: di-hydrogen phosphate
HPO_4 : 2-hydrogen phosphate
mg/kg: milligram/ kilogram
cm: centimetre

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Ethical Approval: This article does not contain any studies with human participants or animals performed by any of the authors.

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