An Experimental Study To Utilize The Processed Vegetable Waste As A Soil Medium

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Abstract: The openly dumped vegetable waste pollutes the soil and releases greenhouse gases which contribute to global warming. In the present study, the discarded vegetable wastes are processed and further, the experiment was carried out to utilize the Processed Waste (PW) as a soil medium for plant growth. For experimentation, five different mix proportions were attempted for assessing the growth of Sorghum bicolor or great millet a grass species largely used for cattle feed. The Processed Waste was mixed with soil (river sand) in the ratios (PW to soil), of 25:75 (P1), 50:50 (P2), 75:25 (P3), 100 (P4) percent PW and 100 (P5) percent soil. The experiment was carried out for 20 days and during experimentation pH, Temperature, Moisture content (MC), Electrical Conductivity (EC), and volume of water supplied were periodically monitored and recorded. The physical characteristics of five mix proportions (P1 to P5) provide optimum conditions for plant growth at the beginning of the experiment. However, the mediums mixed with PW possess 10 to 15 % higher Water Holding Capacity (WHC) than the sand medium. Further, it was observed that air-filled porosity in the mediums mixed with PW was 30 to 40 % higher than sand. The chemical characteristics indicate that the pH of the mix holds PW was slightly towards acidic to neutral (pH of 6.5 to 6.9) and it was acidic in soil (pH of 5.7). The EC of soil (1.3 dS/m) is less than EC (1.9 to 2.2 dS/m) of PW mixed medium this might because of the presence of higher nutrient content in the PW mixed medium. At the end of the experiment, it was inferred that the plants in pot P3 aided with 75% PW and 25% Sand show a higher growth rate than other mix combinations. The growth rate was assessed by determining the Root to Shoot ratio (R: S) and mean weight gained by the plants in the respective bins.

Keywords : Vegetable waste, Processed Waste (PW), Sorghum bicolor, Root to Shoot ratio (R:S).

1. INNTRODUCTION

Discarding a huge volume of solid waste into the natural environment got momentum from the beginning of 2k. Globalization and urbanization encourage man-made pollution to a greater extent. A survey reported that 60% of discarded solid waste is organic, which can be biodegradable. This huge portion of biodegradable wastes is openly dumped most unlawfully in developing nations like India and China. During the degradation of these openly dumped waste, an accountable emission of greenhouse gases were recorded. Further, the leachate produced from the partly digested wastes pollutes the surface and groundwater source to a greater extent. In parallel, highly populated countries suffer in cultivating crops because of the scarcity of land. The growing urban population also reduces the cultivating areas for crop production. These problems paved a new direction in crop production named soilless culture of crops.

Soilless culture is the method of raising plants in soilless condition with their roots submerged in the nutrient solution [1]. Senthilkumar and Murugappan [2] reported that soilless culture found in wall paintings of the temple of Deir el Bahari. But soilless cultivations has its limitations of growing plants and crops. Not all plants can be grown soilless. This method has been used so far in farming the vegetables and garden plants. Late 90's researches identify an alternative medium for soilless culturing. The outcome of these researches was experimented in developed nations like the Netherlands, Spain, Canada, and France by cultivating Tomato, Cucumber, Capsicum, etc. in an alternative soil medium. The alternative media used for cultivations are Perlite and Rockwool [3]. Further researches suggested that using Coconut Coir, Vermiculite, Peat Moss, and Sphagnum Moss also provide a suitable growth environment for plants as a supporting medium. The major difference in cultivating crops in the soil to other medium is the available pores for the root development. The young growing plants should have an optimum amount of water, air and other associated nutrients from the supporting medium. The pore space available in the supporting medium should be in such a manner to eliminate the discharged CO2 in short duration from the root zone. Besides, the root zone of any media should be enough porous to easy the root of the plant to penetrate and should give anchorage in supporting the shoot of a plant. Any medium satisfies the above-said conditions can be utilized for growing plants [4], conducted an experimental study in vermicomposting the vegetable waste by pre-processing it. Further, they reported that the geophysical properties of processed waste possess higher porosity than the soil. Hence, identifying an apt growth supporting medium for plants plays a significant role for plants growth. With this background information, the present study aims to conduct experimentation in growing Sorghum bicolor plant with the aid of processes vegetable waste as a growing medium.

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2 MATERIALS AND METHODS

The experimentation conducted on three phases, 1. Collection and processing of vegetable waste, 2. Preparing different mix proportions of PW with Soil and studying the chemical and Geophysical properties, 3. Experimenting with the different alternate soil mediums for the growth of plants.

2.1 Collecting and processing of vegetable waste

For processing the vegetable market wastes approximately 10 kg is collected from the local vegetable market. The waste chunk holds a heterogeneous mixture of vegetable wastes. The waste processing holds four stages, Chopping, Pulverizing, the addition of binding and bulking agent, and drying. Initially, the collected market wastes are screened manually to remove the inorganic and inert materials. Chopping process will easy the subsequent process, the desirable size of chopped vegetable waste should be between 20 and 30 mm of size. The next stage is pulverizing and it is done with mechanical aid which converts the wastes less than 0.1 mm of size. With this pulverized mixture cow dung and sawdust was added at the ratio of 1:0.15:0.10 (waste: Cow dung: Sawdust). Adding cow dung and sawdust will enhance the porosity of the processed waste and increase the readily available nutrient for plant growth. The final sate is drying the waste at temperature ranges between 32 to 36 ˚C under the sun for two days. The processing of vegetable was shown in Fig 1.

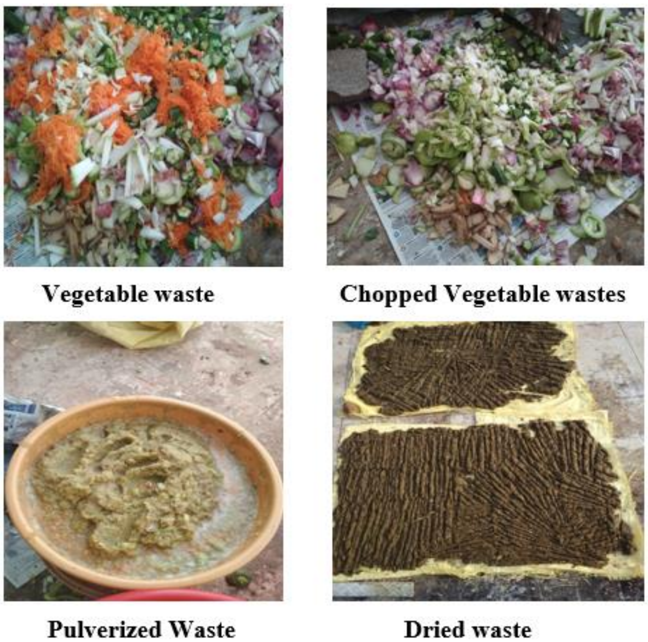


Fig 1: *Processing of vegetable waste*

2.2 Preparing different mix proportions of PW with Soil and studying the Chemical and Geo-physical properties

In this phase, the processed vegetable waste was sieved using IS sieves and categorized based on their size. The result of the sieved processed waste is given in Fig 2 with a five percent probability of error. The secondary advantage of processing the vegetable waste is the waste volume reduction, in the present study approximately 60 to 63 percent of waste volume reduction was achieved after the processing the vegetable waste. After sieve analysis, the processed waste was grouped according to its size to make mix proportions for experimentation. For experimentation, five different mix proportions were prepared. The processed waste having a size between 4.75 mm to 600 microns were used for the study. The mix proportions P1 to P5 prepared properly so that to ensure even distribution of different particle size of processed waste in each mix proportions. Fig 3 shows the mix proportions of the medium used for the experimentation.

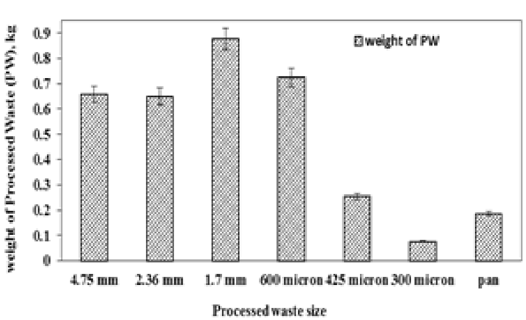


Fig 2: *Particle size of processed waste with respect to weight*

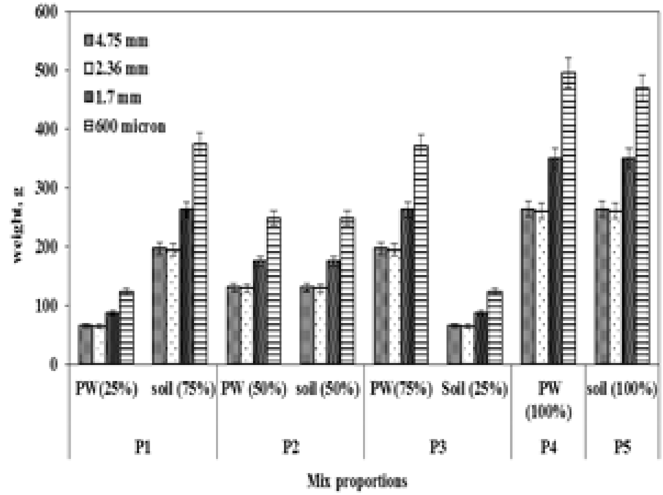


Fig 3: *Mix proportion of PW and Soil for doing experimentation*

The particle size of the growth medium plays an effective role in the distribution of air in the root zone. The high percent of bigger size particles will drain the moisture at a faster rate, while smaller size particles will obstruct the movement of air and interrupt the root penetration. The other disadvantage of smaller size particle is bed consolidation and retention of high bed moisture for a longer duration. Hence, in the present study, the particle having a diameter less than 600 microns are eliminated in preparing the mix proportions of the growth medium. Once the mix proportions were prepared, the geophysical analysis was carried according to the procedures given in "Methods Manual Soil Testing in India, Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India (2011)". Conducting the Geophysical analysis will help to determine the ideal conditions for plant growth. Ranganathan, [9], reported that optimum porosity required for a healthier growth rate of plant ranges between 30 to 70 percent. The results of Geophysical analysis are reported in table 1.

TABLE 1

GEO-PHYSICAL PROPERTIES OF MIX PROPORTIONS

Parameters	P1	P2	P3	P4	P5
Specific gravity, kg/m3	1.97	1.5	1.21	1.21	2.7
Dry density, kg/cm3	1.06	0.74	0.55	0.55	1.8
Voids ratio	0.86	1.02	1.20	1.26	0.5
Porosity	0.46	0.51	0.54	0.54	0.3
Water holding capacity (WHS), %	80	81.5	80	84.5	72
Coefficient of Permeability, x 10-3 cm/s	5.4	6.5	4.9	3.4	5.0

It was observed from the geophysical analysis that the mix proportions hold PW records 10 to 15 % higher water retention capacity (WHC) than soil. This might be due to the spongy nature of the PW, which can hold moisture for a longer duration than the soil. A similar WHC was reported by Asiah (2004) while experimenting Coir Dust (CD) as a supporting medium for the cultivating Cauliflower. Another significant factor noted from the analysis is the voids ratio of the mix proportions. As WHC, the air-filled porosity in mix aided with PW shows 30 to 40 % (varies concerning percent of PW addition) higher than the soil. But the result of the permeability test shows that the soil medium possesses higher permeability rate than the mediums aided with PW. Notably, the permeability of PW (P4) was 24.44 % lower than the sand medium (P5). Looking into the specific gravity values the sand medium possess 2.7 and it got gradually reduced 1.21 concerning the quantum of PW added. At the outset it was inferred from the geophysical analysis all the mix proportions provides an optimum growth environment for the physical properties of soil.

2.3 Chemical properties of processed vegetable Waste

Like growth medium geophysical properties chemical properties also plays a significant role in the growth of plants. The basic nutrient like Organic carbon (C), Nitrogen (N), phosphorus (P), and potassium (K) acts as enzymatic elements for plants growth. The result of chemical analysis is reported in table 2. All the analysis were carried out as per the procedures are given in "Soil testing in India, Methods and Manual, 2011 and APHA, 2005 [5]". pH ranging between 5.3 and 6.3 is ideal substrate conditions for plant growth [6]. The pH of the processed waste was 6.2 and it falls slightly on the neutral side while the EC stood at 2.23 and this might because of the presence of high nutrient values in PW (Table 2).

TABLE 2
CHEMICAL PROPERTIES OF PROCESSED VEGETABLE WASTE AND SAND

Properties	Processed Waste (PW)	Soil
pH	6.7	5.7
Electrical Conductivity (EC), dS.m-1	2.23	1.32
Total Carbon, %	46.35	0.158
Nitrogen, %	1.63	0.0285
phosphorus (P), mg/g	5.32	0.0349
potassium (K), mg/g	3.26	0.0257

3 EXPERIMENTATION

For conducting experiments five identical transparent rectangular PVC pots with dimensions of 15 cm length, 5 cm width and 7 cm depth were taken (Fig 4). The Bottom of the pots was drilled with 1 mm diameter holes approximately 10 to 15 numbers.

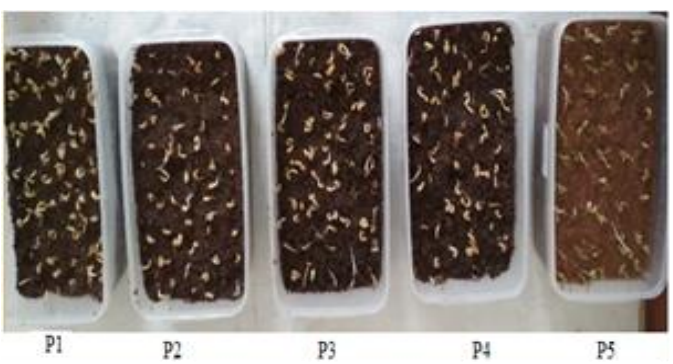


Fig 4: *Experimental arrangement*

This will drain the excess amount of moisture in the substrate. The pots were named P1, P2, P3, P4, and P5 to the percent of PW (25, 50, 75, 100, and 0) added with soil. The pre-prepared moistened growth mediums (Mix P1 to P5) were layered gently inside the PVC pot to a maximum depth of 5 cm and the remaining 2 cm is kept as a freeboard. Equal quantity (10 g) of "Sorghum bicolor" seeds were seeded in the pots. Even though the growth period of this plant is about 90 days but the experiment was concluded within 20 days which is enough to assess the growth rate of the plant.

4 RESULTS AND DISCUSSION

4.1 Influence of temperature on the growth medium

Sub-soil temperature is an important factor which correlates the plant growth than atmospheric temperature. Plant progressions depend on nutrient and water intake with optimum soil temperature, which helps them for sprouting, forking, and growth of root. In the present study, the movement of roots was highly restricted and hence, soil medium temperature is considered as an important factor for accessing the plant growth. Fig 5 shows the variation in soil medium temperature recorded during the experimentation.

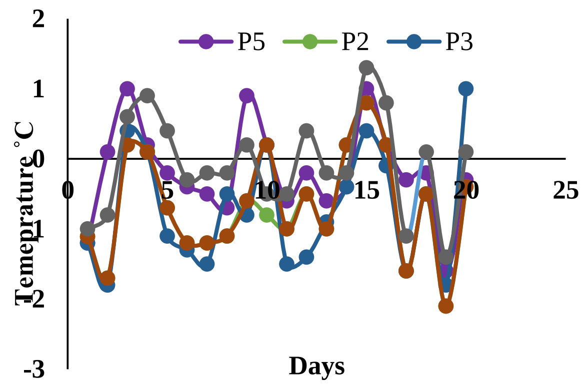


Fig 5: *Temperature variations in the growing medium*

The negative values show the soil medium temperature below the ambient temperature and the positive values show the temperature above the ambient level. Irrespective of the pots (P1 to P5) the soil medium temperature shows a wide variation during the test period. This may attribute to the followings i) Periodical watering to the plants ii) Respiring activity of the microbial community in soil medium iii) Restriction of cross airflow in the soil medium. The highest drop of soil medium temperature was recorded in the pot P4 (-2˚C), followed by pot P3 (-1.8˚C). Moreover, the average soil medium temperature recorded in these two pots were less than the ambient temperature. This might be because of the presence of a high percentage of processed waste in these soil mediums (100% and 75 %) [7]. The spongy nature of the processed waste helps to withhold the soil moisture capacity to a greater extent. In parallel, the temperature profile in the pots loaded with 50 and 25 percent processed waste was slightly below than the ambient level. The temperature profile in the pot loaded with 100 percent of soil (P5) was higher than the ambient level during most of the experimenting period. This might be due to the high infraction capacity of this soil medium which drains the soil water at a high rate. To keep the temperature profile at an optimum level periodical watering was done to all the pots. The watering interval for the pots varied according to the soil moisture and temperature recorded in the soil mediums. It was inferred from the study, the medium possesses high percent of processed waste holds the soil moisture for a longer duration than the other which highly influence the temperature level in the medium. The mean temperature level in the different soil medium was in the flow of P5>P1>P2>P3>P4. It is concluded from the experimentation that the temperature profile plays a significant role in the growth of plants. In real, aiding plant with proper soil medium will influence the soil medium temperature to a greater extent.

4.2 Influence of moisture on the growth medium

The moisture content of the soil media is directly proportional to the Water Holding Capacity (WHC) of the media. The WHC is defined as the ratio between the available pore spaces to the water-filled pores in the soil WHC depends on micro and macropores in the growth medium. Many researchers reported that the porosity and voids ratio varies according to the nature of the medium [8].

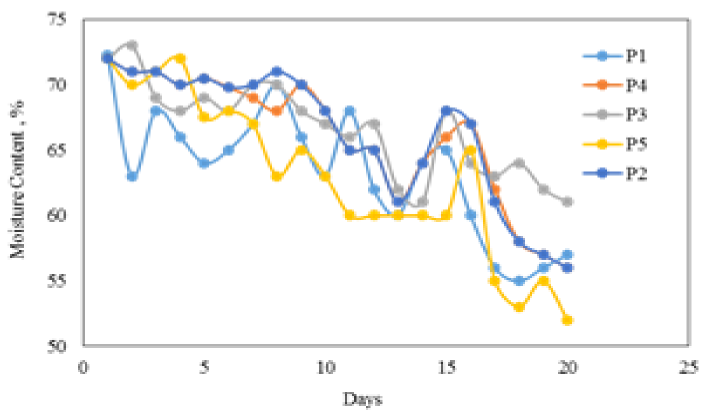


Fig 6: *Moisture content variations in the growing medium*

Ranganathan [9] reported that for a good growing medium the micro and macro pores should be in the proper ratio (60:40, Micro-Macroro). The micropores absorb water while the macropores drain the excess amount of water in the soil bed. Also, the secondary advantage of macropore will enhance the air-filled pores on the top surface of the growth medium. Inappropriate pore ratio will dry the soil bed at a quicker rate or cause waterlogging. The present study witnesses the role of pore space in a processed vegetable growing medium. As discussed earlier the moisture content of the soil medium depends on the available pore space and this was proven in the present study. The bed moisture varied between 53% (minimum) to a maximum of 73% in the experimental pots. The pot which possesses 100 percent soil records poor moisture retaining capacity as it shows a falling trend during the experimenting period. Even though this pot was watered more times than others, still it fails to withhold the water in its pore. This might be because of the absence of water-absorbing matters init. Irrespective of the pots the falling trend persist but it was within the range (60 to 70 percent) in the pots aided with processed vegetable waste. Very particularly the pots mixed with 75% PW and 50% PW records good water holding capacity at an average of 65 percent. The falling nature of moisture content may be due to the penetration of root branches in the soil medium [10]. It was concluded that the moisture retying capacity highly depends on the pores and sponge nature of the growing medium. It was identified from the present study aiding processed waste will enhance WHC of the growing medium and provide optimum nutrients for the plant growth.

4.3 Influence of pH on the growth medium

The pH of a soil medium is a measure of acidity or alkalinity nature of it. For the best plant growth, past studies reported that the pH should be between 5.5 and 6.5. Also, the acidic or alkaline tolerance level of the plant depends on its growth. Soil possess many organic and inorganic nutrient in it, which get reacted with soil water or atmospheric moisture and get dissolved in the growing medium. Due to this action, the pH level in any growing medium shows wide variations and the same has occurred in the present study. The other reasons for the variation in the soil pH level may be associated with the presence of microbial community and the enzymes released by them through a biochemical reaction while digesting the organic portions in the growing medium.

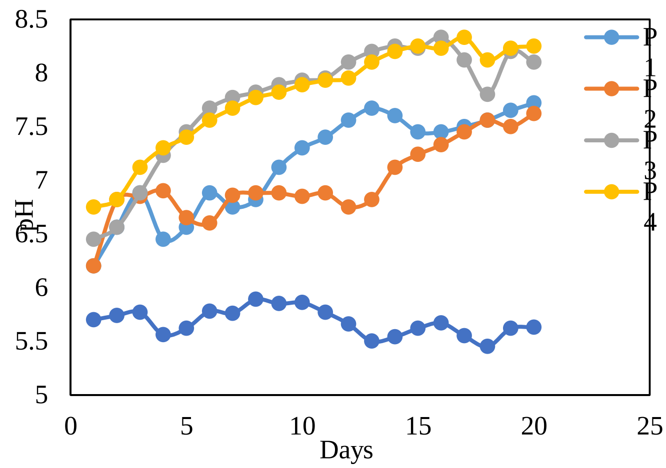
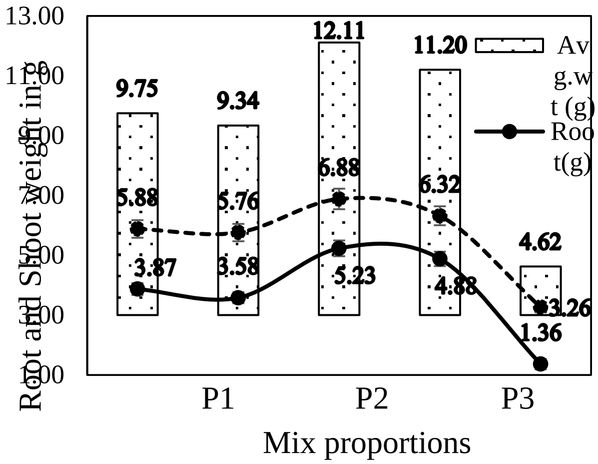


Fig 7: *pH variations in the growing medium*

Many past studies show high pH variation in the growing medium and it was witnessed in the present study also (Fig 7). High pH variations were recorded in the pots aided with a high percentage of processed waste (P3 and P4) and the maximum rise in pH was about 8 to 8.5. This might be due to the presence of abundant level of readily available organic matters in the mass. These organic matters attract multiple microbial communities to digest it. During this bi mechanical process, a high percentage of enzymes realized by them and the same was reported in the study done by [11]. Not many variations recorded in the pot P5 which might be due to the absence or less amount of organic/nutrient supplements in it. Hence, it is concluded that the pH variation in the growing medium associated with the nutrients and organic matters.

4.4 Growth rate assessment of the plants

It is a known fact that root flow medium affects or affect the capacity of the rooting of any plants. Past studies reported that the maximum rooting capacity of many plants achieved within 15 days after planted. The rooting of plants depends on the followings i) Availability of nutrients in the soil, ii) Proper macro to micropore ratio, iii) pH level of the growing medium and iv) Water holding capacity of the growing medium. Past studies reported that artificial growing medium like compost, coir or peat shows good progress in the root and shoot developments of plants. In the present study even though the equal quantity of Sorgam plant seed was seeded in the experimental pots. But the growth rate achieved by the plants varied according to the percentage of PW added in the soil.



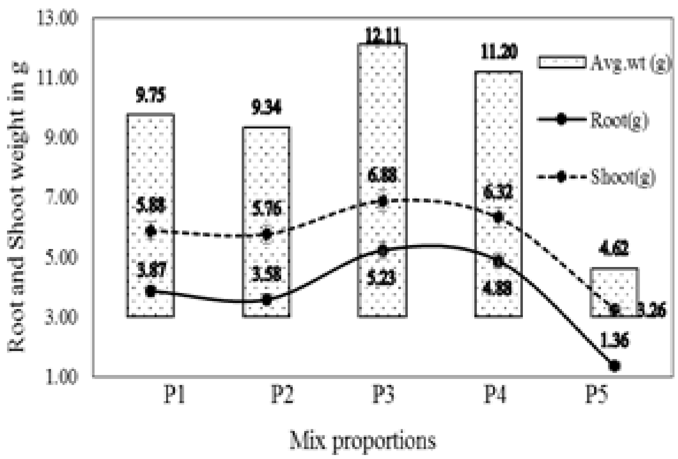


Fig 8: *Root and Shoot growth of plants*

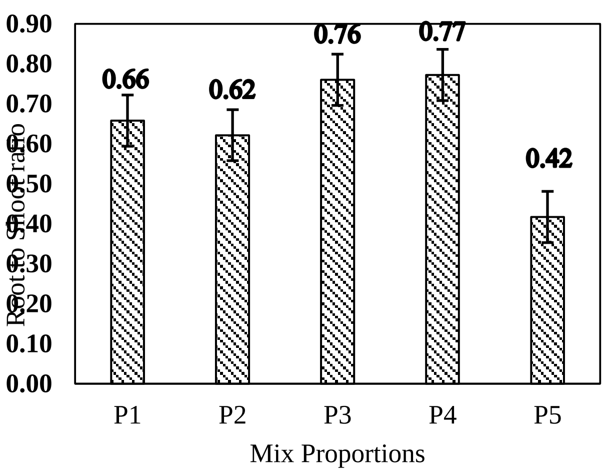


Fig 9: *Root to shoot ration of the plants in different pots*

The growth rate was determined by a mean self of the plants, roots, and shoots in each pot (Fig 8). In addition to finding the root to shoot ratio plants in each pot was hand sorted and the root and shoot were separated and weighed (Fig 9). The Sorgam seeded in 100% soil produced least rooting and shoot compared with those grown on soil and processed mixture. The plant in P3 showed good growth of root and shoot as indicated by a higher number of the visible root (26.6 roots per cutting) and root length (6.65 cm). The higher number of visible roots and longer roots of the cuttings grown on processed waste may be attributed with its better water holding capacity and drainage. Under such favourable condition, the plant was provided sufficient air and oxygen for cell respiration during the rooting process [12]. The moisture in smaller pores served not only for metabolic activities but also provided sufficient humidity to avoid excessive transpiration and destructive temperature fluctuation that may happen in the rhizosphere. The mean weight recorded in pot P3 was triple the times of pot P5 with 62% higher growth rate. The plants in other pots aided with PW also shows good progression than the soil medium. This evidence that the aiding soil with processed vegetable waste will provide good supplements for the growth of plants and also adding PW in the soil will enhance the pore percentage in the growing medium.

5 CONCLUSION

It is inferred from the present experimental study that adding processed waste with soil and utilizing the same as a growing medium augment the growth of plants to a greater extent. The ideal mix proportion of PW with soil id 75:25. This proportion will enhance the macro and micro pores to an optimum level. Besides, adding PW will increase the soil water holding capacity and provide effective organic supplements for plant growth.

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