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GROWTH RESPONSE OF POTATO AND SPINACH CROPS TO VARYING MUNICIPAL SOLID WASTE COMPOST TREATMENTS

Pallavi Bhardwaj[1], Manju Rawat Ranjan[1*], Ashutosh Tripathi[1] and Usha Mina[2]

[1*]Amity Institute of Environmental Sciences, Amity University, Noida, Gautam Buddh Nagar (U.P.), India.
[2]School of Environmental Sciences, Jawaharlal Nehru University, Delhi, India.

Abstract

In the present study an experiment was conducted to assess the response of potato and spinach crops to different types and levels of MSWC. For the experiments, MSWC were obtained from two different manufactures and physiochemically characterised. Vegetative crops were sown in pots filled with different ratios of soil and compost. The soil and compost ratio used was 75:25, 50:50, 25:75, 100% compost and 100% soil (control). Plants could grow in these mixes with no additional supplements. Germination phase and no. of survival days were observed in all compositions to assess the best suitable composition for the growth of crops. Potato and Spinach displayed the best growth in 50% and 75% composition, due to the appropriate balance of nutritive value in compositions.

Key words: Municipal Solid waste, compost, germination, nutrients, growth, health hazards.

Introduction

Waste management is an area of concern world-wide because of the increased environmental pollution and shortage of resources. Population growth, growing urbanization, ascending economy and the rising living standards of community have greatly enhanced *the municipal solid waste* generation rate in the developing countries. Approximately, range of waste generation in developed countries by each person is 1,430-2,080 g/day and 300-1,440 g/day in developing countries. It has been found that globally MSW generation exceeds about 2 billion tons per year (Karak, Bhagat and Bhattacharyya, 2012) and is expected to increase to 9.5 billion tons per year by the year 2050, which ultimately becomes a potential threat to environmental degradation (Pham, Kaushik, Parshetti, Mahmood and Balasubramanian, 2015) if not managed strategically.

In India, The Municipal Solid Waste (MSW) generation has increased from 100 g/day/person to 450 g/day/ person since 1947 (Rawat, Ramanathan and Kuriakose, 2013). As per the present scenario, every year cities in India generate approximately 32 million tonnes of non-segregated MSW and it is estimated that would increase to 299.3 million tonnes by the year 2047 (Karak *et al*., 2012). The management of such large quantity of Municipal Solid Waste is a great challenge for Municipal Corporation. With this, scarcity of land in major cities has worsened this situation of waste disposal. The MSW is categorised into two streams *i.e.* putrescible fraction and non-putrescible fraction (Ghaly and Alkoaik, 2010). In India MSW contains nearly 40-60% compostable, 30-50% inert waste and 10-30% recyclable waste (Joshi and Ahmed, 2016). The components of MSW depends upon topography of the area, seasons, eating habits and commercial level of the place (Thitame, Pondhe and Meshram, 2010). Municipal solid waste includes waste from houses, markets, commercial places, slaughter houses, institutions (*e.g*., from schools, community halls), horticultures (from parks and gardens), road sweepings, silt from drainage and treated biomedical waste (Ahluwalia and Patel, 2018). Developed countries are using waste as a resource and producing energy, fuel and compost. But, developing countries are still facing issues in managing MSW (Ghosh *et al*., 2019). Indian cities, majorly opted method of disposing waste is open dumping in Landfills however; small fraction of organic waste out of it is used for the production of compost in Delhi (National Capital Territory of India) and Mumbai, while in Chennai and Kolkata are also taking initial steps for the same (Jha *et al*., 2008). According to the Indian

****Author for correspondence :*** E-mail: mrranjan@amity.edu

Municipal Solid Wastes (Management and Handling) Rules, 2000, Landfilling shall be restricted to non-biodegradable, inert waste and other waste that are not suitable either for recycling or for biological processing. As per the CPCB report 2019, there are total 3159 existing dumpsites in India and which Delhi has three landfills located at Okhla in South Delhi, Bhalswa in North Delhi and Ghazipur in East Delhi (Ghosh *et al*., 2019). Every day Delhi is generating about 12,000 tonnes of MSW which gets dumped in these oversaturated landfills. These are mainly responsible for the generation of greenhouse gas like methane due to the decomposition of MSW. The conventional treatment of wastes such as open dumping and land filling further deteriorates the condition of environment. Thus, MSW (Management and Handling) Rules, 2000 and amended Rules 2016, made it compulsory to use organic portion of MSW to be used as compost, which accounts for 40-50% of total municipal solid waste.

Composting decreases the demand of landfills for its MSW disposal and decreases methane gas emission thus reducing Global warming. Composting, apart from reducing the volume of waste generated and supplementing nutrients for plants, also promotes waste segregation at source. Compost application is believed beneficial to soil and crops because it improves soil structure via increase in cation exchange capacity and water holding capacity, adds nutrients required for the growth of plants (Kerner *et al*., 2000). One of the characteristics of Indian soils is its low organic matter content due to which the capacity of sub-soil to hold water

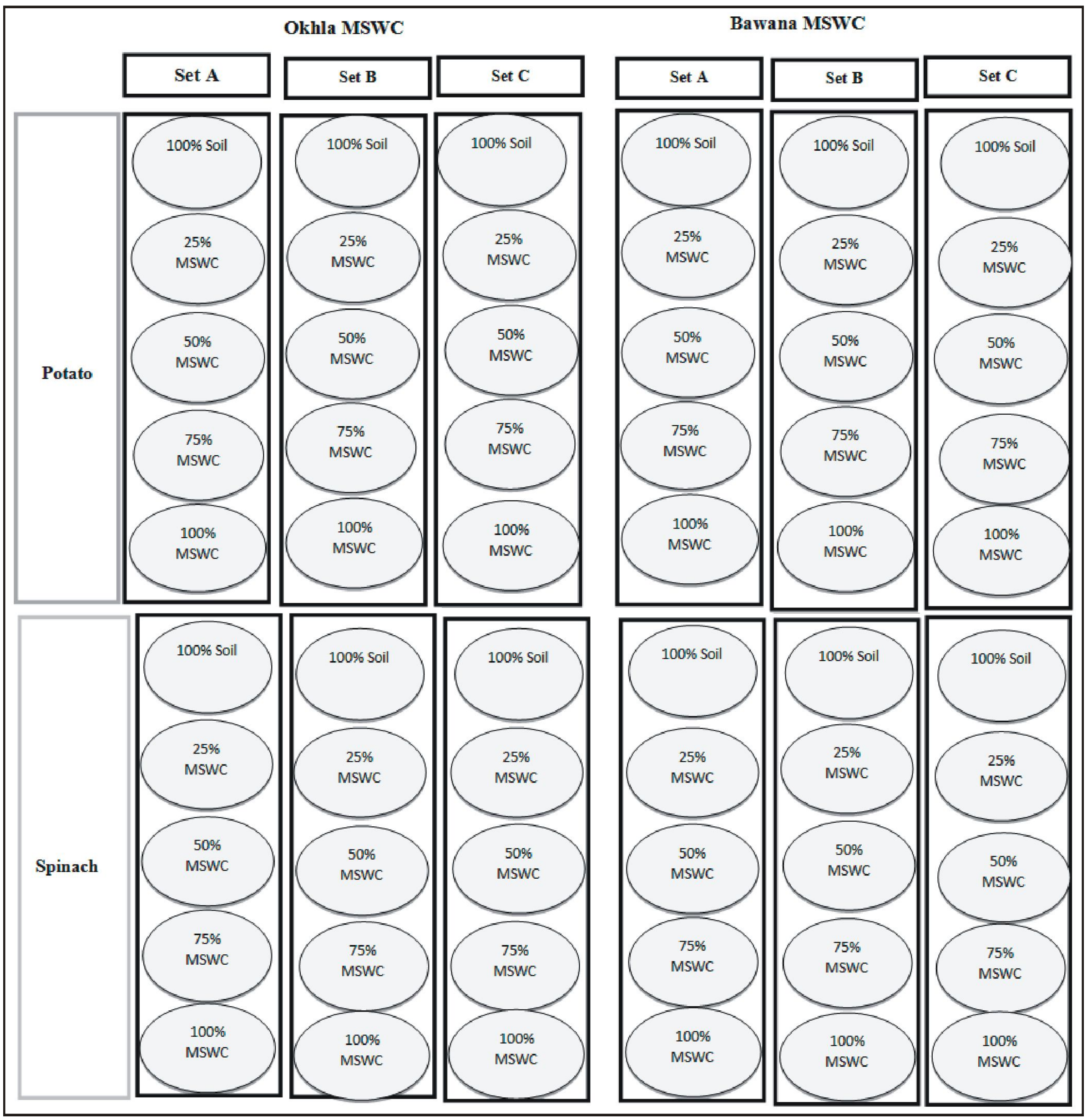

Diagram 1: Experiment layout of the study

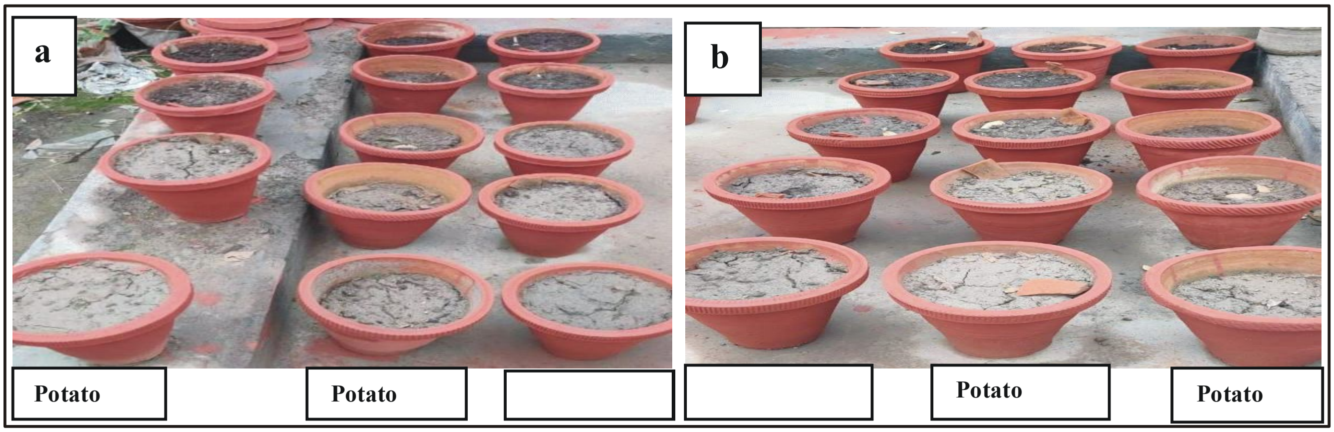

Fig. 1: Growth of crops in Compositions of the compost collected from (a) Okhla and (b) Bawana in initial stage after 10 days of sowing.

gets decreased and affects plant growth (Maruthi, Reddy, Pankaj, Reddy and Reddy, 2019). Water stress conditions affects nutrient transportation to root system in plants (Junjittakarn *et al*., 2013). The decrease in soil organic matter declines soil fertility also (Activities, Biomass and García-gil, 2000). Use of chemical fertilizers changes soil pH, causes soil acidifications and reduce humic acid contents (Suthar, 2009). Thus, instead of fertilizers usage, compost application is essential to maintain soil health. MSW compost (MSWC) benefits soil by increasing its organic matter content and supplying essential plant nutrients (Karak, Sonar, Paul, Frankowski and Boruah, 2015) and increases the plant growth (Valdrighi *et al*., 1996). With the discussed benefits, compost has been proved to be useful in horticultural crop production as it improves physical properties of soil, lowers bulk density and increases water-holding capacity (Rosen, Halbach and Swanson, 2018). The production of compost is a major crisis for the people living in urban as well as rural communities because of the lacking awareness against the disadvantages of using MSWC as soil conditioner for enhancing nutritive value of crops (Sharma and Singh, 2017). That's why before applying MSWC to agricultural land, its physical and chemical composition levels of its salt and metal contents (Hargreaves, Adl and Warman, 2008), should be considered as an area of concern. It includes phytotoxicity, the uncertain plant nutrient value of the material and the environmental consequences of the movement of contaminants into plants and ground water (Wolkowski, 2003). (Paradelo, Villada and Barral, 2011), whereas (Ribeiro, Vasconcelos and Dos Santos, 2000), reported that MSWC, produced from non-

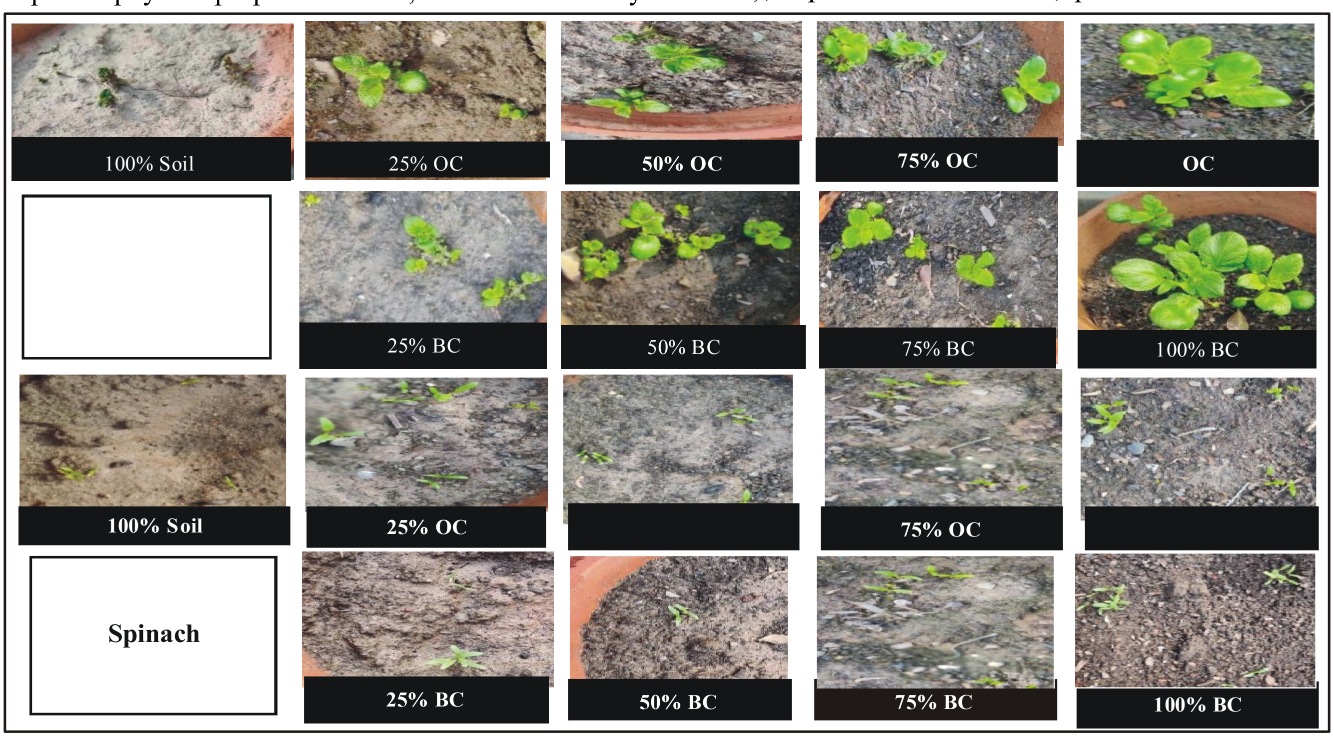

Fig. 2: Crops on reaching the germination stage (a) Potato in Okhla and Bawana compost (b) Spinach in Okhla and Bawana compost.

Table 1: Physio-chemical characterization of the municipal solid waste compost and soil.

S. No.	Parameters	Okhla MSWC	Bawana MSWC	Soil
1.	pH	7.58	7.05	8.48
2.	Electrical Conductivity (mS/m)	5.52	4.61	0.101
3.	Salinity (ppm)	2750	1760	128
4.	TDS (ppm)	3210	2930	163
5.	Water Holding capacity	44%	28%	47%
6.	Moisture content	21.87%	23.829 %	48.07%
7.	Total Nitrogen	1.12 %	1.40 %	0.14 %
8.	Organic carbon	14.66 %	14.5 %	1.37 %
9.	Organic matter	25.27 %	24.998 %	2.36 %
10.	C: N	13.08	10.35	9.78

segregated MSW, acts as a sink of heavy metals and contains organic matter in high amount having strong metal binding capacity via complexation mechanisms. Therefore, it is important to keep a record of nutrients and heavy metals in compost so that the nutritive value and its toxicity can be assessed. With this, toxic levels of trace metals in soil should also be studied as compost application increases level metals in soil (Saleem *et al.*, 2018). In the present study, Pot experiments have been performed in order to monitor the response of Vegetative crops *i.e.*, Potato (*Solanum tuberosum)* and Spinach (*Spinacia oleracea*) to different ratios of Municipal Solid Waste Compost (MSWC) and Soil for 95 and 80 days of period respectively.

Materials and Methods

MSW compost

The compost used to perform this study was obtained from two existing compost plants in Delhi *i.e.*, IL & FS Environmental Infrastructure & Services Ltd., Okhla, Delhi and Delhi MSW solutions Ltd. (RAMKY), Bawana, Delhi, respectively. In the compost plants organic material composted includes cardboards, tree brunches, dry leaves, grass clippings, vegetable and fruit scraps, napkins, food wastes, dairy products, eggshells, fats and greases, paper towels, coffee filter, tea bags, papers, meat, hair, bones, fish etc. Remains of plastic, glass, metals have been found in preliminary tests. The compost samples used were odourless and with moisture in them. Physicochemical characterization of the collected compost samples was done (Table 1).

Soil

Soil used in the study has been collected from the Organic farm at Amity University, Noida, Delhi-NCR.

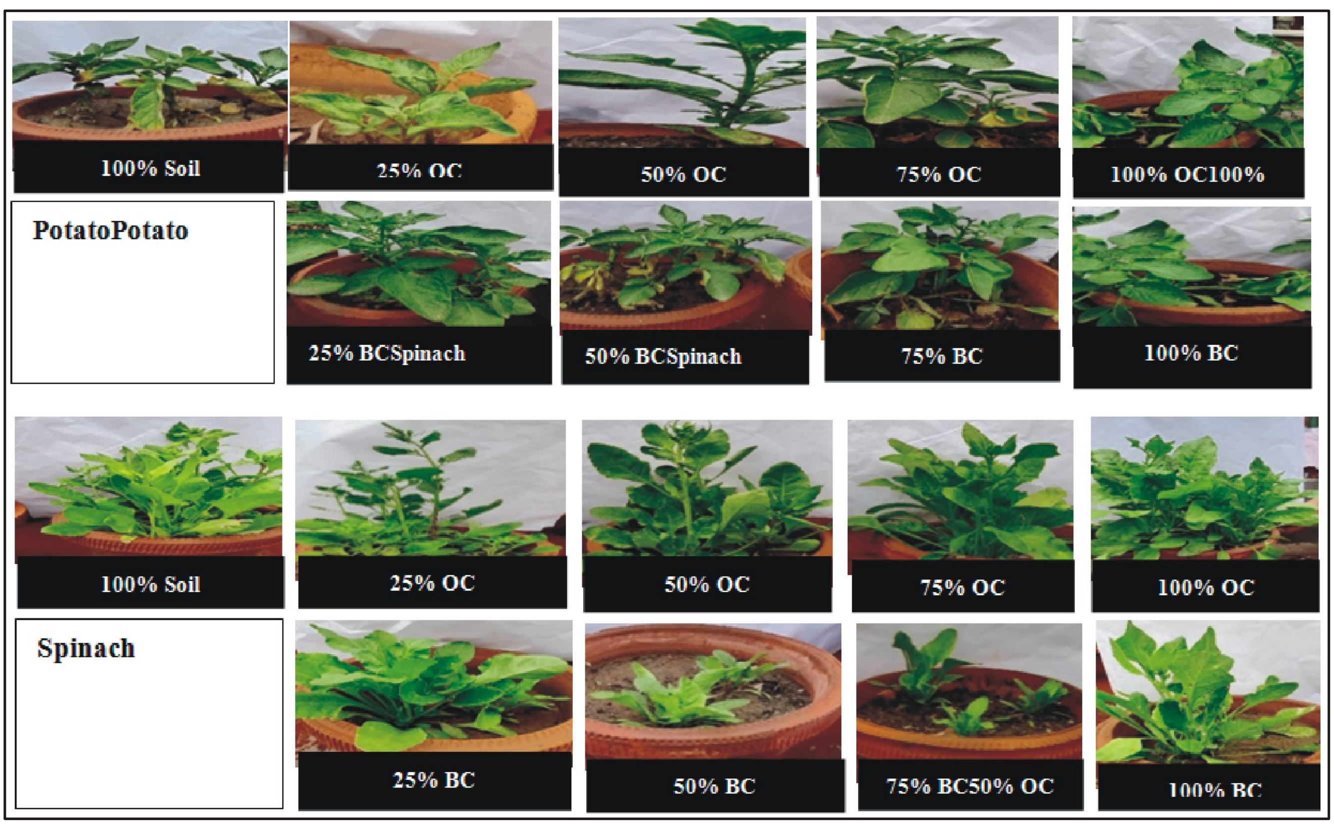

Fig. 3: Crops on reaching the maturation stage (a) Potato in Okhla and Bawana compost compositions and (b) Spinach in Okhla and Bawana compost compositions.100% OC.

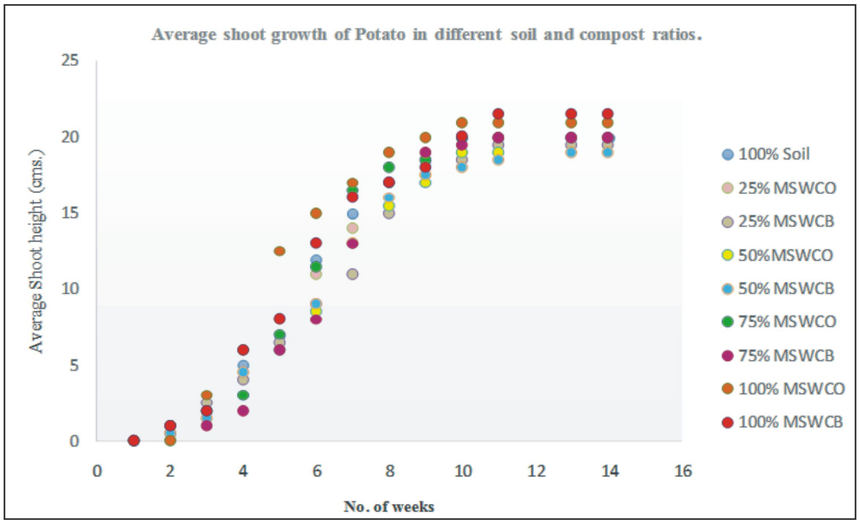

Fig. 4: Graph showing the average shoot growth of Potato in different soil and compost ratios where, MSWCO- Municipal Solid waste compost from Okhla and MSWCB- Municipal Solid waste compost from Bawana.

The soil sample was found to be alkaline in nature with very less organic matter as compared to composts. Soil used in the experiment was also physiochemically characterised (Table 1).

Experiment layout

Two vegetable crops were planted in the pots in lab as well as in open farm. Five different ratios of soil: compost was used as treatment in the study. Three replicates were used for each crop under each treatment (diagram 1).

- Treatment 1 (Control) Soil (100%) and MSWC (0%)
- Treatment 2 Soil (75%) and MSWC (25%)
- Treatment 3 Soil (50%) and MSWC (50%)
- Treatment 4 Soil (25%) and MSWC (75%)
- Treatment 5 Soil (0%) and MSWC (100%)

Pots preparation

Each pot used is of diameter 10 inches. Triplicate pots for every treatment were prepared. The pots after filling of soil-compost mixtures were tilled twice till the depth of 15 cm and organic neem-based fungicide was added to them. Each pot has the capacity of 2 kg soil. That is why compositions prepared were based on the weight. For 100% soil and 100% compost, pots were filled with 2 kg of soil and compost, respectively. For 25:75 composition, 500 g compost was added with 1500 g soil. For 50:50 composition, 1000 g soil and 1000 g compost were mixed and for 75:25 composition, 1500 g compost sample was mixed with 500 g soil.

Crop material

Crops were selected based on season *i.e.* two *rabi* crops. Seeds sowing for both crops was done after making small furrows on December 24, 2019 at the distance of 7-10 cm in pots. This resulted 10 seeds in pot. On January 2, 2020 additional seeds were sowed where germination was not observed. The pots were placed in laboratory as well as in field on a cycle of 16 h light and 8 h of darkness to observe the germination phase. Everyday pots were watered and temperature was maintained less than 23°C for both crops in laboratory. Growth of Potato and spinach crops was monitored for 95 and 80 days, respectively. Crops and soil were sprayed with neem oil in order to prevent from the fungal infection (Hartati, Dono, Meliansyah and Yusuf, 2019). Every 8th day soil was tilled in pots.

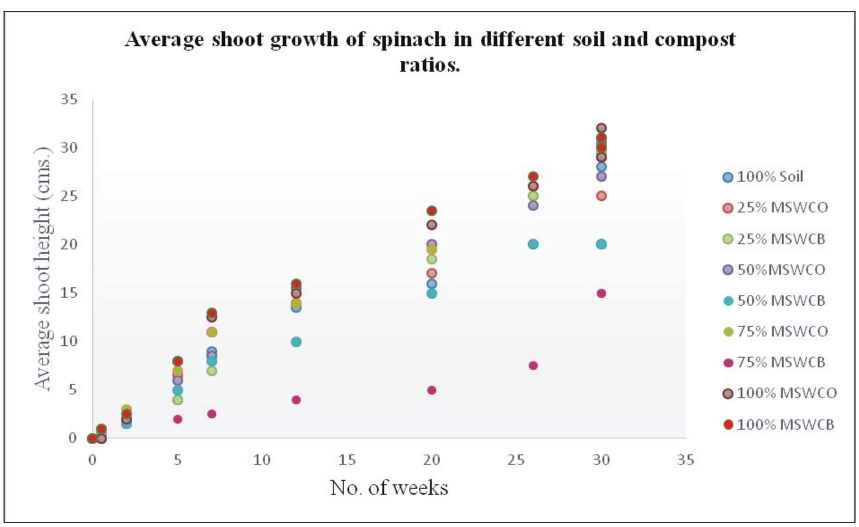

Fig. 5: Graph showing the average shoot growth of Spinach in different soil and compost ratios where, MSWCO- Municipal Solid waste compost from Okhla and MSWCB- Municipal Solid waste compost from Bawana.

Phenology

A visual monitoring has been done to describe the phenology of crops. It includes time taken for the germination phase No. of days plants survived and signs of toxicity.

Biomass Production

Results are analysed in terms of fruit biomass production also which is shown in table 6.

Result and Discussion

Plant growth

The growth of the crops for the

Table 2: Growth performance of Potato.

Treatment	100% Soil		25:75 MSWC		50:50 MSWC		75:25 MSWC		100% MSWC	
	Okhla	Bawana	Okhla	Bawana	Okhla	Bawana	Okhla	Bawana	Okhla	Bawana
Germination (Weeks)	2	3	6	4	6	5	6	5	4	3
Plant Survived (days)	90	95	90	95	89	90	95	95	95	95

Table 3: Average growth of shoot (cms.) in Potato.

No. of Weeks	100% Soil	100% Soil	25% MSWCO	25% MSWCB	50% MSWCO	50% MSWCB	75% MSWCO	75% MSWCB	100% MSWCO	100% MSWCB
1	0	0	0	0	0	0	0	0	0	0
2	0.5	0	1	0.5	0	0.5	1	1	0	1
3	2	1	2	2.5	1.5	1.5	2	1	3	2
4	5	3	3	4	3	4.5	3	2	6	6
5	7	5	6	6.5	6	8	7	6	12.5	8
6	12	8.5	11	9	8.5	9	11.5	8	15	13
7	15	9	14	11	13	13	16.5	13	17	16
8	17	12	17	15	15.5	16	18	17	19	17
9	18.5	15	17.5	17	17	17.5	18.5	19	20	18
10	20	17	19	18.5	19	18	20	19.5	21	20
11	20	19	20	19.5	19	18.5	20	20	21	21.5
12	20	19	20	19.5	20	19	20	20	21	21.5
13	20	19	20	19.5	20	19	20	20	21	21.5

duration is divided into three phases *i.e.* initial stage (0 days after sowing), mid stage (14-15 days after sowing and reaching germination) and final stage (after 85-90 days of sowing, maturing stage) which can be seen in the diagram 1, 2 and 3 respectively. The effects of treatments on two crops on basis of phenological observation of plant health are shown in table 2, 3, 4 and 5 where table 2 and 4 describes the growth performance of plants on basis of time taken for the germination and on the number of survival days. Table 3 and 5 is a collective data of increase in shoot size with increasing time.

In Potato

Germination in all the compositions took 2 weeks with which rapid germination was observed in 100% Bawana compost during the initial stages of growth. Plants in 100% soil and in 25% MSWC composition followed approximately similar pattern of growth and attained stationary phase after 10 weeks of observation on reaching the height of 19-20 cms. Whereas, in 75% and 100% compost compositions growth took place at faster rates as compared to others. In these compositions, shoot grew exponentially up to approximately 22 cms. with increased number of leaves and were observed dead in mid of 13th week. In 50% compost, germination took longer duration, but continuous exponential growth was observed for 10 weeks and remained in stationary phase for 4 weeks. All plants were observed to survive for the whole season but, one of the Plantlets in 50-50 was observed to be dead in 4 weeks of observation. Thus, growth of shoot with increase in time can be seen in the fig. 4.

In Spinach

all the plants grew exponentially with respect to the plants in 100% soil. In second week, 3 weeks, similar Growth of spinach was observed in all compositions with increased size and large number of leaves in 75% Okhla compost compositions. In 4th week, number of leaves remained same with increased leaf surface area approx 4 cm. Growth in 100% Bawana compost compositions was more rapid as compared to Okhla compost compositions. Spinach in 100% soil grew more effectively as compared to the 25% compost compositions. In 5th week, dense growth of spinach was observed in all compositions but Bawana compost supported more dense growth with increased number of 10 cm lengthy leaves and height of shoot increased upto 13 cms. Overall, all

Table 4: Growth performance of Spinach.

Treatment	100% Soil		25:75 MSWC		50:50 MSWC		75:25 MSWC		100% MSWC	
	Okhla	Bawana	Okhla	Bawana	Okhla	Bawana	Okhla	Bawana	Okhla	Bawana
Germination (Weeks)	2	2.5	2	2	3	2	2	2	3	2
Plant Survived (days)	75	75	75	75	75	75	75	75	75	75

Table 5: Average growth of shoot (cms.) in Spinach.

No. of Weeks	100% Soil	100% Soil	25% MSWCO	25% MSWCB	50% MSWCO	50% MSWCB	75% MSWCO	75% MSWCB	100% MSWCO	100% MSWCB
1	0	0	0	0	0	0	0	0	0	0
2	0.5	0	1	0.5	0	0.5	1	1	0	1
3	2	2	2	2	1.5	1.5	3	2	2	2.5
4	5	4	6.5	4	6	5	7	2	8	8
5	7	9	11	7	8.5	8	11	2.5	12.5	13
6	12	13.5	14	14	15.5	10	14	4	15	16
7	20	16	17	18.5	20	15	19.5	5	22	23.5
8	26	25	20	25	24	20	26	7.5	27	27
9	30	28	25	29	27	20	29	15	29	30
10	30	29	29	29.5	30	20	30	15	31	30
11	30	29.5	29	29.5	30.5	20	30	15	32	31

plants the followed same pattern growth but dense and rapid growth was observed in 75% and 100% compost compositions. Almost all plants reached to the stationary phase of growth after 9 weeks and sustained the same for 11 weeks. Tallest shoot system was observed in 100% Okhla compost compositions as compared to others reaching up to approx 30 cms. The growth of shoot in spinach with increase in time can be seen in the fig. 5.

Biomass Production

Results are analysed in terms of fruit biomass production also. In Potato, potatoes obtained after harvesting were weighed and in Spinach, weight of vegetative leaves was observed. Table 6 details vegetable biomass production in the types of treatments. It was observed that in 50:50 ratio, both the crops had the least biomass production in both types of MSWC whereas Compost collected from Okhla resulted in higher biomass production where both potatoes and spinach grew well. In 75:25 ratio of MSWCO, both the potatoes and spinach showed the maximum production whereas in MSWCB, growth was hindered.

Table 6: Vegetable biomass production in different treatments.

Fresh weight (g) after harvesting			
S.No.	Treatment	Potato	Spinach
1.	100% Soil	25	50
2.	100% MSWCO	3	45
3.	100% MSWCB	24	57
4.	25:75 MSWCO	14	47
5.	25:75 MSWCB	17	35
6.	50:50 MSWCO	5	55
7.	50:50 MSWCB	2	6
8.	75:25 MSWCO	21	52
9.	75:25 MSWCB	17	5
Here, MSWCO states Municipal solid waste compost from Okhla and MSWCB states Municipal solid waste compost from Bawana.			

Conclusion

Results showed that crops do follow the visual observation because of healthy vegetation. In all compositions, density and rate of growth was observed less in soil as compared to the other compositions. Adding of municipal solid waste compost increases the survival rate and sustainability of the crops. Although, crops did not respond well in 100% compost for longer durations, might be due to its high toxicological effect on them. All the plants followed similar growth pattern and it appeared that crop growth is best supported by the 75% and 50% compost soil ratio on basis of sustainability. Compost collected from Bawana plant was found to be more yield promoting as compared to Okhla compost when applied 100% in both the crops Thus, on basis of visual observation it is nearly impossible to state which composition has least toxicological effect on crops as dense growth was observed in all compositions. Survival rate *i.e.* no. of days plants survived of crops in 75% and 100% compositions clearly signifies that there are some inhibitors of growth present in compost which does not let the crop grow for longer period and inhibits the survival rate. But, higher biomass production of fruits was observed in 100% as well as in 75% than 25% and 50% which states that adding compost improves crop yield too. According to the observations, long term toxicological effects of MSWC on the structure of soil and health of crops should be studied to obtain which composition maximum favours the growth of crops with highest survival rate and least toxicological effects.

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