RESEARCH ARTICLE

PERFORMANCE OF MANURE DERIVED FROM KITCHEN WASTES USING EFFECTIVE MICROORGANISMS (EM) AND INDIGENOUS MICROORGANISMS (IMO) TECHNOLOGY ON GROWTH AND YIELD PARAMETERS OF OKRA (Abelmoschus esculentus L.) AT BIRATNAGAR, NEPAL.

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ARTICLE DETAILS

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ABSTRACT

An experiment was conducted at Biratnagar, Nepal in completely randomized block design to study the effect of effective microorganisms (EM) and indigenous microorganisms (IMO) along with recommended dose of fertilizers (RDF) on the growth and yield parameters of okra (variety: Arka Anamika). The 6 treatments viz. control, EM enriched manure, IMO enriched manure, RDF, RDF+EM, RDF+IMO and control were replicated thrice. The study showed that indigenous microorganisms when incorporated with recommended dose of NPK fertilizer (RDF+IMO) can produce best result in terms of yield and economic return. Rigorous study in multi location and more crops is suggested to develop an integrated nutrient management plan and household waste management.

KEYWORDS

completely randomized block design, microorganisms, RDF+IMO, waste management.

1. INTRODUCTION

The pace of urbanization and industrialization is being rapid which have created a major impact on the environment by pollution, global warming and health hazards. Coupled with population burst, they are causing in increased generation of complex solid waste (Singh et al., 2011). Rapid and uncontrolled urbanization, lack of public awareness, and poor management by municipalities have intensified environmental problems in towns in Nepal, including unsanitary waste management and disposal (ADB, 2013). Developing countries are generating huge quantity of solid wastes as they lack proper waste segregation and proper disposal facilities (Ngoc and Schnitzer, 2009). Open burning and open dumping are mostly practiced in these countries which not only create pollution and affect the urban landscape but also make unsustainable waste management practice (Amritha and Kumar, 2017). Waste management is the biggest problem for the present generation and challenge for the future doomed to live in this dumping yard called as earth because of haphazard waste management practices (Kale and Yehuda, 2018).

On average, at Nepal, households with monthly expenditures of NRs 40,000 ($417) and above generate more than twice as much waste as households with monthly expenditures of less than NRs5,000 ($52). Households in Terai municipalities generate nearly 80% more waste than those in mountain region municipalities. For institutional establishments, the average daily waste generation was 4.0 kilograms (kg) per school and 1.4 kg per office. Similarly, the average daily waste generation of commercial establishments was 1.4 kg per shop and 5.7 kg per hotel or restaurant. The analysis of household waste composition indicated that the highest waste category was organic waste with 66%, followed by plastics with 12%, and paper and paper products with 9%. The composition analysis of institutional wastes revealed 45% paper and paper products, 22% organic wastes, and 21% plastics. In total, 37% of municipal solid wastes in Nepal is disposed of in sanitary landfills, although not necessarily in a sanitary manner. Of the total budget, the municipalities spend an average of 10% for SWM, of which 60%–70% is used for street sweeping and collection, 20%–30% on transport, and any remaining small amount for final disposal. On average, municipalities spend about NRs 2,840 ($30) per ton of waste for collection, transportation, and disposal (ADB, 2013). The government of Nepal enacted the Solid Waste Management Act of 2011 effective from 15 June 2011. The objectives of the act include maintaining a clean and healthy environment by minimizing the adverse effects of solid waste on public health and the environment. The local bodies, such as municipalities, have been made responsible for the construction, operation, and management of infrastructure for collection, treatment, and final disposal of MSW. The act mandates local bodies to take the necessary steps to promote reduce, reuse, and recycle (3R), including segregation of MSW at source. It also provides for the involvement of the private sector, community-based organizations (CBOs), and nongovernment organizations (NGOs) in SWM through competitive bidding (Acharya, 2017).

When solid wastes are burned or incinerated, it releases polychlorinated dibenzo-p-dioxins, dibenzofurans (PCDD/Fs), noxious and toxic gases whereas when they are openly dumped emits greenhouse gas (e.g., CH4, CO2 and N2O) causing air pollution and global warming (Sharma, et al., 2018). The biodegradable wastes generated in developing countries is one
of the largest sources of anthropogenic greenhouse gases emissions (Tian, et al., 2013). In this context, integrated solid waste management done through agricultural recycling of organic wastes can be more sustainable and eco-friendly approach than traditional methods of waste disposal and energy recovery (Sharma, et al., 2018). Recycling of organic waste into compost/vermicompost in agricultural field is loaded with following benefits:

- Sustainable alternative to chemical fertilizers and conservation of limited and non-renewable rock phosphate utilized as chemical P fertilizer (Hatt and Tare, 2012)
- Improvement in soil nutrient profile and structure with reduced soil erosion
- Better alternative to climate change mitigation due to reduced GHG emissions from waste decomposition in open dumps
- Conservation of land resource due to reduced amounts of landfilled waste
- Reduction in volume of wastes from dumpsites and minimize environmental pollution thereby causing better management (Schulz and Römheld, 2017).

Agricultural wastes are defined as the residues from the growing and processing of raw agricultural products such as fruits, vegetables, meat, poultry, dairy products, and crops. They are the non-product outputs of production and processing of agricultural products that may contain material that can benefit man but whose economic values are less than the cost of collection, transportation, and processing for beneficial use (Agmuth, 2009). Along with agricultural wastes, food wastes have become a hot issue in recent years. Unwanted food and food prepared from residues, commercial establishments such as restaurants, and institutional industrial sources like school canteenas and factory lunchrooms are termed as food wastes.

Out of total, 75% of material in today’s landfill is recyclable or compostable, while 50-70 % of the weight of a foodservice’s garbage consists of compostable items (Saravanan, et al., 2013). Composting can be used for managing food wastes as it is a sustainable method and it produces bio-fertilizers, causes relatively low air and water pollution, is cost friendly and assist in generating income from their products (Li et al., 2013). Effective microbe or microorganisms (EM) is a type of microbial inoculant developed by Teruo Higa (1970s) which can be applied in compost production to accelerate the microbial degradation (Mbooboda et al., 2014).

As stated, the EM consist of mixed cultures of beneficial, naturally-occurring micro-organisms such as photosynthetic bacteria (e.g., Rhodopseudomonas palustris, Rhodobacter sphaeroides), lactocibll (e.g., Lactobacillus plantarum, L. casei, and Streptococcus lactis), yeasts (e.g., Saccharomyces spp. and Actinomycetes (Streptomyces spp.) (Zavaid, 2010). These microorganisms as follows: photosynthetic bacteria (photrophic bacteria) are independent self-supporting microorganisms and they synthesize amino acids, nucleic acids, bio-active substances and sugars, using root secretions, organic matter (carbon), sunlight, and geothermal heat from the soil (Condor et al., 2007). Some researchers stated that the use of effective microorganisms have a number of applications, including agriculture, livestock, gardening and landscaping, composting, bioremediation, cleaning septic tanks, agal control and household uses (Khalqi et al., 2006). In this regard, this study was done inorder to study the effectivenss of effective microorganisms in generating compost using food wastes.

2. MATERIALS AND METHODS

2.1 Selection of study area

Biratnagar metropolitan city was selected for the purpose of the study. It is the capital of province no 1, Nepal. Its total area is 76.99 km² and has population of 241,663 with 105,637 females and 108,827 males (Biratnagar Metropolitan, 2020). The altitude ranges from 62 m to 76m above sea level. It is bordered by two rivers - Sighiha in the east and Kesalia in the west. It is located in the Indo-Gangetic plain at 26°29'N and 86°19'E and is bordered by international boundary with India in the south. The area is composed mainly of quaternary sediments with very fertile soil mixed with clay, silt and sand. The climate at Biratnagar is subtropical monsoon type. The mean annual temperature ranges from about 25°C to 30°C, and the maximum and minimum temperature is 42°C and 5°C respectively. The annual precipitation ranges from about 1595-2279 mm. More than 80 percent of the total annual rainfall occurs in four summer months (June to September). Average sunshine duration ranges from 6.97-7.23 hrs/day and average wind speed ranges from 1.2 km/hr to 1.8 km/hr (ADB, NEPAL: Preparing the Secondary Towns Integrated Urban Environmental Improvement Project, 2008).

2.2 Collection and preparation of Indigenous microorganisms (IMO)

Indigenous Micro-organisms (IMO) were collected from Following steps as given by were followed during this process (Abu-Bakar and Ibrahim, 2013):

i. One third of 1.8 m × 0.7 m sized plastic container was filled with cooked rice. The wasted rice was collected from nearby restaurants and houses nearby.
ii. Plastic was used to wrap the container to protect it from rodents, insects, direct sunlight and rainfall.
iii. The container was then buried 10cm deep in the soil for seven days and was covered by dried leaves.
iv. Formation of white micellium indicated that the IMO was ready. Now 1:1 ratio of IMO 1 and molasses was made and kept in shade for seven days.

2.3 Collection and preparation of Effective microorganisms (EM)

i. EM-1 supplied by EMCO-Nepal was used for the purpose.
ii. A thick layer of rice bran was added at the bottom of a bucket.
iii. Food wastes were added to bucket and EM-1 was sprinkled to it. Waste layers were added until it was full.
iv. The bucket was full on 1 week time.
v. It was kept as such to facilitate pickling of food waste for 2 weeks.
vi. A trench was dug and the wastes were kept to it.

2.4 Land preparation and planting

2.4.1 Description of site selected

The experiment was conducted at Biratnagar for 88 days from April 5, 2019 to July 1, 2019 from sowing to economic harvesting. The site was with latitude 26.48° and longitude as 87.24°.

2.4.2 Treatment details

The land was cleared, ploughed and harrowed before laying the plots. The experimental design was randomized complete block with three replications. Treatments were control, EM only, IMO only, RDF only, RDF+EM and RDF+IMO. The treatment detail is shown in table 1. The NP 0.008 content of EM and IMO fertilizers was assessed which is shown in the table 2.

2.5 Soil characteristics

The site was selected at the bank of Kesalia River at the ratio of 1:1. It was kept as such for a week after which white micellium was noticed.

Table 1: Description of treatments used in the research

| Symbol | Description |
|--------|-------------|
| T1     | Control     |
| T2     | EM enriched manure |
| T3     | IMO enriched manure |
| T4     | RDF (Recommended dose of fertilizer) |
| T5     | RDF+ EM enriched manure |
| T6     | RDF+ IMO enriched manure |

Table 2: Organic matter, NPK content and pH of manure used

| Type of fertilizers | Organic matter (%) | N | P | K | pH |
|---------------------|--------------------|---|---|---|----|
| EM enriched manure  | 33.59              | 2.7 | 2.24 | 1.41 | 6.6 |
| IMO enriched manure | 35.33              | 2.9 | 3.08 | 1.79 | 6.8 |
The spacing of 50cm × 30cm and wide spacing of 1m around the research plot was used. Spacing of 75cm was used to separate the treatments and replications. The size of each plot was 2.5m × 1.8m. The research filed covers the entire area of 163.8 m². The number of plants in each plot were 30 out of which 18 were border plants and 12 plants located at inner side were the source of 5 sample plants in each plots.

The seeds were soaked overnight and were sowed. The recommended dose of fertilizer as given by Nepal Agriculture Research Council for okra is 200:180:60 kg/ha so for the plot prepared, 90:81:27 g NPK/ha was applied. 1.33 T/ha (600 gm per prescribed plot) of IMO and EM enriched manure were applied.

2.4.3 Data collection

2.4.3.1 Vegetative parameters

| Table 4: Vegetative parameters of okra considered during study |
|-----------------------------------|-----------------|-----------------|
| S.N. | Parameters | Recorded at (Days after sowing) | Way of doing |
| 1. | Plant height | 20, 40, 50 and 60 | Measured from base to the tip |
| 2. | Plant diameter | 20, 40, 50 and 60 | Measured just below the 1st node |
| 3. | Number of leaves | 20, 40, 50 and 60 | Fully grown leaves were counted |

2.4.3.2 Reproductive parameters

| Table 5: Reproductive and yield parameters of okra considered during study |
|---------------------------------|-----------------|-----------------|
| S.N. | Parameters | Recorded at (Days after sowing) | Way of doing |
| 1. | Number of buds | 40, 50, 60 and 70 | Total number of floral buds were counted |
| 2. | Number of flowers | 40, 50, 60 and 70 | Total number of open flowers were counted |
| 3. | Number of fruits | 40, 50, 60 and 70 | Total number of fruits were counted |
| 4. | Yield | 3 days interval after 45 DAS | Collected and weighed. Harvesting was done 20 times and were weighed |

2.4.4 Data entry and analysis

The data were entered in MS-EXCEL 2013 and were imported in R Studio where one-way ANOVA was performed.

3. Result and Discussion

3.1 Vegetative parameters

The effect of different fertilizers on plant height was not found to be significant at 20 DAS, 40 DAS and 60 DAS. However, significant difference was observed at 50 DAS. Maximum plant height was observed in RDF+ IMO enriched manure which was at par with RDF+ EM enriched manure and RDF whereas significantly higher than other treatments as shown in table 6.
The type of fertilizer used significantly affected the number of fruits obtained at 40 DAS and 60 DAS. Only RDF+ EM enriched manure was the best performer in both the case followed by RDF+ EM enriched manure and sol application of RDF. Detail is shown in table 11.

Table 12: Effect of different fertilizers on plant diameter of okra

| Number of fruits | 40 DAS | 50 DAS | 60 DAS | 70 DAS |
|------------------|--------|--------|--------|--------|
| Control          | 0.40 **| 1.47   | 2.34 **| 2.27  |
| EM enriched manure | 0.60 **| 1.47   | 2.40 **| 2.34  |
| RDF (Recommended dose of fertilizer) | 0.66 **| 1.67   | 2.90 **| 2.47  |
| RDF+ EM enriched manure | 0.86 **| 1.69   | 3.10 **| 2.54  |
| RDF+ IM enriched manure | 0.93 **| 1.73   | 3.67 **| 2.62  |
| SEM (±)          | 0.24   | 0.34   | 0.04   | 0.73  |
| LSD(0.05)        | 2.09   | 2.19   | 0.26   | 3.45  |
| CV (%)           | 20.87  | 16.89  | 22.77  | 16.3  |
| F value          | **     | **     | **     | **    |

Note: Means with the same letter are non-significant at p=0.05 by DMRT. CV=Co-efficient of variation, NS=Non-significant, *:5% level of significance, **:5% level of significance.

### 3.3 Economic parameter

Based on the rates available for the inputs used the total common cost was calculated to be NRs. 253,500 (Table 13). The total cost on each treatment is shown in table 14. RDF+IMO showed maximum B:C ratio of 1.87, followed by RDF and RDF+EM with 1.79 and 1.75 respectively as shown in table 15.

Table 13: Estimation of common cost incurred in okra cultivation

| Particulars | Amount (Rs/ha) |
|-------------|----------------|
| Land renting | 120,000         |
| Field preparation | 6,500       |
| Cost of seed | 23,000          |
| Irrigation   | 62,000          |
| Manuring cost of labor | 1,500        |
| Weeding      | 16,000          |
| Harvesting   | 24,500          |
| Total        | 253,500         |

Table 14: Estimation of total cost incurred in okra cultivation

| Particulars | Total cost (Rs/ha) | Revenue (Rs/ha) | B:C |
|-------------|--------------------|-----------------|-----|
| 1 EM enriched manure | 254,650 | 253,500 | 278,965 |
| 2 IMO enriched manure | 26,674  | 253,500 | 280,174 |
| 3 Control | -  | 253,500 | 253,500 |
| 4 RDF | 7,632 | 253,500 | 253,500 |
| 5 RDF+EM | 33,097 | 253,500 | 253,500 |
| 6 RDF+IMO | 33,306 | 253,500 | 286,806 |

Table 15: Estimation of B:C ratio in okra cultivation

| Particulars | Total cost (Rs/ha) | Revenue (Rs/ha) | B:C |
|-------------|--------------------|-----------------|-----|
| 1 EM enriched manure | 278,965 | 375,300 | 1.34:1 |
| 2 IMO enriched manure | 280,174 | 439,500 | 1.56:1 |
| 3 Control | -  | 253,500 | 253,500 |
| 4 RDF | 286,597 | 502,200 | 1.75:1 |
| 5 RDF+EM | 287,806 | 540,300 | 1.87:1 |

### 4. Conclusion

This study concluded that the highest benefit cost ratio of 1.87 was found in case of integrated application of recommended dose of NPK fertilizer along with enriched IMO manure with the productivity of 18.01 t/ha. The combination was found to be superior in most of the growth parameters.
of plant. It has shown that the waste food materials can be also a viable manure option. Hence, incorporating indigenous microorganisms in nutrient management plan of crops was observed to be beneficial in terms of yield and economic perspectives. Further expansion of trials in multi location should be carried out to suggest more concrete way of management and application of the manure and reduction and management of household wastes.

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