# Mango Compost Extract for Enhancing Growth and Yield of *Momordica charantia*

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## ABSTRACT

*Mango as a climacteric fruit is known to have increased auxins with concomitant increased ethylene and carbon dioxide production during ripening. Such hormonal properties alongside many other nutritional benefits prepared in the form of compost extract were tested for enhancing production of medicinal bitter gourd of Momordica charantia. This cucurbit was planted on field beds at 0.8 x 0.5 m followed by application of compost extract prepared with anaerobic decomposition of rotting mango fruits, fish wastes of gills and internal organs and brown sugar at different ratios in plastic containers. The results obtained showed that mango:fish wastes:sugar compost extract of 2:1:1 applied to soil around the root collar at 10 ml at fortnight intervals allowed the plants to gain the highest mean number of fruits per plant of 18.3, mean individual fruit weight of 25.95 g or mean yield of 11.80 tonnes per hectare. Mango compost extract is, hence, beneficial in organic production of this medicinal bitter gourd.*

**Keywords:** *climacteric fruit, auxin, nutrient, fruit weight, organic production*

## INTRODUCTION

Fruits of *Mangifera indica* (mango) are climacteric fruits with increased respiration rate and ethylene production during ripening. Hence, the fruits have short shelf life and rot fast with rapid fungal invasion and cell death, leading to very much reduced edible values. The rotting fruits should, however, not be wasted in garbage bins and landfills but are worth to be decomposed for the benefits of crop production.

Past studies found that fruit wastes with high vitamins, minerals, hormones and enzymes were excellent raw materials for compost used for enhancing flowering and fruit production in some crops [1-4]. In addition, climacteric fruits have also frequently been reported to have concomitant increased auxin upon ripening, which is beneficial in promoting female flower and subsequent fruit production in many crop species. In reported cases, auxins enhance acetyl-CoA carboxylase (ACC) production, leading to more female flower development in some cucurbits [5-7]. These plant hormones applied at low levels also generally regulate maturing fruits of many plant species, preventing premature development of abscission layers that may result in early fruit loss [8-10]. High doses of auxins, however, can cause fruit abscission and are used commercially to promote a coordinated fruit harvesting.

This study, hence, investigated the application of mango compost extract for promoting growth and yield of a medicinal cucurbit of *Momordica charantia*, which is commonly known as peria katak among the locals. It is a climbing annual herb producing fruits that notably contain phytonutrients of polypeptides that can reduce blood sugar levels [11-13]. This medicinal plant is also among the highly sought after species in medicinal product development.

## MATERIALS AND METHODS

### Study Location

Planting of *M. charantia* was carried out in field experimental plot near the greenhouse in Puncak Alam campus, Universiti Teknologi MARA (N 3°11.84', E 101°26.93'). Chemical analytical and other laboratory work was conducted in Laboratory of Faculty of Plantation and Agrotechnology in the same campus.

### Preparation of Compost for Planting Hole Amendment

Rotting mango fruits were first used for preparing compost for planting hole amendment as a standard agronomic practice, except for the planting holes of the control plants. The compost provides nutrients for the initial establishment of the seedlings after transplanting to the field.

Raw materials of fresh fish wastes of gills and internal organs, rotting mango fruits and fresh shredded coconut wastes after milk extraction obtained from a local market were decomposed at 1:2:2 ratio concurrently using two electric powered mini composters to obtain sufficient amount of compost for this study. An amount of 400 g fish wastes, 800 g rotting mango fruits (inclusive of weight of seeds within them) and 800 g shredded coconut wastes after milk extraction was loaded into the chamber of each composter twice weekly. Mango fruits were sliced accordingly to expose their mesocarp before being decomposed in the mini composters. The three angled bars in each composter turned automatically for 2 min at 30-min intervals to enhance aeration and growth of microorganism population to facilitate decomposition process. There was no addition of any water, microbial inoculant or enzyme throughout the compost preparation procedure. Loading of raw materials was continued for a period of six weeks and the materials were then left to decompose and mature in the following six weeks. The temperature of the decomposing materials was higher but had always been below 55 °C as indicated by the temperature indicator on the composter. It could be attributed to the frequent turning of the materials in the chamber. This allowed enzymes and hormones remain intact to be beneficial to plants.

After three months, the temperature of the compost dropped to ambient temperature. The compost was then taken out from the composters and sun dried for three days. After cooling to room temperature, the compost was packed in plastic bags until use. In the above procedure, approximately 12 kg raw materials were decomposed in each mini composter to eventually obtain a total of approximately 4 kg compost from these two mini composters. Nutrition analysis using elemental analyser (Thermo Scientific Flash 2000) and inductively coupled plasma optical emission spectrometry (ICP-OES, PerkinElmer Optima 4300 DV) indicated that the compost contained approximately 48.7% carbon (C), 2.27 % nitrogen (N), 3.11% phosphorous (P), 1.40% potassium (K), 0.12% magnesium (Mg) and 0.49% calcium (Ca).

## Preparation of Compost Extract

On the other hand, compost extract was applied as soil dench after establishment of the seedlings on the field beds to enhance fruit production. In the preparation of compost extract, rotting mango fruits, fresh fish wastes and brown sugar were decomposed anaerobically in enclosed plastic containers in the dark at room temperature. Different types of compost extract of 1:1:1, 2:1:1 and 3:1:1 were prepared with 500 g, 1,000 g and 1,500 g rotting fruits, respectively, in mixture with 500 g fish wastes and 500 g brown sugar. Decomposition of the wastes was also carried out with only naturally occurring microorganisms within the raw materials and enclosed containers with no addition of any water, microbial inoculant or enzyme. There were three replicates for each type of compost extract. The covers of the plastic containers were only loosened for a few seconds for the release of gasses produced by microorganisms in the beginning few days. Otherwise, the covers were always kept tightly close to ensure anaerobic decomposition of the fruits and fish wastes with sugar and microorganisms. Preparation of compost extract took a period of one month. By the end of the preparation of compost extract, the mixture was separated through a piece of cotton cloth. The liquid with very fine suspended materials was collected as compost extract. Compost extract was labelled and kept in enclosed plastic bottles until use.

## Properties of Compost Extract

The amount of compost extract obtained (v/w %) was determined using a measuring cylinder and calculated as percent to raw materials used. Then, samples of each replicate of compost extract were measured for pH and electrical conductivity (EC) using a pH/EC meter in laboratory. Total N content was analysed using Kjeldahl digestion and distillation method. Soluble nitrate ($N\text{-}NO_3^-$) was detected using a nitrate meter (LAQUAtwin). Organic C in compost extract was analysed using Wakley and Black's rapid titration method. Other macro nutrients of P, K, Mg and Ca and micro nutrients of ferum (Fe), manganese (Mn), copper (Cu) and zinc (Zn) in the compost extract were determined by ICP-OES as mentioned.

Indole-3-acetic acid (IAA) content in compost extract as the major natural auxin in plant tissues was determined using Salkowski's reagent. An amount of 1 ml compost extract was added with 2 ml Salkowski reagent [50 ml of 35% perchloric acid ($HClO_4$) and 1 ml of 0.5 M iron (III) chloride ($FeCl_3$)]. Mixture was incubated in the dark at room temperature for 20-30 min. The absorbance of mixture was then read at 530 nm using an UV spectrophotometer (Sastec/ST-UV8000), and calculated using plant cell culture IAA (Sigma Aldrich) as the standard. Absorbance readings of IAA standards of 0, 5, 10, 20, 50, and 100 µg/ml at 530 nm were used to obtain an equation with $R^2$ of 0.99 for calculation of IAA content in compost extract.

## Field Bed Preparation

Raised beds of 5 x 0.4 m were prepared for this purpose. The soil was sandy loam with pH 5.59. Beds were separated from one another to allow distance of 0.8 m between centres of beds, while the distance between planting points within the same beds was 0.5 m. The planting points were arranged in a rectangular pattern. This gave plant density of approximately 25,000 plants/ha. In field bed preparation, beds were first cleared from tall weeds manually at one month before planting. Then, the beds were covered with silver colour plastic mulching sheets for two weeks to kill the short type of weeds. After weed control procedure, mulching sheets were removed and the beds were ploughed using a mini ploughing machine.

Planting points were marked after ploughing and all planting holes, except the controls, were each applied with 60 g mango-fish-coconut shred waste compost as described above. Compost was applied at a depth of approximately 10 cm and covered with soil and mulching sheet again for two weeks until transplanting of the seedlings. Lastly, staking with wooden poles of 1.5 m in height, fixing wires on top of the poles and having the wires running above the beds were carried out. Then, raffia strings were fixed on the wires at positions above each planting point and the strings were cut to a length of 80% wire-planting point height. Staking and trellising are known as important cultural practices to increase fruit production of this cucurbit.

## Experimental Procedure

*Momordica charantia* seeds were germinated at two weeks before transplanting to the field beds. Seeds purchased from a local vegetable seed supplier were sown in moist top soil in a 82 hole-germination tray measuring 56 x 36 x 4 cm in the greenhouse. There was one seed sown in each hole on the germination tray. Watering was carried out when necessary. Seedlings with height of approximately 10 cm were then transplanted to field beds at 2 weeks after sowing (WAS). Plastic mulching sheets were cut at planting points with diameter of approximately 15 cm for transplanting of the seedlings. Seedlings were transplanted to the beds with their respective root balls attached to soil medium in the evening to minimize transplanting shock. In the following week after transplanting, the seedlings showed growth of new leaves. Compost extract of 1:1:1, 2:1:1 and 3:1:1 as described above was applied to the seedlings at this point of time at 5 and 10 ml, respectively. Compost extract was made up to 100 ml with tap water before drenching to the soil around the root collar of the seedlings. Application of compost extract was repeated fortnightly until the plants were 14 WAS. Plants subjected to only compost treatment in planting holes but received no compost extract application were used for comparison with plants applied with compost extract, while plants with no compost or compost extract application served as controls. There was no other fertilization treatment carried out throughout the experimentation. Watering was carried out manually when necessary. Pest, disease and weed problems were minimal and only manual control measures were taken when necessary.

### Plant Growth Performance and Yield

Plant vines started climbing onto raffia string at two to three weeks after transplanting. Plants were, hence, measured for height (length of main vine), number of leaves and relative chlorophyll content using SPAD502 (Spectrum) on 4 and 5 WAS. Flowering started on 5 WAS and fruit harvesting was carried out from 8 WAS onwards, twice weekly, for the following period of six weeks. Fruit count, weight, length and diameter were recorded with every harvesting. At the end of the experiment, yield of each treatment in MT/ha was calculated based on plant density of 25,000 plants/ha.

### Experimental Design and Statistical Analysis

The experiment was based on a completely randomized design with three replicates. There were two plants in each replicate. Data collected were subjected to analysis of variance and treatment means were compared using Tukey's Studentized Range Test (HSD) at 5% level of significance.

## RESULTS

### Compost Extract Properties

In terms of product availability, there was 39% v/w mango:fish wastes:sugar compost extract of 1:1:1 obtained based on total weight of raw materials (Table 1). Lower amount of 35% and 32% v/w was obtained with compost extract of 2:1:1 and 3:1:1, respectively. Mango pericarp and seeds remained visible by the end of anaerobic decomposition period of one month in all three types of compost extract preparation. For compost extract 1:1:1, all mango mesocarp was almost degraded into fine suspended materials. There was, however, small quantity of fruit mesocarp remained visible by the end of one month with compost extract of 2:1:1 while more fruit mesocarp was found not decomposed in compost extract of 3:1:1 indicating incomplete decomposition by microorganisms within the containers due to limited sugar source. Adding higher ratio of sugar source may enhance the growth of microorganism population to enhance decomposition process in compost extract 3:1:1.

Fish wastes, on the other hand, were easily decomposed as such materials were lack of cell wall. Only gills remained undecomposed in all types of compost extract by end of the decomposition period of one month. All types of compost extract were acidic with pH below 4, highly concentrated with EC above 3,300 μS and contained good amount of essential elements and IAA for plants (Table 1). Compost extract was more acidic and had increased EC, N-$NO_3^-$ in readily available form to plants, K, Mn and Zn but lower total N, organic C, P and IAA content when more mango fruits were decomposed anaerobically in compost extract of 2:1:1 and 3:1:1, as compared to compost extract of 1:1:1. Lower decomposition efficiency in compost extract of 2:1:1 and 3:1:1 could have resulted in lower concentrations of certain nutrients in these two types of compost extract. As for higher IAA content in compost extract of 1:1:1, sufficient sugar source could have enabled higher population growth of microorganisms while auxin producing bacteria could be among the microorganisms, contributing to higher IAA content in this compost extract of 1:1:1. There was no detectable Cu in all types of compost extract.

**Table 1: Properties of Compost Extract**

| | Compost extract | | |
|---|---|---|---|
| Element | 1:1:1 | 2:1:1 | 3:1:1 |
| Compost extract: raw material (v/w) (%) | 39±1 | 36±2 | 32±1 |
| pH | 3.92±0.09 | 3.69±0.10 | 3.63±0.10 |
| EC (μS) | 3,323±252 | 4,122±191 | 5,426±162 |
| Total N (%) | 0.95±0.04 | 0.87±0.04 | 0.66±0.08 |
| N-$NO_3^-$ (mg/l) | 173±22 | 210±21 | 223±3 |
| Organic C (%) | 15.34±0.39 | 11.12±0.20 | 8.27±1.34 |
| P (%) | 0.23±0.01 | 0.21±0.01 | 0.18±0.03 |
| K (%) | 0.72±0.13 | 0.94±0.04 | 0.87±0.05 |
| Mg (%) | 0.10±0.02 | 0.11±0.01 | 0.09±0.00 |
| Ca (%) | 1.04±0.24 | 1.14±0.09 | 0.81±0.05 |
| Fe (mg/l) | 28.91±1.36 | 36.55±4.69 | 22.97±2.99 |
| Mn (mg/l) | 1.13±0.73 | 1.16±0.43 | 5.60±3.20 |
| Cu (mg/l) | n.a. | n.a. | n.a. |
| Zn (mg/l) | 24.15±10.42 | 33.22±7.44 | 30.47±6.88 |
| IAA (mg/l) | 103.53±9.57 | 69.27±2.58 | 66.41±6.22 |

Mean±SE; means having the same letter within column are not significantly different at 5% level of significance.

## Vegetative Growth Performance

Control plants generally had the lowest vegetative growth performance in terms of plant height, number of leaves and relative chlorophyll content as expected (Table 2). Plants receiving planting hole amendment with mango-fish-coconut shred waste compost, on the other hand, had rather comparable vegetative growth as those receiving additional fertilization with mango:fish wastes:sugar compost extract. Among plants treated with compost extract, different types of compost extract of 1:1:1, 2:1:1 and 3:1:1 applied at 5 or 10 ml generally did not result in great differences in the above vegetative growth parameters (Table 2).

**Table 2: Vegetative Growth Performance at 4 and 5 WAS as Affected by Application of Mango:Fish Wastes:Sugar Compost Extract**

| | Height (cm) | | No. of leaves | | Relative chlorophyll content | |
|---|---|---|---|---|---|---|
| Treatment | 4 WAS | 5 WAS | 4 WAS | 5 WAS | 4 WAS | 5 WAS |
| Control | 20.0±2.0$^{b}$ | 38.0±2.3$^{c}$ | 9.0±0.3$^{c}$ | 14.2±0.6$^{b}$ | 32.7±1.5$^{a}$ | 31.2±0.7$^{b}$ |
| Compost (M) | 49.8±1.6$^{a}$ | 97.8±3.9$^{a}$ | 18.8±2.1$^{a}$ | 58.0±7.8$^{a}$ | 33.8±0.7$^{a}$ | 32.3±0.5$^{ab}$ |
| M+1:1:1, 5 ml | 41.5±2.5$^{a}$ | 79.5±5.8$^{ab}$ | 13.7±0.7$^{abc}$ | 49.3±4.7$^{a}$ | 32.5±1.4$^{a}$ | 33.9±0.7$^{ab}$ |
| M+1:1:1, 10 ml | 38.7±5.4$^{a}$ | 63.0±7.2$^{bc}$ | 12.3±1.5$^{bc}$ | 31.7±9.1$^{ab}$ | 33.4±1.8$^{a}$ | 35.8±1.2$^{a}$ |
| M+2:1:1, 5 ml | 44.3±2.6$^{a}$ | 86.5±5.9$^{ab}$ | 15.0±0.8$^{ab}$ | 45.0±4.0$^{a}$ | 35.14±0.5$^{a}$ | 33.7±1.3$^{ab}$ |
| M+2:1:1, 10 ml | 50.8±0.8$^{a}$ | 93.5±4.1$^{ab}$ | 15.3±0.3$^{ab}$ | 50.2±2.9$^{a}$ | 33.7±0.5$^{a}$ | 35.0±0.2$^{ab}$ |
| M+3:1:1, 5 ml | 41.2±3.2$^{a}$ | 78.3±10.0$^{ab}$ | 13.7±0.7$^{abc}$ | 40.0±2.6$^{ab}$ | 34.4±0.4$^{a}$ | 34.9±1.0$^{ab}$ |
| M+3:1:1, 10 ml | 40.0±2.8$^{a}$ | 82.0±7.3$^{ab}$ | 13.3±0.9$^{bc}$ | 40.5±6.2$^{ab}$ | 35.2±1.0$^{a}$ | 33.2±0.2$^{ab}$ |

Mean±SE; means having the same letter within column are not significantly different at 5% level of significance.

## Fruit Production

As for reproductive growth performance as the main concern of this cucurbit, application of compost extract was beneficial for enhancing fruit development and ultimately its yield in MT/ha (Table 3). The current study showed that compost extract of 2:1:1 applied at 10 ml per plant fortnightly resulted in the highest number of fruits of 18.3 per plant and highest single fruit weight of 25.95 g and fruit diameter of 34.3 mm.

This treatment, hence, enabled significantly the highest yield of 11.80 MT/ha fruit based on plant density of 25,000 plants/ha. Despite differences in number of fruits, fruits of plants subjected to different compost extract treatments generally did not differ greatly in fruit length.

**Table 3: Fruit Production, Fruit Attribute and Yield as Affected by Application of Mango:Fish Wastes:Sugar Compost Extract**

| Treatment | No. of fruits | Fruit weight (g) | Fruit length (mm) | Fruit diameter (mm) | Yield (MT/ha) |
|---|---|---|---|---|---|
| Control | 10.3±1.0$^{c}$ | 25.38±0.67$^{ab}$ | 70.2±1.6$^{a}$ | 32.5±1.1$^{ab}$ | 6.65±0.96$^{b}$ |
| Compost (M) | 12.0±0.3$^{bc}$ | 23.49±0.43$^{ab}$ | 69.2±2.7$^{a}$ | 32.6±0.7$^{ab}$ | 7.19±0.08$^{b}$ |
| M+1:1:1, 5 ml | 15.2±0.9$^{abc}$ | 21.90±0.95$^{ab}$ | 63.2±5.8$^{a}$ | 32.5±1.1$^{ab}$ | 8.55±1.08$^{ab}$ |
| M+1:1:1, 10 ml | 13.8±1.9$^{abc}$ | 20.66±0.81$^{b}$ | 70.0±2.4$^{a}$ | 29.7±1.3$^{b}$ | 7.28±1.09$^{ab}$ |
| M+2:1:1, 5 ml | 13.0±1.2$^{bc}$ | 24.62±1.15$^{ab}$ | 66.3±2.7$^{a}$ | 32.4±0.4$^{ab}$ | 7.79±1.11$^{ab}$ |
| M+2:1:1, 10 ml | 18.3±0.3$^{a}$ | 25.95±1.39$^{a}$ | 66.4±3.0$^{a}$ | 34.3±0.5$^{a}$ | 11.80±0.63$^{a}$ |
| M+3:1:1, 5 ml | 13.0±1.3$^{bc}$ | 23.85±0.42$^{ab}$ | 69.1±1.1$^{a}$ | 32.5±0.8$^{ab}$ | 8.25±1.18$^{ab}$ |
| M+3:1:1, 10 ml | 15.5±0.3$^{ab}$ | 23.60±1.51$^{ab}$ | 69.8±0.4$^{a}$ | 31.7±0.2$^{ab}$ | 9.63±0.88$^{ab}$ |

Mean±SE; means having the same letter within column are not significantly different at 5% level of significance.

## DISCUSSION

The good macronutrient and micronutrient contents in compost extract in this study were among the essential elements that promoted fruit production and yield of *M. charantia* [2, 14-18]. Compost extract of 2:1:1 could probably be the optimal compost extract as compared to compost extract of 1:1:1 which generally had lower quantity of nutrients. However, having more mango fruits as that in compost extract of 3:1:1 was not advantageous while limiting the amount of carbohydrate as source of energy for microorganisms performing decomposition of the rotting fruits and fish wastes.

Many hormones and vitamins within mango fruits with increased carbon dioxide and ethylene production during ripening could have also contributed to higher yield of *M. charantia* in a complex and interactive manner [19-20]. In cucurbits, synthetic auxin of IAA was found beneficial to induce more female flower development leading to higher fruit production and yield [21-24]. However, there were also reports indicating that high doses of IAA caused fruit abortion in *Cucurmis sativus* [25]. In some cases, differences in plant hormone concentrations affected photoassimilate distribution among fruit and vegetative organs and hence, could cause variations in fruit production. However, past studies mainly reported specific synthetic plant growth regulators and plant growth promoting rhizobacteria (PGPR) in fruit enhancement and yield of other crops but there were limited records on the specific effects of hormones in compost or compost extract, including those brought by auxins, on the fruit production of *M. charantia* [26-27].

In the current study, higher IAA content in compost extract of 1:1:1 could probably be attributed to also auxins obtained from IAA producing bacteria living alongside in the decomposition container as there was sufficient energy source from sugar to support their population growth throughout the decomposition process. In contrast, IAA content from compost extract 2:1:1 was probably mainly limited to that extracted from rotting mango fruits by microbial decomposition while microorganism population growth was eventually ceased or even reduced as time passed with reducing sugar source during decomposition procedure of one month. Concurrent to this argument, IAA content from compost extract 3:1:1 was found rather comparable to that in 2:1:1.

Since appropriate IAA concentration is important for inducing female flower development and fruit set in cucurbits, higher IAA content but lower nutrition in compost extract 1:1:1 in this study could probably be less ideal while compost extract of 2:1:1 with relatively higher nutrition but lower IAA content could hence, be better for enhancing productivity of *M. charantia*. As any compost or compost extract contains multiple hormones in addition to many essential nutrients for plants, the specific and multiple hormonal interactions in crop-compost extract relation should further be studied in enhancing plant health, growth and fruit production of this medicinal bitter gourd.

## CONCLUSION

Mango compost extract of 2:1:1 applied at 10 ml per plant at fortnight intervals was beneficial for enhancing fruit development and yield of *M. charantia*. Further study aiming on the interactive effects of certain elements can be carried out to optimize the usage of rotting mango fruits for enhancing organic production of this medicinal plant.

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