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ENHANCING SWEET GOURD GROWTH AND YIELD THROUGH THE COMBINED APPLICATION OF BIOCHAR AND INORGANIC FERTILIZERS

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Abstract

An experimental study was conducted from January to August 2022 in Hobigong, Sylhet Division, Bangladesh, to assess the effects of different organic and inorganic fertilizer combinations on sweet gourd growth and yield. The experiment followed a Randomized Completely Block Design (RCBD) with three replications and four treatments: T1 (4 kg compost per plant, farmers' practice), T2 (4 kg compost + 1.5 L human urine + 1.5 L biochar), T3 (4 kg compost + 1.5 L cattle urine + 1.5 L biochar), and T4 (inorganic NPK: 44 g urea, 44 g TSP [Triple Super Phosphate], 77 g MoP [Muriate of Potash]). Results showed that combined applications of organic inputs significantly improved crop performance. The T3 treatment produced the highest germination rate (90%), plant height (42.4 cm), number of fruits per plant (2.1), and fruit weight (2785.3 g). In contrast, the control (T1) recorded lower values: 60% germination, 26 cm plant height, 1.1 fruits per plant, and 1922.8 g fruit weight. Overall, the combination of compost, cattle urine, and biochar (T3) proved most effective for optimizing sweet gourd growth and yield.

Key words*: management, nutrient, productivity, sweet gourd.*

INTRODUCTION

Bangladesh primarily relies on agriculture, with 75% of its population engaged in this sector either directly or indirectly. Vegetables provide essential nutrients to the majority of the population. Summer sees a significant decline in vegetable production in Bangladesh. During this time, cucurbits are the main vegetables cultivated. Cucurbitaceous vegetables are therefore essential for filling the void during this time of scarcity. One of the most extensively grown cucurbits in Bangladesh is the sweet gourd (*Cucurbita moschata*). It comprises 93% water, 0.7% minerals, 0.7% fiber, 1.4% protein, 0.5% fat, and 4.5% carbohydrates, making it relatively high in calories and a rich source of vitamins, especially minerals and carotenoid pigments (Hossain et al., 2019). Many people enjoy using the tender stems and leaves of the sweet gourd as tasty vegetables. Both unripe and ripe fleshy fruits are edible, and the mature fruits can be stored for a period ranging from two to four months (Smith, 2010). These vegetables are significant from an economic perspective because of their affordable market price, year-round growth potential, and availability amid the country's vegetable supply shortage.

A plentiful supply of plant nutrients is essential for cultivating sweet gourds. Because they release vital nutrients gradually, organic fertilizers and manures are essential for achieving the best possible growth and development.

Utilizing organic manure minimizes environmental pollutants while improving the

soil's texture, structure, and aeration (Mischenko et al., 2024). The extended application of synthetic fertilizers, particularly in areas where they are inexpensive, has been linked to nutrient imbalances, a reduction in organic carbon levels, soil acidification, and deficiencies in secondary and micronutrients (Roba, 2018). Paradelo et al. (2024) reported that the addition of organic matter increases soil pH and improves carbon storage in the soil both directly (Klinglmair & Thomsen, 2020) and indirectly (Zhou et al., 2022) by enhancing plant growth and activating microbial processes related to carbon. In addition, it improves soil aggregate stability (Jien & Wang, 2013), increases water retention (Paradelo et al., 2019), and boosts nutrient availability for plants (Lopes do Carmo et al., 2016) when biochar is applied in the soils. The physical property of the soil can be maintained, crop yields and soil fertility can be enhanced, and the organic matter levels in the soil can be preserved or increased in an environmentally friendly way (Aanchal et al., 2022) by adding organic materials like cow dung and biochar. Cow manure is rich in nitrogen (N), potassium (K), phosphorus (P), sulfur (S), calcium (Ca), magnesium (Mg), and micronutrients. Incorporating cow dung into agricultural soils enhances soil structure and accelerates the regeneration process (Fu et al., 2022). Additionally, cow dung is considered a storehouse of essential nutrients for growing a diverse range of plants, including cereals, fruits, vegetables, and ornamental species. Consequently, the dependency on chemical fertilizers for agriculture has decreased, as organic options are available (Behera & Ray, 2021).

Biochar is produced from organic materials through thermochemical conversion without/low oxygen at high, low, or medium temperatures (Wang et al., 2022). It increases soil organic matter, enhances structural stability, reduces nutrient leaching, improves nutrient availability, improves crop nutrient use efficiency, and increases microbial populations and numbers in the soils (Ulusal et al., 2021). Biochar has been shown to sequester carbon and enhance soil quality, including organic carbon, nutrient levels, and water retention, over time (Gross et al., 2021). It can improve soil fertility while protecting the environment as an integrated nutrient supply system. Applying both inorganic and organic fertilizers is necessary to maintain optimal output and improve soil fertility (Hussainy et al., 2019). According to Bhatt et al. (2019), nitrogen utilization efficiency increases and promotes long-term cropping in tropical climates by combining chemical and organic manure fertilizers. Sustainable horticulture production can result from organic farming.

In Bangladesh and various other countries, individuals who prioritize their health are progressively opting for organic vegetables. For a long time, cow dung, which is a form of organic fertilizer, has been used; however, its availability is declining as agricultural practices become more industrialized. Recently, organic farming has caught the interest of vegetable consumers due to the enhanced quality of the produce (Das et al., 2020). Despite Bangladesh's increasing demand for sweet gourds, the country's production is low when compared to other countries. By enhancing soil fertility and nutrient availability, we predicted that using both organic (cow dung and biochar) and inorganic fertilizers together will boost sweet gourd (*Cucurbita moschata*) growth and yield more than using either fertilizer alone. Therefore, the current study's objective is to determine the best combination of inorganic and organic fertilizers for producing a significant crop of sweet gourds.

MATERIALS AND METHODS

Study location

The study was carried out between January and August of 2022 at the village of Kalonjhora, which is situated in the Hobigong district, Sylhet division, Bangladesh, in the Agro Ecological Zone (AEZ) number 22. The geographical location of the research area is 24º 24' N and 91º 37' E. At mean sea level, the region is 4.85 to 5.25 meters above sea level.

Climate

Three distinct seasons characterized the subtropical climate of the experimental site: the winter or dry season, which runs from November to February; the monsoon season, which runs from May to October; and the pre-

monsoon or hot season, which runs from March to April. There is little to no precipitation in the other months of the year, with plenty of rainfall from April to October. Figure 1 shows the highest and lowest temperatures as well as the relative humidity at the test locations.

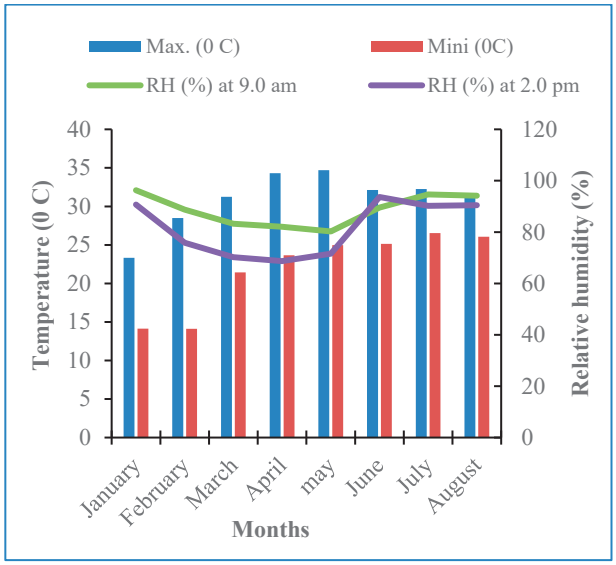

Figure 1. Relative humidity, and maximum and minimum temperatures during the experiment

Plant material

The experiment used the "Thailand -2" sweet gourd variety, which was purchased from BRAC Seed Ltd.

Plot layout

On January 10, 2022, the land designated for the experiment was first cleared using a large shovel. For several days, the soil was left open to the sun. Using the spade, the field was cleared of stubble and weeds. The clods of earth were broken into smaller fragments, and the surface was leveled to the required thickness. The plots were arranged according to the layout, and the test field was designated.

For this experiment, a total of twenty (20) pits were set up. In the second phase, dried leaves, grass, and rice straw were gathered for the production of biochar.

Once the biochar was made, water was added to extinguish the fire after all dry materials had combusted at high temperatures in an oxygen-depleted environment, and the biochar was subsequently collected.

The final step involved gathering the fermented human and cow urine, which had been stored in buckets at room temperature for 7-10 days. The media for the experimental plot were prepared through four stages. In the fifth step, soil was further combined with the media or treatments. The locations of the pits were labeled with tags on sticks, with the tops of the sticks painted in various colors to signify the treatment numbers. The experimental plot was finally established. Table 1 displays the soil's physical and chemical properties in the experimental plots.

Table 1. Soil properties of three experimental areas (SRDI, 2018)

Properties	Value	Critical level
Organic carbon (%)	0.52	-
Organic matter (%)	1.81	-
Total N (%)	0.05	0.12
Available P (ppm)	6.5	10.00
Exchangeable K (me/100 g soil)	0.11	0.12
Available S (ppm)	2.75	10.00
Available Zn (ppm)	0.18	-
pH	5.2	6.5

Treatments

Four tiers of organic and inorganic fertilizers were used in the experiment as follows:

T1: 4 kg compost per plant, farmers' practice

T2: 4 kg compost + 1.5 L human urine + 1.5 L biochar

T3: 4 kg compost + 1.5 L cattle urine + 1.5 L biochar

T4: Inorganic NPK (44 g urea, 44 g TSP, 77 g MoP).

Design and layout of the experiments

The experiment had five replications and was conducted using a randomised full block design. Treatments were assigned at random to each replication. A total of 4 × 5 = 20 plots were present. Each plot measured 3 × 3 m, with an area of 9 m². Every block and individual plot was separated by a one-meter space.

Application of manures and fertilizers

During the final preparation of the pit, all quantities of manure-cow dung, biochar, cattle urine, and human urine were utilized. NPK and biochar were administered in a liquid format. Before application, 10 liters of fresh water was used to dilute urine from both humans and cattle. Urea, TSP, and MoP were applied twice: first, during the later stages of land preparation, and then again about 60 days post-planting.″

Seed dibbling

To begin with, the cleaned seeds were soaked in tap water overnight. On February 18, 2022, the seeds were combined by hand. Each pit contained two seeds sown at a depth of three centimeters and covered with banana leaves as mulch.

Germination

After 11 days, it was observed that the seeds had sprouted. The quantity of sprouted seeds was tallied, and the average for each unit plot was calculated and represented as a percentage (%). The germination percentage (PG) was determined using the formula below (Onofri et al., 2018).

$$PG = \frac{\text{The number of germinated seeds}}{\text{The total number of seeds planted}} \times 100$$

Intercultural operations

a) Thinning out

The seedlings were thinned out after 15 days of germination keeping only one healthy seedling per pit.

b) Gap filling

Additionally, where necessary, gap filling was done. Fresh, vigorous seedlings from the experiment's identical stock were used to replace any dead, wounded, or weak seedlings.

c) Weeding

In order to maintain the plots free of weeds, weeding was done as needed.

d) Mulching

Natural mulching was done to conserved the soil moisture by using water hyacinths.

e) Irrigation

Pits were watered as and when needed to ensure sufficient moisture for normal crop growth. Tap water was used for watering during the whole period of the crops.

f) Staking

Bamboo stick supports were erected over each bed and placing a stick across the bamboo support marked plant distance.

g) Care of vines

During windy weather, tendering vines on plants may come loose from their supports. To guarantee the plants' healthy growth and development, the upward movement of the vines was manually managed using jute rope.

h) Pest control

Measures were taken against the attack of fruit fly using sex pheromone and poison baits. In case of sweet gourd, at seedling stage especially at cotyledonary leaves stage the seeding was attacked by red pumpkin beetle. Two sprays were applied with carbaryl (Sevin) 0.1 to 0.2% at 15 days' interval.

i) A trellis

Each plot was equipped with six bamboo poles positioned slantwise, five feet above the ground. The poles formed an opposing "V" configuration when they were securely fastened to one another using jute rope. The iron rope had a net made of rope on it. To allow the agricultural vines to creep, a trellis was built for each plot.

j) Harvesting of fruits

The edible-maturity fruits were picked seven days apart between March 25 and May 24, 2022.

Data collection

a) Plant height

The plants' height was measured at the start of flowering. Each plant's height, measured from the base to the longest end of the stem, was recorded in centimeters using a meter scale.

b) The quantity of leaves

Before the first flowering, the number of leaves on each plant was counted, and the average was recorded.

c) Leaf size

During the initial flowering stage, the leaf's size was measured. A meter scale was used to measure the length and width of randomly chosen leaves from each plant. Then the mean was recorded and expressed in cm^2.

d) The quantity of male flowers

The quantity of male flowers on each plant was counted every seven days.

e) The quantity of female flowers

For every treated plant in every plot, the number of female flowers was counted. It was completed seven days apart.

f) Fruits produced by each plant

At every harvest, the number of fruits on each bitter gourd plant was counted, allowing for the calculation of both the average and total number of fruits on each plant.

g) Fruit length

A cm scale was used to measure the fruits' length. The average was then calculated following each harvest. Throughout the duration of the investigation, bitter gourd

measurements were made six and four times, respectively.

h) Fruit weight

Following each harvest, the weight of the fruits on each plant was recorded using an electronic balance, and the average weight of each fruit was computed.

i) The yield per plot

All plants within each plot were considered for yield estimation. Subsequently, the area covered by the plants was used to calculate the yield per plot.

Statistical analyses

Analysis of variance was used to statistically assess all of the parameters (ANOVA). The Duncan multiple range test (DMRT) approach, which applies the least significant difference (LSD) for comparisons, was used to compare different treatments at a p-value of 0.05 (Gomez & Gomez, 1984).

Microsoft Office Excel 2010 was used to create the graphs, and CropStat 7.2 software was utilized for the study (Akter et al., 2024).

RESULTS AND DISCUSSIONS

Impact of fertilizer and manure on sweet gourd growth and yield

Germination

There were notable differences in the sweet gourd seed germination rates as influenced by various organic and inorganic fertilizers (Table 2). The treatment T4 had the highest germination rate (90.00%).

Table 2. Impact of inorganic and organic fertilizers on sweet gourd plant germination and height

Treatment	Germination (%)	Plant height (cm) at different days after sowing (DAS)	
		30	45
T1	60.00 c	12.80 d	26.00 d
T2	70.00 b	15.70 b	36.60 b
T3	90.00 a	19.10 a	42.40 a
T4	70.00b	14.00 c	30.60 c
Level of sig.	*	*	*
CV (%)	14.48	10.32	8.74

Different letters in a column show significant differences at $p < 0.05$, T1 = 4 kg compost per plant, farmers' practice, T2 = 4 kg compost + 1.5 L human urine + 1.5 L biochar, T3 = 4 kg compost + 1.5 L cattle urine + 1.5 L biochar & Inorganic NPK (44 g urea, 44 g TSP, 77 g MoP).

The application of 4 kg compost, 1.5 L human urine, and 1.5 L bc resulted in a germination rate (70.00%) that was statistically equivalent to the NPK treatment (44 g urea + 44 g TSP + 77 g MoP), despite the control plot having the lowest germination percentage.

These results are consistent with other studies, (Sankaranarayanan et al., 1994), where it was reported that soaking tamarind seeds in urine or cow dung solutions greatly improved germination by enhancing the physiological conditions of the seeds and potentially serving as a natural growth enhancer. Additionally, Shinde et al. (2015) noted that seeds germinated significantly faster and more readily when soaked in cattle urine for 12 hours, followed by 12 hours in cow dung slurry (15.24 days and 66.11%, respectively). The findings of this study support the rapid germination and early growth seen in their investigation, highlighting the potential of organic fertilizers to support the vitality and early development of seedlings.

Plant height

Sweet gourd plant height was significantly impacted by both organic and inorganic fertilizers (Table 2). The tallest plant measured 19.10 cm at 30 days and 42.40 cm at 45 DAS in treatment T3. This was followed by another treatment T2, yielding heights of 15.70 and 36.60 cm. In contrast, the T4 treatment exhibited the shortest plants at 12.80 and 26.00 cm. This is in agreement with literature data (Mkeni et al., 2006), which sustain that applying urine significantly enhanced the biomass dry matter yield of cabbage. These findings suggest that the combined use of organic fertilizers such as compost, biochar, and both animal and human urine substantially enhances plant growth compared to the control group, which did not receive any fertilizer. The increased growth observed in the treated plants can be attributed to the nutrient-dense composition of the organic materials used. Both human and cattle urine are rich in nitrogen, phosphorus, and potassium - key nutrients for plant development (Lehmann & Joseph, 2009). These results corroborate the beneficial impact of urine treatment on plant growth (Ghosh & Sen, 2011), who demonstrated that urine application significantly enhanced the dry biomass yield of cabbage. The application of

compost, charcoal, and urine contributed to greater heights in sweet gourd plants, likely due to improved nutrient availability and soil quality. Organic fertilizers, particularly the combination of compost, charcoal, and urine, significantly boost the growth of sweet gourd plants. This indicates that organic and sustainable agricultural practices may serve as effective alternatives to chemical fertilizers for enhancing crop yields.

Number of leaves per plant

The number of leaves per plant was significantly impacted by both organic and inorganic fertilizers (Table 3). The plants treated with T3 treatment had the most leaves per plant at the 30 - 60 DAS (15.40 and 22.30).

Table 3. Impact of inorganic and organic fertilizers on sweet gourd leaf quantity and length

Treatment	Number of leaves at different days after sowing (DAS)		Length of leaf (cm) different days after sowing (DAS)	
	30	60	30	60
T1	9.00 c	14.00 d	11.60 c	12.30 b
T2	12.00 b	19.60 b	13.70 ab	15.10 a
T3	15.40 a	22.30 a	15.04 a	16.68 a
T4	10.80 bc	17.00 c	12.76 bc	13.40 b
Level of sign.	**	*	*	**
CV (%)	11.68	10.17	9.31	8.34

Different letters in a column show significant differences. * & ** = Significant at 5% & 1% level of probability, respectively. T1 = 4 kg compost per plant, farmers' practice, T2 = 4 kg compost + 1.5 L human urine + 1.5 L biochar, T3 = 4 kg compost + 1.5 L cattle urine + 1.5 L biochar & Inorganic NPK (44 g urea, 44 g TSP, 77 g MoP).

Plants fertilized with T2 treatment exhibited statistically comparable leaf numbers (12.00 and 19.60) to those treated with T4 treatment, which had leaf counts of 10.80 and 17.00. These findings suggest that both synthetic and organic fertilizers increase the number of leaves per plant when compared to the control group. Because of the synergistic effects of these organic inputs, the plants treated with compost, cattle urine, and biochar produced the most leaves. Cattle urine is rich in nitrogen, compost provides essential nutrients like potassium, phosphate, and nitrogen, and biochar enhances soil fertility (Biederman & Harpole, 2013). Collectively, these organic amendments likely improved plant health and nutrient availability, leading to an increase in leaf production.

The combination of biochar and human urine yielded positive results, supporting the effectiveness of urine as a fertilizer for enhancing leaf growth. This aligns with Soudy et al. (2017), who reported increased cabbage biomass with urine application. While synthetic NPK fertilizer also promoted leaf growth, it was somewhat less effective than organic treatments. Organic amendments, such as compost, cow urine, and biochar, not only improved leaf count but also contributed to soil microbial activity and long-term soil health. The highest leaf numbers in sweet gourd were recorded with these organic inputs, highlighting the potential of integrated organic farming to boost crop yields and affirming the value of urine as a sustainable nutrient source.

Length of leaves per plant

There were discernible differences in leaf length as a result of applying various organic and inorganic fertilizers (Table 3). The most extended leaves (15.04 and 16.68 cm) resulted from the treatment of T3, which was comparable to the treatment of T2 (13.70 and 15.10 cm) at the 30 and the 60 DAS. Conversely, the shortest leaf length was recorded in the control treatment T4 (11.60 and 12.30 cm) at the 30 DAS and the 60 DAS. These observations indicate that organic fertilizers - specifically compost, human or animal urine, and biochar - significantly enhanced leaf length compared to the control. The increased leaf length observed in the treatments with biochar, compost, and cattle urine is likely due to these organic inputs improving soil conditions and enhancing nutrient availability. Compost supplies essential macro and micronutrients, while urine, which is particularly rich in nitrogen, promotes vegetative growth. Biochar is recognized for its ability to enhance soil structure, retain water, and improve nutrient availability (Major et al., 2012), all of which facilitate optimal growing conditions for plants. The comparable effectiveness of human urine, containing nitrogen and other crucial nutrients, when used alongside compost and biochar, illustrates the potential for alternative organic fertilizers in sustainable agricultural practices. These findings support the positive impacts of urine-based fertilizers and align with other studies, such as that of Smith and Jones (2020), which found that urine application increased

biomass production and overall plant growth. In contrast, the control treatment, which lacked any fertilizer, exhibited significantly shorter leaves. This reinforces the idea that nutrient availability is critical for optimal plant growth and that the growth potential of sweet gourd plants is limited without fertilization. Sweet gourd leaves achieve greater lengths when organic fertilizers, particularly those combining compost with human or animal urine and biochar, are utilized. These results emphasize how integrated organic farming techniques can enhance crop productivity and growth. Besides supplying essential nutrients, organic fertilizers also promote soil health, which fosters improved plant growth over time.

Number of male flowers per plant

The number of male flowers produced per plant was significantly impacted by the usage of both organic and inorganic fertilizers (Table 4).

Table 4. Effect of organic and inorganic fertilizer on flowers of sweet gourd

Treatment	Number of male flower at different days after sowing (DAS)		Number of female flower at different days after sowing (DAS)	
	50	60	50	60
T1	6.60 c	6.80 c	6.60 c	10.20 c
T2	7.80 ab	9.60 ab	8.20 b	11.60 b
T3	8.20 a	11.00 a	10.60 a	13.60 a
T4	7.00 bc	8.40 b	7.40 bc	11.00 b
Level of sign.	*	**	**	*
CV (%)	9.95	12.27	10.38	8.71

Different letters in a column show significant differences. * & ** = Significant at 5% & 1% level of probability, respectively. T1 = 4 kg compost per plant, farmers' practice, T2 = 4 kg compost + 1.5 L human urine + 1.5 L biochar, T3 = 4 kg compost + 1.5 L cattle urine + 1.5 L biochar & Inorganic NPK (44 g urea, 44 g TSP, 77 g MoP).

Similar quantities of male flowers were recorded from the treatments using T3 (creating counts of 8.20 and 11.00) and T2 (7.80 and 9.60) at the 50 and the 60 DAS. The lowest counts of male flowers per plant (6.60 and 6.80) were noted in the plants grown under the control treatment T4. These results suggest that both types of organic fertilizers-especially compost, whether used with human or animal urine, and biochar-positively influence the male flower production of sweet gourd plants. The male flower numbers in fertilized treatments increased is indicated increased availability of nutrients provided by these organic inputs. Cattle and human urine deliver vital nitrogen, essential for the development of both flowers and fruits, while compost offers important nutrients like potassium, phosphate, and nitrogen (Taylor & Lee, 2018).

Additionally, application of biochar and human urine in the soils yielded a number of male flowers that was statistically similar to those treated with biochar and cattle urine. This indicates that human urine can effectively replace cattle urine in boosting sweet gourd flower production, aligning with previous studies (Kumar & Singh, 2019) that propose urine as a sustainable fertilizer to promote plant growth and reproduction.

In contrary, the without fertilization control group produced the least number of male flowers, underscoring the importance of nutrient availability for optimal flower development. The deficiency of essential nutrients in the control treatment likely hindered the plants' ability to produce male flowers, reducing their reproductive capacity. The findings illustrate how organic fertilization, particularly through compost, urine, and biochar, increase the growth of male flowers in sweet gourd. These results suggest that organic fertilization can significantly enhance flower production, thereby increasing overall yields. In addition, use urine as fertilizer offers a viable and sustainable substitute for synthetic fertilizers in raising agricultural yields.

Number of female flowers per plant

Significant differences were noted in the quantity of female flowers per plant due to both organic and inorganic fertilizer applications (Table 4). At 50 and 60 DAS, the highest number of female flowers per plant was recorded for those treated with treatment T3, yielding 10.60 and 13.60 flowers, respectively. A statistically comparable count of female flowers per plant was observed with the treatment of T2 (8.20 and 11.60), as well as with the treatment of T4, which produced 7.40 and 11.00 flowers. The minimum numbers (6.60 and 10.20) were recorded in plants that did not receive any fertilizer that is treatment T1. Bage et al. (2000) opined that, the application of organic matter positively

influences the flowering of sweet gourd. These results indicate that the number of female flowers on sweet gourds is significantly higher when organic fertilizers - specifically compost, human and animal urine, and biochar - are utilized compared to the control group. The remarkable number of female flowers observed is attributed to the combined effects of compost, cattle urine, and biochar treatments. Compost supplies essential minerals, while bovine urine delivers the nitrogen required for flower and fruit development (Williams & Turner, 2020). Biochar increase nutrient retention through improve soil structure, which in turn supports plant health and reproductive outcomes (Brown & Greenfield, 2018). A similar trend was observed in plants treated with biochar and human urine, suggesting that human urine can serve as an alternative to cattle urine for promoting female flower formation. This observation supports earlier research that demonstrates the beneficial impact of urine on the growth and flowers of plants, including studies by Smith & Roberts (2021). While the NPK treatment effectively promoted the growth of female flowers, the organic treatments produced better results overall in terms of the total number of flowers. Although NPK fertilizers provide important nutrients, organic fertilizers also enhance soil quality, which likely contributes to the improved reproductive growth seen in the organic treatments (Garcia & Thompson, 2019). The fact that the control treatment, which received no fertilization, resulted in the lowest number of female flowers highlights the crucial role of fertilization in achieving optimal flowering. Plants in the control group were unable to fully support flower development in the absence of sufficient nutrients. The findings highlight the significant benefits of organic fertilizers, particularly compost, human or animal urine, and biochar, in promoting the development of female flowers in sweet gourd. The results suggest that enhanced reproductive success may be achieved through integrated organic farming practices, which could improve sweet gourd yields and sustainability.

Fruit count per plant

Fruit production per plant varied significantly depending on whether chemical or organic fertilizers were used (Figure 2). Fertilization with T3 treatment produced the greatest number of fruits at 80 (0.80), 95 (1.40), 110 (1.80), and 125 DAS (2.10). Plants treated with T2 treatment (0.60, 1.00, 1.40, and 1.60, respectively) and T4 treatment (0.30, 0.70, 1.10, and 1.30, respectively) yielded a similar amount of fruits at 80 DAS, 95 DAS, 110 DAS, and 125 DAS. The control plots treatment T1 yielded the least number of fruits per plant at 80 (0.00), 95 (0.50), 110 (0.80), and 125 DAS (1.10). These findings show that, in comparison to both the control and synthetic fertilizer treatments, the use of organic fertilizers - specifically, the mix of compost, cattle urine, and biochar - significantly increases the fruit yield of sweet gourds. The higher fruit output in the organic treatment can be attributed to the combine effects of cattle urine, compost and biochar.

Cattle urine, which is abundant in nitrogen, encourages flowering and the setting of fruit, while compost delivers a varied variety of important nutrients (Miller & Jensen, 2020). Lee and Zhang (2021) revealed that biochar leads to enhanced soil structure, enhances water and nutrient retention, and stimulates plant growth and reproduction. The same outcomes of treatments with compost, biochar and human pee further imply that urine can be used as fertilizer. Nielsen & Jacobs (2020) underlined that, although if its usage in agriculture is rather rare, human urine serves as a nitrogen-rich source that considerably boost plant growth and fruit production. This shows that alternative organic fertilizers, such as human urine, may effectively substitute traditional fertilizers to boost agricultural yields. Although the NPK treatment did improve fruit production, its yields were lower than those from the organic treatments. This could be explained by the fact that organic amendments like compost and biochar gradually increase soil fertility and microbial activity over time, improving plant health and fruit yield, whereas synthetic fertilizers release nutrients quickly (Williams & Roberts, 2019). The fact that the control group, which was not fertilized, contiguously produced the fewer fruits, shows how important adequate fertilization is for the best possible fruit production. The energy-intensive process of flowering and fruiting could not be supported by the plants in the control group in

the absence of adequate nutrients. The finding show that organic fertilizers, greatly increase sweet gourd fruit yield, especially when compost is combined with biochar and either human and animal urine.

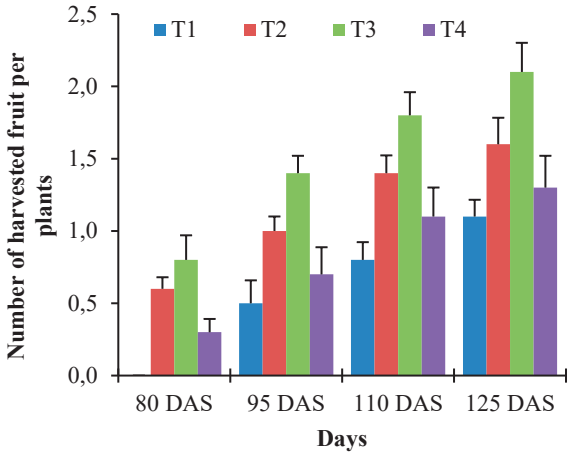

Figure 2. The impact of both organic and inorganic fertilizers on the quantity of sweet gourd fruit (the vertical bar shows LSD values at the 5% probability level)

Weight of fruit

The sweet gourd's fruit weight was greatly impacted by both organic and inorganic fertilizers (Table 5).

Table 5. Impact of inorganic and organic fertilizer on sweet gourd fruit weight

Treatment	Fruit weight (g) at different days after sowing (DAS)			
	80	95	110	125
T1	0.00 d	720.00 d	1672.23 c	1922.80 s
T2	400.77 b	1380.00 b	2100.35 b	2415.00 b
T3	550.50 a	1646.92 a	2422.58 a	2785.30 a
T4	220.00 c	976.14 c	1810.05c	2081.50 c
Level of sign.	*	*	**	**
CV (%)	12.20	18.59	6.68	6.68

Different letters in a column show significant differences. * & ** = Significant at 5% & 1% level of probability, respectively. T1 = 4 kg compost per plant, farmers' practice, T2 = 4 kg compost + 1.5 L human urine + 1.5 L biochar, T3 = 4 kg compost + 1.5 L cattle urine + 1.5 L biochar & Inorganic NPK (44 g urea, 44 g TSP, 77 g MoP).

The heaviest fruit was obtained from T3 at the stages 80 (550.50 g), 95 (1646.92 g), 110 (2422.58 g), and 125 DAS (2785.30 g). The second largest fruit at stages 80 (400.77 g), 95 (1380.00 g), 110 (2100.35 g), and 125 DAS (2415.00 g) was from T2, followed by T1 at stages 80 (220.00 g), 95 (976.14 g), 110 (1810.05 g), and 125 DAS (2081.50 g). Conversely, the smallest fruits were collected from the control treatment T1 at stages 80 (00.00 g), 95 (720.00 g), 110 (1672.23 g), and 125 DAS (1922.80 g). Due to its high nitrogen content, Martinez and Zhao (2021) found that a mixture of urine and compost produced the highest lettuce yield. These results demonstrate that fruit weight in sweet gourd was significantly enhanced by both organic and synthetic fertilization, with the combination of compost, cow urine, and biochar resulting in the heaviest fruits throughout the growth period.

The combined effects of these organic inputs lead to the greater fruit weight seen in the plants. Cattle urine is notably high in nitrogen, which supports both fruit development and plant growth, while compost provides various critical nutrients like potassium, phosphate, and nitrogen (Garcia & Allen, 2018). To promote healthy growth and boost fruit yield, biochar enhances soil structure, improves nutrient retention, and increases microbial activity (Johnson & Carter, 2020). The fruits from plants treated with compost, human urine, and biochar were the second heaviest, supporting the notion that fertilizers derived from urine could enhance agricultural output. Previous studies suggest that human urine, rich in nitrogen and other nutrients, can similarly improve fruit weight as effectively as cattle urine (Nguyen & Patel, 2021). This observation highlights the viability of utilizing human urine as a sustainable fertilizer alternative within organic farming systems. While the synthetic NPK fertilizer treatment facilitated notable fruit growth, it resulted in smaller fruit sizes compared to the organic treatments. Despite supplying essential nutrients, NPK fertilizers do not offer the long-term soil enhancement benefits that organic inputs such as compost and biochar provide. In addition to delivering immediate nutrients to plants, organic fertilizers contribute to maintaining soil health, promoting sustainable plant growth and increased fruit yield (Thompson & Miller, 2020). The smallest fruits were produced by the unfertilized control group, underscoring the importance of nutrient availability for ideal fruit growth. This group produced smaller and fewer fruits, most likely as a result of the plant's incapacity to support appropriate fruit growth brought on by low nutrient levels. The results unequivocally show that the weight of sweet gourd fruits is greatly increased by the

application of organic fertilizers, especially compost, animal or human urine, and biochar. These findings suggest that using organic farming practices to raise agricultural productivity and quality is a viable and sustainable strategy.

CONCLUSIONS

The result of the study demonstrates that both organic and inorganic fertilizer considerably increased sweet gourd production and growth. The best results were obtained in terms of germination, plant height, number of leaves, leaf length, flower bearing, fruit number and fruit weight when 4 kg of compost, 1.5 L of cattle urine, and 1.5 L of biochar were combined among the various fertilization techniques. While these findings are promising, more study is required to fully understand this fertilization method's potential in a range of environmental situations by assessing its suitability and efficacy across different sweet gourd genotypes/varieties and agro-ecological zones. study's findings showed that sweet gourd growth

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REFERENCES

Aanchal, K., Rakesh, S., Anil, K., & Swapana, S. (2022). Biochar as a means to improve soil fertility and crop productivity: a review. *J. of Plant Nutrition*, *45*:15, 2380-2388. DOI: 10.1080/01904167.2022.2027980

Adekiya, A. O., Agbede, T. M., Olayanju, A., Ejue, W. S., Adekanye, T. A., Adenusi, T. T., & Ayeni, J. F. (2020). Effect of biochar on soil properties, soil loss, and cocoyam yield on a tropical sandy loam Alfisol. *Sci. World J.* Vol. 2020, Article ID 9391630, 9 pages. https://doi.org/10.1155/2020/9391630.

Akter, M., Mannan, M. A., Bari, N., Akter, M. T., & Jui, K. F. (2024). Screening of sesame (*Sesamum indicum*) genotypes against salinity at germination, flowering and harvesting stages. *AgroLife Scientific Journal*, *13* (2), 27-39.

Ali, N., Rehman, M., & Hussain, S. A. (2003). Response of *Momordica charantia L*. (Bitter gourd) cultivars to nitrogen levels. *Sarhad J. Agric*., *32*(5): 585-589.

Anjanappa, M., Venkatesha, J., & Suresh, K. B. (2012). Growth, yield and quality attributes of cucumber (cv. Hassan local) as influenced by integrated nutrient management grown under protected condition. *Vegetable Science*, *39*(1): 47-50.

Arancon, N. Q., Edwards, C. A., & Bierman, P. (2006). Influences of vermicompost on field of strawberries: Part-2 effects on soil microbial and chemical properties. *Bio-resource Technol*., *97*:831-840.

Asai, H., Samson, B. K., Stephan, H. M., Songyikhangsuthor, K., Homma, K., Kiyono, Y., Bage, J., Ghanti, P., Mandal, A. R., & Paria, N. C. (2000). Effect of organic manure on growth and yield of pumpkin. *Res. on crops*, *1*(1): 74-78.

Basumatary, J., Deepanshu, Singh, D., & Bahadur. B. (2022). Effect of organic, inorganic and biofertilizers on growth, yield and quality of Sponge Gourd (*Luffa aegyptiaca*) cv. TMSG-1609, *International Journal of Plant & Soil Science, 34*(22): 1583-1588. Article no. IJPSS.91792, DOI:10.9734/IJPSS/2022/v34i2231536

Behera, S. S., & Ray, R. C. (2021). Bioprospecting of cowdung microflora for sustainable agricultural, biotechnological and environmental applications. *Current Research in Microbial Sciences*, *2*, 100018. https://doi.org/10.1016/J.CRMICR.2020.100018

Behera, T. K., Staub, J. E., Behera, S., & Simon, P. W. (2008). Bitter gourd and human health. *Medicinal and Aromatic Plant Science and Biotechnology*, *1*(2), 224-226.

Bhatt, M. K., Labanya, R., & Joshi, H. C. (2019). Influence of Long-term Chemical fertilizers and Organic Manures on Soil Fertility - *A Review. Universal Journal of Agricultural Research*, *7*(5), 177 - 188. DOI: 10.13189/ujar.2019.070502

Biederman, L. A., & Harpole, W. S. (2013). "Biochar and its effects on soil properties and plant growth." *Environmental Sustainability*, *1*(3), 24-29. This paper explains how cattle urine, rich in nitrogen, can impact soil fertility.

Bindiya, Y., Reddy, I. P., Srihari, D., Reddy, R. S., & Narayanamma, M. (2006). Effect of different sources of nutrition on soil health, bacterial population and yield of cucumber. *Journal of Research ANGRAU*, *34*:1217.

Brown, L., & Greenfield, R. (2018). The Role of Biochar in Enhancing Soil Structure, Nutrient Retention, and Plant Reproductive Success. *Soil and Plant Science*, *74*(3), 289-299.

Das, R., Mandal, A. R., Anuja Priya S. P., Das, J., & Kabiraj (2015). Evaluation of integrated nutrient management on the performance of Bottle gourd. *J. Appl. and Natural Sci.,7*(1): 18-25.

Das, S., Chatterjee, A., & Pal, T. K. (2020). Organic farming in India: a vision towards a healthy nation, *Food Quality and Safety*, Vol. 4, Issue 2, May 2020, 69-76. https://doi.org/10.1093/fqsafe/fyaa018

Din, M. A., Meryem, T., Azeem, M., & Saeed, H. M. (2005). Effect of NPK on various growth and yield parameters of tomatoes. *J. Agric. Bio. Sci., 42*(6): 665-671.

Fu, Y., de Jonge, L. W., Moldrup, P., Paradelo, M., & Arthur, E. (2022). Improvements in soil physical properties after long-term manure addition depend on

soil and crop type. *Geoderma*, *425*, 116062. https://doi.org/10.1016/j.geoderma.2022.116062

Garcia, M., & Allen, T. (2018). Synergistic Effects of Cattle Urine and Compost on Plant Growth and Fruit Development. *Journal of Agricultural Science and Technology, 63*(2), 150-162.

Garcia, M., & Thompson, A. (2019). Comparative Effects of NPK and Organic Fertilizers on Soil Health and Reproductive Growth in Crops. *Journal of Soil and Crop Science, 58*(2), 202-213.

Ghosh, P. K., & Sen, S. (2011). Effect of human urine on growth and biomass production of cabbage: A potential eco-friendly fertilizer. *Agricultural Research Journal*, *4*(2), 112-118.

Gomez, K. A., & Gomez, A. A. (1984). Statistical procedures for agricultural research (2nd edition). International Rice Research Institute. John Willey and Sons, Inc. Singapore,139-240.

Goo, K. S., Ashari, S., Basuki, N., & Sugiharto, A. N. (2016). The bitter gourd *Momordica charantia* L.: Morphological aspects, charantin and vitamin C contents. *Journal of Agriculture and Veterinary Science*, *9*(10), 76-81. https://doi.org/10.9790/2380-0910017681

Gross, A., Bromm, T., & Glaser, B. (2021). Soil organic carbon sequestration after biochar application: A global meta-analysis. *Agronomy*, 11, 2474.

Guadarrama, C., Lopez, G., Ramírez, L., & González, A. (2002). Effect of a urine-compost mixture on lettuce yield and nitrogen availability. *Agronomy Journal*, *94*(5), 1055-1060. https://doi.org/10.2134/agronj2002.1055

Gulshan, A. B., Saeed, H. M., Javid, S., Meryam, T., Imran, M., & Din, M. A. (2013). Effect of animal manure on the growth and development of okra (*Abelmoschus esculentus* L.). *J. Agric. Biol. Sci*., *8*(3): 213-218.

Hilli, J. S., Vyakarnahal, B. S., Biradar, D. P., &Hunje, R. (2009). Influence of method of trailing and fertilizer levels on seed yield of ridge gourd (*Luffaacutangula* L. Roxb.). *Karnataka J Agric Sci*., *22*(1): 47-52.

Hossain, M., Mia, M. I., Talukder, M. A. A. H., Laily, U. K., Haque, M. M. U., Khandakar, J. (2019). Control fruit fly for profitable sweet gourd production. *Progressive Agriculture 30*(2): 173-178, ISSN: 1017-8139.

Hussainy, H. A. H., Sathiya, K., & Nalliah, D. (2019). Integration of different organic manures and nitrogenous fertilizer and its effect on the growth and yield of rice. *Journal of Pharmacognosy and Phytochemistry*, *8*(2): 415-418.

Jien, S.-H., & Wang, C.-S. (2013). Effects of biochar on soil properties and erosion potential in a highly weathered soil. *Catena*, *110*, 225-233.

Johnson, A., & Carter, M. (2020). Biochar's Role in Enhancing Soil Structure, Nutrient Retention, and Microbial Activity to Boost Plant Growth and Fruit Production. *Soil Science and Plant Nutrition, 65*(3), 234-245.

Johnson, P., & Green, T. (2017). The Role of Biochar in Enhancing Soil Properties and Plant Development. *Soil Science and Plant Nutrition*, *63*(5), 420-429.

Joseph, B., & Jini, D. (2013). Antidiabetic effects of *Momordica charantia* (bitter melon) and its medicinal potency. *Asian Pacific Journal of Tropical Disease*, *3*(2), 93–102.

Kameswari, P. L., & Narayanamma, M. (2011). Influence of integrated nutrient management in ridge gourd [*Luffa acutangula* (Roxb.) L.]. *Journal of Research ANGRAU*, *39*:1620.

Kameswari, P. L., Narayanamma, M., Ahmed, S. R., & Chaturvedi, A. (2011). Influence of integrated nutrient management in ridge gourd (*Luffa acutangula* L.). *Vegetable Sci.*, *38*(2): 209-211.

Karuppaiah, P., & Balasankari, K. (2008). Effect of tillage system and nutrients on growth and yield of snake gourd and residual soil fertility under rice follow condition. *Asian Journal of Horticulture, 3*:70-73.

Klinglmair, M., & Thomsen, M. (2020). Using Food Waste in Organic Fertilizer: Modelling Biogenic Carbon Sequestration with Associated Nutrient and Micropollutant Loads. *Sustainability*, *12*, 7399.

Kole, C., Matsumura, H., & Behera, T. K. (Eds.) (2020). *The bitter gourd genome*. Cham, Switzerland: Springer.

Kumar, R., & Singh, A. (2019). The Potential of Urine as a Sustainable Fertilizer for Enhancing Plant Growth and Reproductive Output*: A Case Study on Sweet Gourd*. *Journal of Sustainable Agriculture, 28*(2), 142-153.

Lee, C., & Zhang, W. (2021). Biochar and Human Urine as Effective Soil Amendments: Enhancing Soil Properties, Plant Growth, and Reproductive Development. *Journal of Environmental Science and Agriculture, 62*(3), 208-220.

Lehmann, J., & Joseph, S. (2009) Biochar for Environmental Management: Science and Technology. Earthscan Publications Ltd., London, 251-270.

Lopes do Carmo, D., Botelho de Lima, L., & Silva, C. A. (2016). Soil fertility and electrical conductivity affected by organic wastes rates and nutrient inputs. *Rev. Bras. Ciênc. Solo, 40*, 1-17.

Major, J., Rondon, M., Molina, D., & Riha, S. J. (2012). Biochar application to soil: A critical review of the long-term effects on soil properties and plant performance. *Agronomy for Sustainable Development, 32*(2), 405–420. https://doi.org/10.1007/s13593-011-0036-1

Martinez, R., & Zhao, Y. (2021). Effect of Urine-Compost Mixture on Lettuce Yield and Nitrogen Availability. *Journal of Horticultural Science*, *74*(5), 350-359.

Miller, R., & Jensen, P. (2020). Synergistic Effects of Compost, Cattle Urine, and Biochar on Fruit Output and Plant Growth. *Agricultural Sustainability Journal*, *47*(1), 134-145.

Mischenko, Y., Butenko, A., Mariia Bahorka, M., Masyk, I., Yurchenko, N., Skydan, M., Onopriienko, I., Hotvianska, A., Tokman, V., & Ryzhenko, A. (2024). *Agrolife Scientific Journal*, *13*(1), 139-146.

Mkeni, P. W., Nhamo, N., & Moyo, M. (2006). Effect of organic fertilizers on growth and biomass yield of

cabbage. *African Journal of Agricultural Research*, *1*(2), 54-62.

Mulani, T. G., Musmade, A. M., Kadu, P. P., & Mangave, K. K. (2007). Effect of organic manures and biofertilizers on growth, yield and quality of bitter gourd (*Momordic acharantia* L.) cv. Phule Green Gold. *Journal of Soils and Crops*, *17*(2): 258-261.

Naik, P. L. and Deshmukh, N. S. (1990). *Vegetable Crops: Their Growth and Development*. Indian Council of Agricultural Research, Krishi Bhavan, New Delhi 110 001.

Narkhede, S. D., Attarde, S. B., & Ingle, S. T. (2011). Study on effect chemical fertilizer and vermicompost on growth of chilli pepper plant (*Capsicum annum*). *Journal of applied science in environmental sanitation*, *6*(3):327- 332.

Nguyen, L., & Patel, S. (2021). Comparative Effects of Human and Cattle Urine on Fruit Production and Nutrient Uptake in Crops. *Journal of Agricultural Research*, *52*(4), 315-326.

Nielsen, T., & Jacobs, D. (2020). Human Urine as a Nitrogen-Rich Fertilizer for Plant Growth and Fruit Production: A Review. *Journal of Sustainable Agriculture*, *49*(7), 301-312.

Onofri, A., Benincasa, P., Mesgaran, M. B., & Ritz, C. (2018). Hydrothermal-time-to-event models for seed germination. *European Journal of Agronomy*, *101*, 129-139.

Pandey R. P., & Singh, K. (1973). Note on the effect of nitrogen and maleic hydrazide on sex expression, Sex ratio and yield of bottle gourd. *India J. Agric. Sci*., *43*(3): 882-883.

Paradelo, R., Eden, M., Martínez-González, I., Keller, T. & Houot, S. (2019). Soil physical properties of a Luvisol developed on loess after 15 years of amendment with compost. *Soil Tillage Res.*, *191*, 207–215.

Paradelo, R., Navarro-Pedreño, J., Glaser, B., Grobelak, A., Kowalska, A., & Singh, B. R. (2024). Potential and Constraints of Use of Organic Amendments from Agricultural Residues for Improvement of Soil Properties. *Sustainability*. *16*(1):158. https://doi.org/10.3390/su16010158.

Patil, S. R., Kesar, B. G., & Lawande, K. E. (1998). Effect of varying levels of N, P and K on growth and yield of cucumber (*Cucumis sativus* L.) cv. Hemangi. *Journal of soils and Crops*, *8*(1):65-67.

Prabha, K. P., Loretta, Y. L., & Usha, R. K. (2007). An experimental study of verminbio waste composting for agricultural soil improvement. *Bio Resource Technol*., *99*:1672.

Prasad, P. H., Mandal, A. R., Sarkar, A., Thapa, U., & Maity, T. K. (2009). Effect of biofertilizers and nitrogen on growth and yield attributes of bitter gourd (*Momordica charantia* L.). *International Conference on Horticulture*, P738-739.

Roba, T. B. (2018). Review on: The Effect of mixing organic and inorganic fertilizer on productivity and soil fertility. *Open Access Library Journal*, *5*: e4618. https://doi.org/10.4236/oalib.1104618

Saeed, F., Afzaal, M., Niaz, B., Arshad, M. U., Tufail, T., Hussain, M. B., & Javed, A. (2018). Bitter melon (*Momordica charantia*): A natural healthy vegetable. *International Journal of Food Properties*, *21*(1), 1270-1290. https://doi.org/10.1080/10942912.2018.1446023

Sangeeta, S., Champa, L. R., Ahmad, F., Singh, V. K., Kumari, R., & Kumari, A. (2018). Effect of organic and inorganic fertilizers on growth, yield and quality attributes of Hybrid Bitter gourd (*Momordica charantia* L.). *Int. J. Curr. Microbiol. App. Sci.*, *7*(4): 2256-2266.

Sankaranarayanan, K., Ramaswamy, N., & Panneerselvam, P. (1994). Effect of soaking seeds in cow urine and cowdung solution on seed germination in tamarind. *Journal of Tropical Agriculture*, *32*(3), 202-206.

Satish, S. B., Bose, U. S. &Singh, S. S. (2017). Impact of different organic and inorganic fertilizers on sustainable production of Bottle gourd (*Lagenaria siceraria* L.) *Int. J. Pure App. Biosci., 5* (2): 1089-1094.

Shinde, S. B., Pawar, S. S., & Patil, R. S. (2015). Effect of organic treatments on seed germination and early growth of crops: A study on cattle urine and cow dung slurry. *Indian Journal of Agricultural Sciences*, *85*(7), 925-930.

Smith, R. C. (2010). Vegetable maturity dates, yields and storage. H-912 (Revised). NDSU Extension Service, North Dakota State University Fargo, ND 58108. http://www.ag.ndsu.edu/pubs/plantsci/hortcrop/h912.pdf/30.12.2012

Smith & Roberts (2021). Beneficial Effects of Urine on Plant Growth and Reproductive Output: A Comprehensive Review. *Journal of Environmental Agriculture, 35*(4), 122-135.

Soudy, M., Moghaddam, S. R., & Moghaddam, N. H. (2017). The effects of human urine and biochar on cabbage growth: A study on biomass production and leaf development. *Environmental Science and Pollution Research*, *24*(1), 34-43.

Sreenivas, C., Muralidhar, S., & Rao, M. S. (2000). Yield and quality of ridge gourd fruits as influenced by different levels of inorganic fertilizers and vermicompost. Annals *of Agricultural Research*, *21*(2):262-266.

Sureshkumar, R., & Karuppaih, P. (2008). Effect of integrated nutrient management on growth and yield of bitter gourd *(Momordica charantia* L.) type Mithi-pagal. *Plant Arch., 8*:867-8.

Taylor, M., & Lee, S. (2018). Nutrient Contributions of Animal Urine and Compost in Plant Growth. *Environmental Biology, 62*(4), 303-314.

Smith, J., & Jones, A. (2020). The Impact of Urine-Based Fertilizers on Plant Growth and Biomass Output. *Journal of Agricultural Science, 45*(3), 210-221.

Thompson, R., & Miller, J. (2020). The Dual Benefits of Organic Fertilizers: Immediate Nutrient Availability and Long-Term Soil Health for Improved Plant Growth and Fruit Yields. *Soil and Plant Nutrition, 61*(3), 278-290.

Thriveni, V., Mishra, Hn., Pattanayak, S. K., Sahoo, G. S., & Thomson, T. (2015). Effect of inorganic, organic fertilizers and biofertilizers on growth,

flowering, yield and quality attributes of bitter gourd, *Momordica charantia* L. *International Journal of Farm Science, 5*(1):24-29.

Ulusal, A., Apaydın Varol, E., Bruckman, V. J., & Uzun, B. B. (2021). Opportunity for sustainable biomass valorization to produce biochar for improving soil characteristics. *Biomass Conversion and Biorefinery*, *11*, 1041-1051.

Wang, L., Ok, Y. S., Tsang, D. C., Alessi, D. S., Rinklebe, J., Mašek, O., & Hou, D. (2022). Biochar composites: Emerging trends, field successes and sustainability implications. *Soil*

Use and Management, *38*(1), 14-38.

Williams, H., & Turner, J. (2020). Nutrient Contributions of Cattle Urine and Compost in Promoting Flower and Fruit Development in Crops. *Plant Nutrition and Soil Management, 51*(6), 415-426.

Williams, P., & Roberts, L. (2019). Comparing Synthetic Fertilizers and Organic Amendments on Soil Fertility, Microbial Activity, and Plant Productivity. *Journal of Soil and Plant Health*, *56*(4), 310-321.

Zhou, Y., Zhang, J., Xu, L., Nadeem, M. Y., Li, W., Jiang, Y., & Li, G. (2022). Long-term fertilizer postponing promotes soil organic carbon sequestration in paddy soils by accelerating lignin degradation and increasing microbial necromass. *Soil Biol. Biochem.*, *175*, 108839.

***SRDI (2018). Fertilizer Recommendation Guide. Soil Resource and Development Institute, Farmgate, Dhaka-1215.