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Mst. Ami Begum
Department of Horticulture, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh

Mahbub Robbani
Department of Horticulture, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh

Jewel Howlader
Department of Horticulture, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh

Litun Ahmed Labib
Department of Horticulture, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh

Md. Shaon Sharif
Department of Horticulture, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh

Md. Mainul Islam
Department of Horticulture, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh

Correspondence Author:
Litun Ahmed Labib
Department of Horticulture, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh

Co-benefits of cow urine and biochar-based fertilizer on flowering, fruiting and fruit quality of dragon fruit

Mst. Ami Begum, Mahbub Robbani, Jewel Howlader, Litun Ahmed Labib, Md. Shaon Sharif and Md. Mainul Islam

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Abstract
Dragon fruit (*Hylocereus* sp.) is esteemed for its popularity and nutritional value within the Cactaceae family. This study was conducted at the Germplasm Center, Department of Horticulture, Patuakhali Science and Technology University, from January 2021 to October 2021 to assess the performance of cow urine and biochar-based fertilizer on flowering, fruiting, and fruit quality of dragon fruit. This investigation was carried out in a Randomized Complete Block Design (RCBD) with four replications. Four treatments *viz.* M_0= Control (no NPK, biochar and cow urine), M_1= NPK (Urea= 100 g, TSP= 84 g and MOP= 84 g) + biochar (5 kg), M_2= Cow urine (3 L) + biochar (5 kg) and M_3= NPK (Urea= 100 g, TSP= 84 g and MOP= 84 g) + cow urine (3 L) + biochar (5kg) with four replications were applied to the 4 years aged "BARI Dragon Fal-1" plants. The highest number of flower buds (12.75), number of flowers (12.75), number of mature fruits (12.75), individual fruit weight (277.00 g), fruit length (10.78 cm), fruit diameter (6.60 cm) and pulp weight (208.50 g) were found at 60 days after first flower bud emergence in the treatment combination of M_3. However, biochar-based fertilizer combinations did not significantly affect the qualitative parameters of dragon fruit. These findings underscore the synergistic effect of NPK, cow urine, and biochar in enhancing the flowering and fruiting of dragon fruit. This finding also suggests the potential applications of cow urine and biochar with rational use of urea for optimizing cultivation practices of dragon fruit in the studied area.

Keywords: Dragon fruit, cow urine, biochar-based fertilizer, flowering, fruit quality, sustainable agriculture

1. Introduction
The dragon fruit (*Hylocereus* sp.*)* belongs to the Cactaceae family and thrives in dry, tropical, or subtropical conditions [1]. *Hylocereus* has nearly 18 different species all over the world. Pitaya is a fruit that is popular in Latin America. It's a long-day plant with a lovely night-blooming blossom known as "Noble woman," "Queen of the Night," or "moon flower". It is currently grown in at least 22 tropical nations, including Vietnam, Australia, Cambodia, China, Malaysia, Thailand, Sri Lanka, and Bangladesh [2]. Dragon fruit was first commercially grown by some of Bangladesh's elite farmers in regions like Ashulia, Dhaka, and Halda Valley. It has already begun to be researched at BARI, BAU, and PSTU. Rich in dietary fiber, vitamins, minerals, and antioxidants, dragon fruit has shown promise in preventing various human ailments, including cancer, digestive issues, and diabetes [3, 4, 5]. However, further research is crucial to validate and expand our understanding of its therapeutic potential [6]. The fruit also includes oligosaccharides, which have been shown to help the digestive environment [7, 8].
In recent years, sustainable agricultural practices have gained traction, aiming to enhance productivity while minimizing environmental impact. Biochar, a byproduct of biomass pyrolysis, affects a wide range of soil characteristics and agronomic performance metrics, including yield, root biomass, water usage efficiency, microbial activity, soil organic carbon, and greenhouse gas emissions. Regional levels of sustainable soil management could be impacted by biochar [9, 10]. Two primary features of biochar's contribution as a soil amendment are currently being evaluated [11]. One is connected to its potential to increase agricultural systems' productivity and counteract land degradation by enhancing the physical, biological, and chemical characteristics of soil [12]. The other is its role in carbon sequestration since it has stable forms of carbon that remain in the soil for a longer period of time [13, 14]. Moreover, cow urine, rich in essential nutrients such as nitrogen, potassium, and

phosphorus, offers significant benefits to soil health through both direct application and formulation-based approaches. Additionally, its composition includes sulfur, sodium, manganese, iron, enzymes, and chlorine, rendering it a holistic natural pest-repellent [15, 16]. Farmers can easily find biochar and cow urine, which are also less expensive than chemical fertilizers. Despite the promising attributes of biochar and cow urine, their combined effects on dragon fruit cultivation remain underexplored, particularly in the context of replacing synthetic fertilizers. Understanding the impact of biochar-based fertilization on dragon fruit flowering, fruiting, and fruit quality is crucial for optimizing sustainable cultivation practices and potentially reducing production costs. Therefore, this study aims to investigate the impact of cow urine and biochar-based fertilizer on the flowering, fruiting, and fruit quality of dragon fruit (*Hylocereus sp.*), with the goal of enhancing understanding of sustainable cultivation practices and potentially reducing production costs.

2. Materials and Methods

2.1 Experimental design and treatments

A single factor experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications and four treatments *viz*. M_0= Control (no NPK, biochar, and cow urine), M_1= NPK (urea= 100 g, TSP= 84 g, and MOP= 84 g) + biochar (5 kg), M_2= Cow urine (3 L) + biochar (5 kg), M_3= NPK (urea= 100 g, TSP= 84 g and MOP= 84 g) + cow urine (3 L) + biochar (5kg). BARI recommended doses of NPK, two-liter cow-urine, and 5 kg of biochar was applied as treatments in three splits. Fresh cow urine was collected and applied after two days of collection with adding extra 2 L of water. Required amount of biochar was collected from the Agronomy Department, Patuakhali Science and Technology University. According to Bristow AW, 1992 [17] total N in cow urine ranged from 6.8 to 21.6 g N/liter, of which an average of 69% was present as urea. Considering that urea contains 46% nitrogen and to obtain that amount of nitrogen from cow urine we used 3-liter cow urine per pillar of dragon fruit.

2.2 Flowering, fruit development and quality analysis of dragon fruit: The experiment evaluated the effects of different treatments on various aspects of the number of flower buds and flowers, number of mature fruits, individual fruit weight (g), fruit length and diameter (cm), pulp weight (g), peel weight (g), and peel thickness of fruit (mm). pH of dragon fruit was measured using a glass electrode pH meter (GLP 21, Crison, Barcelona, ECC), while titratable acidity (TA) was assessed using the procedure outlined by Ranganna [18] and expressed as a percentage. The total soluble solid (TSS) content of dragon fruit was estimated using Digital Refractometer (BOECO, Germany) and expressed in percent. Ascorbic acid content was measured following the protocol outlined by Ramganga and expressed in mg/100g [18].

2.3 Statistical analyses

The data collected from the experiment were statistically analyzed through computer based statistical program STAR following the basic principles. The mean value for all the treatments was calculated and the analysis of variance for most of the characteristics was accomplished by F variance test. For the significance of difference between the pair of means lettering was tested with the help of Tukey's honestly significant differences (HSD) at 5% level of probability.

3. Results and Discussions

3.1 Number of flower buds and flowers

Number of flower buds was significantly affected by the cow urine and biochar-based fertilizer treatments (Table 1). The highest number of flower buds per plant (12.75, 10.75, and 9.75) was recorded in M_3 and the lowest number of flower buds per plant (10.75, 8.75, and 7.50) was recorded in M_0 at 60, 120, and 180 days respectively after first flower bud emergence. The biochar amendment has succeeded in improving soil quality which was helpful to increase the number of flower buds [19]. A significant effect of biochar-based fertilizer treatments was also found in the number of flowers (Table 1). The highest number of flowers per plant (12.75, 10.50, and 9.75) was found in M_3 and the lowest number of flowers per plant (9.50, 8.25 and 7.25) was found in M_0 at 60, 120, and 180 days respectively after the first flower bud emergence.

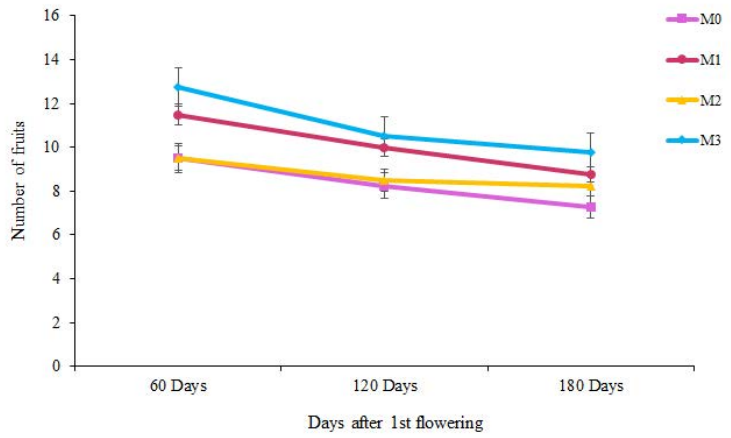
Table 1: Effect of biochar-based fertilizer combination on the total number of flower buds and flowers of dragon fruit.

	Number of flower bud			Number of flowers		
Treatments	**60 Days**	**120 Days**	**180 Days**	**60 Days**	**120 Days**	**180 Days**
M_0	10.75 c	8.75 b	7.50 b	9.50 c	8.25 b	7.25 c
M_1	11.75 b	10.50 a	9.25 a	11.50 b	10.00 a	8.75 b
M_2	10.50 c	9.50 b	9.00 a	9.50 c	8.50 b	8.25 b
M_3	12.75 a	10.75 a	9.75 a	12.75 a	10.50 a	9.75 a
LS	**	**	**	**	**	**
CV (%)	4.19	5.06	7.77	6.58	5.73	7.34

Here, means in a column followed by the different letter (s) differ significantly but with same letter (s) do not differ significantly at 5% level of probability analyzed by Tukey HSD test. LS= Level of significance, ** = Significant at 1% level of probability, M0= Control (no NPK, biochar and cow urine), M1= NPK (urea= 100 g, TSP= 84 g and MOP= 84 g) + biochar (5 kg), M2= Cow urine (3 L) + biochar (5 kg) and M3= NPK (urea= 100 g, TSP= 84 g and MOP= 84 g) + cow urine (3 L) + biochar (5 kg).

3.2 Number of mature fruits

There was a significant difference among the four treatments (Figure 1). The highest number of mature fruits (12.75, 10.50, and 9.75) was found in M_3, and the lower number of mature fruits (9.50, 8.25, and 7.25) was found in M_0 at 60, 120, and 180 days respectively after the first flower bud emergence. According to Situmeang *et al.,* 2017 [20], the treatment without biochar yields the lowest value in the pakchoi plant while the dosage of biochar that produces the most economical results tends to be similar to other biochar doses treatments.



Here, vertical bar represents standard error, M_0= Control (no NPK, biochar and cow urine), M_1= NPK (urea= 100 g, TSP= 84 g and MOP= 84 g) + biochar (5 kg), M_2= Cow urine (3 L) + biochar (5 kg) and M_3= NPK (urea= 100 g, TSP= 84 g and MOP= 84 g) +cow urine (3 L) + biochar (5kg)

Fig 1: Effect of biochar-based fertilizer application on number of fruits of dragon fruit

3.3 Individual fruit weight (g), fruit length (cm), and diameter (cm)

Fruit weight of these four treatments showed a significant difference (Table 2). The highest fruit weight (277.00, 273.50, and 277.00 g) was recorded in case of M_3 and the lowest fruit weight (183.50, 178.00, and 178.50 g) was recorded in case of M_0 at 60, 120, and 180 days after the first flower bud emergence respectively. Nurida 2021 [21] reported that the application of biochar + urea and biochar + urine significantly increased the dry grain of maize by 7.49 tons/ha and 6.05 tons/ha respectively compared to the without biochar which is approximately 5.11 tons/ha (urea) and 4.24 tons/ha (urine). A significant difference was found in case of fruit length (Table 2). Where, the highest (10.78, 10.70, and 10.75 cm) fruit length was recorded from M_3, and the lowest (8.40, 8.45, and 8.32 cm) fruit length was recorded from M_0 at 60, 120, and 180 days respectively after the first flower bud emergence. The biochar amendment has succeeded in improving soil quality which was helpful to increase fruit length [19]. Biochar-based fertilizer treatments showed significant differences in case of diameter of the fruit (Table 2). Where, the highest (6.60, 6.53, and 6.60 cm) diameter was recorded from M_3, and the lowest (5.75, 5.83, and 5.75 cm) was recorded from M_0 at 60, 120, and 180 days respectively after the first flower bud emergence. The result was near about similar to Saputra 2020 [19].

Table 2: Effect of biochar based fertilizer combination on individual fruit weight, length, and diameter of dragon fruit

Treatments	Individual fruit weight (g)			Fruit length (cm)			Fruit diameter (cm)		
	60 Days	120 Days	180 Days	60 Days	120 Days	180 Days	60 Days	120 Days	180 Days
M_0	183.50 d	178.00 d	178.50 d	8.40 d	8.45 d	8.32 d	5.75 d	5.83 d	5.75 d
M_1	241.00 b	239.25 b	239.75 b	10.43 b	10.43 b	10.35 b	6.20 b	6.20 b	6.17 b
M_2	210.50 c	213.50 c	214.00 c	10.10 c	10.12 c	10.18 c	5.97 c	6.03 c	6.00 c
M_3	277.00 a	273.50 a	277.00 a	10.78 a	10.70 a	10.75 a	6.60 a	6.53 a	6.60 a
LS	**	**	**	**	**	**	**	**	**
CV (%)	3.00	4.25	3.74	1.11	1.32	1.00	1.81	1.72	1.44

Here, means in a column followed by the different letter (s) differ significantly but with same letter (s) do not differ significantly at 5% level of probability analyzed by Tukey HSD test. LS= Level of significance, ** = Significant at 1% level of probability, M0= Control (no NPK, biochar and cow urine), M1= NPK (urea= 100 g, TSP= 84 g and MOP= 84 g) + biochar (5 kg), M2= Cow urine (3 L) + biochar (5 kg) and M3= NPK (urea= 100 g, TSP= 84 g and MOP= 84 g) + cow urine (3 L) + biochar (5 kg).

3.4 Pulp weight (g), peel weight (g), and peel thickness of fruit (mm)

Pulp weight of these four cow urine and biochar-based fertilizer treatments showed significant differences (Table 3). The highest pulp weight (216.00, 214.25, and 216.75 g) was recorded in case of M_3 and the lowest pulp weight (115.00, 109.50, and 110.00 g) was recorded in case of M_0 at 60, 120, and 180 days after the first flower bud emergence respectively. In response to biochar-based fertilizer, the highest peel weight (68.50, 68.50, and 68.50 g) was found in M_0 and the lowest (61.00, 59.25, and 60.25 g) was found in M_3 at 60, 120, and 180 days respectively after first flower bud emergence (Table 3). Significant difference was also found in case of the peel thickness of the fruit (Table 3). Where, the highest (2.90, 2.80, and 2.83 mm) peel thickness was recorded from M_0 (Control), and the lowest (2.23, 2.15, and 2.17 mm) was recorded from M_3 (NPK, cow urine, and biochar) at 60, 120 and 180 days respectively after the first flower bud emergence.

Table 3: Effect of biochar-based fertilizer combination on pulp weight, peel weight, and peel thickness of dragon fruit

Treatments	Pulp weight (g)			Peel weight (g)			Peel thickness (mm)		
	60 Days	120 Days	180 Days	60 Days	120 Days	180 Days	60 Days	120 Days	180 Days
M_0	115.00 d	109.50 d	110.00 d	68.50 a	68.50 a	68.50 a	2.90 a	2.80 a	2.83 a
M_1	175.25 b	174.50 b	174.25 b	68.75 c	64.75 b	65.50 a	2.27 c	2.38 b	2.30 b
M_2	143.50 c	146.00 c	146.50 c	67.00 b	67.50 a	67.50 a	2.67 b	2.67 a	2.73 a
M_3	216.00 a	214.25 a	216.75 a	61.00 d	59.25 c	60.25 b	2.23 c	2.15 c	2.17 b
LS	**	**	**	**	**	**	**	**	**
CV (%)	4.21	5.86	4.92	0.81	1.85	2.28	4.60	4.99	4.32

Here, means in a column followed by the different letter (s) differ significantly but with same letter (s) do not differ significantly at 5% level of probability analyzed by Tukey HSD test. LS= Level of significance, ** = Significant at 1% level of probability, M0= Control (no NPK, biochar and cow urine), M1= NPK (urea= 100 g, TSP= 84 g and MOP= 84 g) + biochar (5 kg), M2= Cow urine (3 L) + biochar (5 kg) and M3= NPK (urea= 100 g, TSP= 84 g and MOP= 84 g) + cow urine (3 L) + biochar (5 kg).

3.5 Fruit quality characteristics

No significant difference was found in case of pH, titratable acidity, total soluble solids, and vitamin-C contents of dragon fruits due to the effects of cow urine and biochar-based fertilizer combinations (Table 4). However, the amount of pH ranged from 5.02 - 5.29, titratable acidity 0.25 – 0.28, total soluble solids 13.57 – 14.00 (%), and vitamin-C 16.88 – 18.12 (mg/100 g).

Table 4: Effect of biochar-based fertilizer application on pH, Titratable Acidity (TA), Total Soluble Solids (TSS) and Vitamin C of dragon fruits

Treatments	pH	TA (%)	TSS (%)	Vitamin C (mg/100 g)
M_0	5.02	0.28	13.57	18.12
M_1	5.29	0.25	14.00	17.50
M_2	5.14	0.28	13.95	16.88
M_3	5.02	0.28	13.62	17.50
LS	NS	NS	NS	NS

LS= Level of significance, NS= Non-significant, M_0= Control (no NPK, biochar, and cow urine), M_1= NPK (urea= 100 g, TSP= 84 g and MOP= 84 g) + biochar (5 kg), M_2=Cow urine (3 L) + biochar (5 kg) and M_3= NPK (urea= 100 g, TSP= 84 g and MOP=(84g) + cow urine (3 L) + biochar (5 kg).

4. Conclusion

Results showed significant variations in the flowering and fruiting performance of dragon fruit plants under different cow urine and biochar-based fertilizer combinations. Among these combinations, the mixture of BARI recommended NPK (urea = 100 g, TSP= 84 g, and MOP = 84 g) + cow urine (3 L) + biochar (5 kg) demonstrated the best flowering and fruiting performance. Biochar contributed to the reduction of nutrient losses, while cow urine provided an additional readily available nutrient source, resulting in enhanced flowering and fruiting of dragon fruit. Fruit quality parameters had no significant difference due to the influence of cow urine and biochar-based fertilizer.

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