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OPTIMIZING CABBAGE YIELD THROUGH INTEGRATED BIOCHAR AND COW URINE APPLICATIONS

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Abstract

This investigation was carried out at the Germplasm Center of Patuakhali Science and Technology University (PSTU) from mid November 2019 to early February 2020 with an obejective is to enhance cabbage (cv. F1 Atlas 70) yield by combined use of fertilizers, biochar and cow urine. The treatments consisted of T_1 = Control, T_2 = Biochar + Cow urine, T_3 = Recommended manures, T_4 = Recommended fertilizers, T_5 = Recommended fertilizers + biochar + cow urine, and T_6 = Recommended manures and fertilizers. The result showed a substantial impact of combined use of biochar, cow urine and recommended dose of fertilizers (T_5) on the growth and yield of cabbage. Significant improvements were noted for plant height (33.6 cm), leaf no. (22.8), plant spread (64.52 cm^2), leaf weight (0.25 kg $plant^{-1}$), and length of the stem (4.77 cm) as well as cabbage head characteristics such as head length (20.0 cm), diameter (24.6 cm), weight (2.17 kg), and overall head yield (77.9 t/ha). Next to T_5, T_6 i.e., combined use of recommended manure and fertilizers showed identical performances. The findings underscore the potential of integrating fertilizers, biochar and cow urine to enhance cabbage growth and yield..

Keywords: Biochar, Cabbage yield, Cow dung, Cow urine, Fertilizers

Introduction

Cabbage (*Brassica oleracea* var. capitata) is one of the most economically and nutritionally important vegetables globally (Weerakkody *et al.,* 2020). However, as the world population surpasses 9.7 billion by 2050 (FAO, 2017), the demand for sustainable agricultural practices intensifies, compelling agricultural researchers and practitioners to explore innovative approaches to optimize crop yield while mitigating environmental degradation (Lindblom *et al.,* 2017). In this context, the integrated application of biochar and cow urine along with chemical fertlizers emerges as a promising strategy to enhance cabbage cultivation practices and address the challenges posed by conventional agricultural methods (Mithu *et al.,* 2022).

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Biochar, a carbon-rich substance produced through the pyrolysis of organic materials, has gained recognition for its multifaceted benefits in soil improvement (Khan *et al.,* 2024). Studies have demonstrated that biochar application enhances soil structure, promotes water retention and improves nutrient availability (Lehmann *et al.,* 2011; Jeffery *et al.,* 2017). Cow urine, a natural byproduct of bovine metabolism, has long been utilized in traditional agriculture for its rich nutrient content and plant growth-promoting properties (Singh *et al.,* 2023). Cow urine contains a variety of essential nutrients, including nitrogen, phosphorus, potassium, and micronutrients, which serve as vital elements for plant growth and development (Pandey *et al.,* 2017; Singh ., 2020). Moreover, cow urine exhibits bio-stimulant properties that enhance nutrient uptake, stimulate root growth, and improve plant vigor, thereby reducing the need for synthetic fertilizers and minimizing environmental pollution (Chaudhari *et al.,* 2023).

Despite the individual merits of biochar and cow urine in agriculture, limited research has explored their effects on cabbage cultivation. Understanding the synergistic interactions between biochar and cow urine and their impact on cabbage growth and yield deserves attention for developing sustainable land management (SLM) practices that optimize resource utilization and environmental stewardship. Hence, the present study was undertaken to examine the effect of biochar and cow urine together with chemical fertilizers on the growth parameters and yield of cabbage.

Materials and Methods

The experiment was carried out at the Germplasm Center within the premises of the Department of Horticulture at Patuakhali Science and Technology University (PSTU) Campus, situated at coordinates 22°27'53.9"N and 90°23'06.8"E. The experiment was aid out in a randomized complete block design (RCBD) with six treatments and seven replications. The treatments consisted of control (T_1), biochar + cow urine (T_2) where biochar rate was 1 ton per hectare and cow urine application 1000 liters per hectare, 20 ton/ha cow dung for manure application (T_3), recommended fertilizers per hectare - 300 kg Urea (N), 300 kg TSP (P), and 250 kg MoP (K) (T_4). recommended fertilizers along with biochar and cow urine (T_5), and recommended manure and fertilizers (T_6). Biochar used in this experiment was produced through a process of pyrolysis. Biomass feedstock, sourced locally, underwent thermal decomposition in the absence of oxygen at temperatures ranging from 300 to 700 degrees Celsius.

The resulting biochar was finely ground and applied to the soil. Fertilizers were applied in the root zone during land preparation. The recommended full quantity of phosphorus and potassium, as well as half of the nitrogen dose were evenly distributed in the root zone. The remaining half of the nitrogen was applied in two equal splits at 20 and 35 days after transplanting (DAT) as a local application. Each experimental unit consisted of 10 cabbage plants. Transplantation of 25-day old cabbage seedlings was done in mid November 2019 and harvesting was in early February 2020. The cabbage variety used F1 Atlas 70. Each field plot measured 2.8 m², with plant spacing set at 30.48 cm x 30.48 cm. All necessary intercultural operations and plant protection measures were done. The data were subjected to analysis of variance (ANOVA) at 5% level of significance. Means were separated using Tukey's Honestly Significant

Difference (HSD) test at a 5% level of significance. This data analysis was performed using an automated software, 'JMP 8.'

Results

Impact of recommended fertilizers, biochar, and cow urine treatment on cabbage growth

Plant height exhibited significant differences across the treatments (Table 1). At 30 DAT, the recommended fertilizers + biochar + cow urine treatment (T_5) showed the highest height (23.8 cm), with the increase of approximately 94.5% over the control (T_1). This trend persisted at 45 DAT, with T_1 measuring 19.2 cm and T_5 reaching 27.8 cm, indicating a significant 44.0 % increase. At 60 DAT, T_1 maintained a height of 22.7 cm, and T_5 exhibited the highest height of 30.4 cm, showcasing a 34.1% increase. At, 75 DAT, T_1 recorded a height of 26.1 cm, while T_5 showed the maximum height (33.6 cm), reflecting 28.4% increase.

Similarly, the number of leaves per plant showed significant variations among the treatments (Table 2). At 30 DAT, treatment (T_1) exhibited an average of 10.5 leaves per plant, while T_5, showed the highest leaf count of 12.9, indicating a 22.1% increaseover control. This trend continued at 45 DAT, where T_1 had 13.5 leaves per plant, and T_5 had 16.6,with an increase of 23.2% . At 60 DAT, T_1 maintained 16.2 leaves per plant, and T_5 exhibited the highest (18.5), indicating 14.1% increase. The pattern persisted at 75 DAT, with T_1 having 18.9 leaves per plant where T_5 maximum count at 22.8, showed 20.2% increase over control.

Table 1. Plant height (cm) of cabbage at different days after transplantation (DAT) for various treatments (Mean±SE)

Treatment	Days after transplanting			
	30	45	60	75
T_1	12.27±0.38c	19.18±0.42b	22.67±0.73b	26.13±0.63c
T_2	13.17±0.98c	19.34±1.15b	25.46±1.57ab	29.52±1.44c
T_3	19.42±0.25b	22.86±1.25ab	25.95±2.23ab	29.66±1.89ab
T_4	19.57±0.70b	22.81±0.93ab	27.62±0.89ab	30.66±0.91ab
T_5	23.81±1.14a	27.78±2.25a	30.40±2.17ab	33.55±1.85ab
T_6	22.62±0.69ab	26.70±0.64a	28.40±0.36a	32.20±0.79b
CV (%)	15.45	18.14	14.73	11.98
Level of significance	**	**	**	**

T_1= Control, T_2= Biochar + Cow urine, T_3= Recommended manures, T_4= Recommended fertilizers, T_5= Recommended fertilizers + biochar + cow urine, T_6=Recommended manures and fertilizers, SD= Standard deviation, CV= Coefficient variance, *= 5% Level of significance and **= 1% Level of significance, NS= Non-significance

Table 2. Number of leaves per cabbage at different days after transplantation (DAT) for various treatments (Mean±SE)

Treatment	Days after transplanting			
	30	45	60	75
T_1	10.50±0.49	13.48±0.24b	16.24±0.85ab	18.92±0.05c
T_2	11.04±0.70	13.84±0.39b	15.72±0.28b	19.24±0.32bc
T_3	12.32±0.10	15.20±0.21ab	17.00±0.62ab	20.40±0.06bc
T_4	11.96±0.62	15.16±0.35ab	15.92±0.48b	20.56±0.23b
T_5	12.88±1.02	16.60±0.63a	18.52±0.64a	22.84±0.77a
T_6	12.38±0.95	16.36±0.47a	17.56±0.35ab	22.68±0.24a
CV (%)	14.16	9.55	9.12	8.27
Level of significance	NS	**	**	**

T_1= Control, T_2= Biochar + Cow urine, T_3= Recommended manures, T_4= Recommended fertilizers, T_5= Recommended fertilizers + biochar + cow urine, T_6=Recommended manures and fertilizers, SD= Standard deviation, CV= Coefficient variance, *= 5% Level of significance and **= 1% Level of significance, NS= Non-significance

Leaf breadth, measured in centimeters (cm), exhibited significant variations across treatments (Table 3).There was trend of increasing leaf breadth with the advancement of days after plaanting from 30 to 75 DAT. The maximum breadth increased at 30 DAT (66.4%) while minumum at 75 DAT (24.3%) over control. These results showed the positive effect of the recommended fertilizers + biochar + cow urine treatment on promoting broader leaf breadth throughout the cabbage cultivation period.

Impact of recommended fertilizers, biochar, and cow urine on cabbage diameter, length, weight, dry weight and head yield

The characteristics of cabbage heads, including diameter, head length, head weight, and dry weight, exhibited significant variations across the different treatments (Table 4). At the final harvest, T_5 showed the largest cabbage heads with a diameter of 24.6 cm with increase of 27.6% over the control (T_1) . Similarly, T_5 showed the longest head length (20.0 cm), significant improvement of about 20.8% compared to T_1. In terms of head weight, T_5 recorded the highest weight (2.17 kg), indicating a remarkable increase of approximately 24% over T_1. Additionally, T_5 exhibited the highest dry weight of the head (fresh 20g) at 5.53, showed an increase of 22.4% over T_1..

Table 3. Leaf breadth (cm) of cabbage at different days after transplantation (DAT) for various treatments (Mean±SE)

Treatment	Days after transplanting			
	30	45	60	75
T_1	8.60 ±0.26d	13.76±0.46d	19.24±0.33c	26.68±0.39c
T_2	9.16±0.70d	13.88±1.13d	19.68±0.86c	26.64±0.76c
T_3	11.76±0.18c	17.60±0.36c	23.16±0.07b	30.92±0.24b
T_4	11.88±0.42bc	18.48±0.85bc	23.20±0.62b	30.96±0.64b
T_5	14.28±0.52a	21.52±0.48ab	27.52±0.89a	33.08±0.39ab
T_6	13.76±0.25ab	21.16±0.13a	27.16±0.25a	32.56±0.16b
CV (%)	10.09	12.25	14.96	9.3
Level of significance	**	*	*	*

T_1= Control, T_2= Biochar + Cow urine, T_3= Recommended manures, T_4= Recommended fertilizers, T_5= Recommended fertilizers + biochar + cow urine, T_6=Recommended manures and fertilizers, SD= Standard deviation, CV= Coefficient variance, *= 5% Level of significance and **= 1% Level of significance

Table 4. Effect of recommended fertilizers, biochar, and cow urine treatment on diameter, length, weight, and dry Weight of cabbage (Mean±SE)

Treatment	Diameter of cabbage (cm)	Head Length (cm)	Head Wt. (kg)	Dry Wt. of the head (Fresh 20 gm)
T_1	19.28±0.34c	16.56±19d	1.75±0.02c	4.53±0.02c
T_2	19.08±0.89c	16.55±53d	1.78±0.07c	4.52±0.07c
T_3	22.04±0.29b	18.11±04c	1.98±0.01b	5.00±0.06b
T_4	22.56±0.64ab	18.31±0.27bc	1.99±0.03b	5.07±0.11b
T_5	24.63±0.35a	20.00±0.37a	2.17±0.04a	5.53±0.09a
T_6	24.32±0.19a	19.62±0.06ab	2.13±0.01ab	5.49±0.03a
CV(%)	11.15	8.20	9.06	8.70
Level of significance	*	*	**	*

T_1= Control, T_2= Biochar + Cow urine, T_3= Recommended manures, T_4= Recommended fertilizers, T_5= Recommended fertilizers + biochar + cow urine, T_6=Recommended manures and fertilizers, SD= Standard deviation, CV= Coefficient variance, *= 5% Level of significance and **= 1% Level of significance

Table 5. Impact of recommended fertilizers, biochar, and cow urine treatment on head weight per plot and hectare (Mean±SE)

Treatment	Head weight per plot (kg)	Head yield (ton /ha)
T_1	17.48±0.22c	62.72±0.77c
T_2	17.76±0.67c	63.72±2.41c
T_3	19.84±0.07b	71.19±0.27b
T_4	19.92±0.27b	71.47±0.95b
T_5	21.72±0.38a	77.93±1.37a
T_6	21.32±0.14ab	76.50±0.49ab
CV(%)	9.06	9.06
Level of significance	*	*

T_1= Control, T_2= Biochar + Cow urine, T_3= Recommended manures, T_4= Recommended fertilizers, T_5= Recommended fertilizers + biochar + cow urine, T_6=Recommended manures and fertilizers, SD= Standard deviation, CV= Coefficient variance, *= 5% Level of significance and **= 1% Level of significance

Treatment T_5 exhibited the highest head weight per hectare(77.9 ton) with the increase of 24.4% compared to the control (62.7 ton) (Table 5). These results highlight the efficacy of the recommended fertilizers + biochar + cow urine treatment in enhancing cabbage yield, emphasizing its potential for optimizing production..

Discussion

The findings of this study reveal a significant and consistent enhancement in various growth parameters of cabbage plants when subjected to the recommended fertilizers, biochar, and cow urine treatment. The substantial increase in plant height observed in the recommended fertilizers + biochar + cow urine treatment with highlighting the benefits of biochar in improving soil structure and nutrient retention, consequently promoting plant growth (Lehmann *et al.,* 2011). Cow urine, known for its rich nutrient content, can contribute essential elements for plant development (Pandey *et al.,* 2017). The synergistic effects of these components might have played a crucial role in the observed superior plant height throughout the cultivation period. Cow urine, with its nitrogen-rich composition, could have contributed to the increased leaf count, as nitrogen is a key element in leaf formation (Kumar *et al.,* 2015). Cow urine, acting as a natural growth promoter, could have also played a role in stimulating lateral growth (Bakshi, 2017). Leaf breadth, an essential indicator of plant health, demonstrated consistent improvement with the recommended fertilizers + biochar + cow urine treatment. The larger cabbage heads observed in the recommended fertilizers + biochar + cow urine treatment reflect the combined benefits of enhanced nutrient availability and improved soil structure. Regarding stem and root development, the treatment's positive effects of biochar in promoting root growth and nutrient In terms of cabbage yield,emphasizing the positive impact of organic and bio-based treatments on overall crop productivity (Elad *et al.,* 2010). The synergistic effects of biochar and organic inputs, particularly cow urine, demonstrate the potential of integrated and sustainable approaches for optimizing crop productivity.

Conclusion

This study showed a high productivity of integrating biochar and cow urine with fertilizers in the cabbage cultivation practices. For optimal cabbage growth parameters, including plant height, leaf development, and head characteristics, the combined use of fertilizers, biochar and cow urine (T_5) was proven to be very effective and thus it is recommended for adoption.

Conflicts of interest

The authors declare no conflicts of interest regarding publication of this paper.

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