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Prospect and profitability of integrated manure and fertilizer application on three potential indigenous medicinal leafy vegetables in Khulna, Bangladesh

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ABSTRACT

Indigenous vegetables like Thankuni, Pipil and Brahmi Shak commercially in Southwest Bangladesh are problematic for the growers due to lack of appropriate technology and knowledge for cultivation. The present investigation was taken to assess the prospect and profitability of three potential indigenous leafy and medicinal vegetables cultivation in the field condition under various levels of urea and vermicompost. The experiment of the study comprised growing the indigenous leafy vegetable with six combinations of urea and vermicompost at Germplasm Center of Agrotechnology Discipline, Khulna University Bangladesh, from September 2019 to August 2020. Six urea and vermicompost combinations were T_0= Control, T_1= 50% urea (125 kgha^{-1}) + 50% vermicompost (7.5 t ha^{-1}), T_2 = 75% urea (187.5 kg ha^{-1}) + 25% vermicompost (3.75 t ha^{-1}), T_3 = 25% urea (62.5 kgha^{-1}) + 75% vermicompost (11.25 t ha^{-1}), T_4 = 100% urea (250 kgha^{-1}), and T_5 =100% vermicompost (15 t ha^{-1}) replicated four times. Significantly higher biological yield (22.37, 27.95 and 28.43 t ha^{-1}, respectively), net return (301,000, 300530 and 320,000 Tk. ha^{-1}, respectively) and benefit-cost ratio (BCR) (1.37, 1.65 and 1.39, respectively) were obtained Thankuni, Pipil Shak and Brahmi Shak, respectively, while treated with 75% urea + 25% vermicompost. Different levels of urea and vermicompost had significant effects on the average yield, gross return and net return of the three indigenous vegetables. The highest yield gross return, net return and BCR (19.81 t ha^{-1}, 877,690, 279,800 and 1.50, respectively) were found from Brahmi Shak and the lowest from Thankuni Shak (15.42 t ha^{-1}, 761,160, 173280 BDT t ha^{-1} and 1.28, respectively). The higher yield enhanced the profitability from the cultivation of the three vegetables. The findings of the study could accelerate the modifications in cropping patterns by the farmers and the policymakers dealing with the cultivation of indigenous leafy vegetable crops in the Khulna region of Bangladesh.

***Key Words**: Thankuni, Pipil Shak, Brahmi Shak, Vermicompost, Medicinal vegetables and Indigenous Vegetables*

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I. Introduction

Indigenous vegetables are the low-priced source of vitamins, minerals, proteins and medicinal values that most people can easily purchase. Limited cultivation of Indigenous vegetables and surroundings in volunteer plants or unwanted plant growing with other crops are treated as negligible indigenous vegetables (Rashid et al., 2006). To keep good health, an adult should take at least 100 g day^{-1} and 200 g day^{-1} of leafy vegetables and non-leafy vegetables, respectively (BIRDEM, 2013). On the contrary, the per capita vegetable consumption in Bangladesh is only 167.30 g/day, including tuber crops (potato, sweet potato, aroids) (Hossain, 1998; BBS, 2016). This is far below the minimum daily requirement of about 400 g of vegetables and fruit suggested by the Food and Agricultural Organization and the World Health Organization (FAO, 2003). As a result, the people of Bangladesh are suffering from various malnutrition problems.

Leafy vegetables are typically low in calories and fats, high in protein, dietary fiber, iron and calcium, and enormous phytochemicals (Gupta and Sharma, 2007). Lots of people in South Asia are usually eaten leafy vegetables as a typical dish. Thankuni (*Centella asiatica* L.), *Pipil Shak* (*Aristolochia elegans)* and Brahmi Shak *(Bacopa monnieri)* are leafy medicinal vegetable belongs to Apiaceae, Aristolochiaceae and Scrophulariaceae family, respectively, and widely distributed throughout tropical and subtropical regions (Lopes et al., 2001; Khare, 2003 and Gogte, 2012). The herbs are propagated mainly from stolons and cuttings and can be grown on various soils, shady and moist locations are more suitable (Sharma et al., 2002). The species is widely used in pharmaceutical companies, ayurvedic formulations, insomnia, epilepsy, high blood pressure, memory enhancer and nervine tonic (Gupta and Sharma, 2007). Now-a-days these vegetables have high market demand due to their widespread uses, but no systematic and organized effort has been made for its planned cultivation. Successful cultivation of these plants is economically eye-catching, where marketing is not a big problem. Better management can result in much higher income and net profit than traditional crops (Gohil et al., 2010).

In Bangladesh, nearly 20 % area covers the coastal belt, whereas more than 30% of the total cultivable land in this area (Haque, 2006). The cropping intensity of coastal regions is too low, mainly due to salinity and waterlogging challenges (Petersen and Shireen, 2001). Different indigenous vegetables such as Bathua (*Chenopodium album* L.), *Noteys hak (Amaranthus viridis L.), Thankuni shak (Centella asiatica* L.*), Amrul shak (Oxalis corniculate L.) Pipil Shak* (*Aristolochia elegans) and Brahmi shak* (*Bacopa monnieri* L.) are important providers of minerals, vitamins, essential amino acids and medicinal properties. That also provides an option for the whole year production in marshy waterlogged conditions and in the homesteads of Bangladesh and that may enhance the food and nutritional security of the country. Rapid erosion of the natural habitat of native vegetables due to uncontrolled use of herbicides, soil erosion, dramatic drop in water levels in rivers, canals and irrigation canals, or addition of sewage to rivers has resulted in degradation of biodiversity (Das et al., 2008). There is a vast knowledge gap among the vegetable growers of appropriate technologies to cultivate the three vegetables. Innovative agricultural practices can address those challenges by maximizing organic horticulture production in fields and the space around households.

Vermicompost contains several nutrient elements and can play an essential role to make soil fertile. The use of vermicompost in crop production is a primary aspect of organic farming. It is a biofertilizer that ensures the nutrition of crop fields and keeps the soil healthy (Edwards and Lofty, 1977; Lee, 1985). It is a good source of micronutrients, humus, helpful soil microorganisms, N_2-fixing and phosphate solubilizing bacteria and actinomycetes, as well as growth hormones (Sinha et al., 2010). Now-a-days peoples demand safe vegetables is growing gradually, but the supply is meager. Also, safe vegetables cultivation allows women to manage better their food security, nutrition and consumption of fresh vegetables. Consider the issues mentioned above, the present research was undertaken to determine the prospect and profitability of *Thankuni Shak, Pipil Shak and Brahmi Shak* cultivation as a prospective indigenous leafy vegetable both in the field conditions under various levels of urea and vermicompost pertinent to Khulna, Bangladesh.

II. Materials and Methods

The field trials were done at the Germplasm Center of Khulna University, Khulna, Bangladesh from September 2019 to August 2020. The experimental site was located at 89°34' E Longitudes and 22°47' N Latitude (FAO, 1988).

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To assess the profitability of the indigenous vegetables Thankuni, Pipil and Brahmi Shak and find out the right combination of urea and vermicompost for field condition, six different proportions viz. T_0= Control, T_1= 50% urea (125 kg ha^{-1}) + 50% vermicompost (7.5 t ha^{-1}), T_2 = 75% urea (187.5 kg ha^{-1}) + 25% vermicompost (3.75 t ha^{-1}), T_3 = 25% urea (62.5 kg ha^{-1}) + 75% vermicompost (11.25 t ha^{-1}), T_4 = 100% urea (250 kg ha^{-1}), and T_5 =100% vermicompost (15 t ha^{-1}) were used as treatments. The single factor research was laid out in a Randomized Complete Block Design (RCBD) with four replications. The three indigenous leafy vegetables viz Thankuni (*Centella asiatica), Pipil Shak (Aristolochia elegans*) and Brahmi Shak (*Bacopa monniera)* were used in the experiment.

Stolons and cuttings of the three indigenous vegetables were used as planting material produced in the germplasm center of Khulna University, Khulna. The plot was 2 m × 2.5 m in size with block-to-block distance 1.0 m and plot to plot distance 0.5 m. The healthy thirty days old saplings were transplanted to the respective plots containing different manures and fertilizers compositions as per treatments. Irrigation was done daily until the stolons or cuttings were fully established. Irrigation cycles were adjusted based on crop needs and soil conditions. The incidence of pests and diseases was regularly monitored and its level was much below the action threshold level. All the intercultural operations were performed following standard cultivation methods for the crops.

The offsets and branches with leaves were harvested at a mature stage. The cost of production was analyzed according to the procedure followed by Ozkan et al. (2004) and Das et al. (2018) to find out the most economical return under different treatment combinations. The gross yield in kilogram (kg) plot^{-1} was converted into yield hectare^{-1} basis and was expressed in ton (t). The marketable yield in kg plot^{-1} was converted into yield hectare^{-1} basis and was expressed in ton (t). In case of pot experiment, the yield was calculated on kg plot^{-1} basis. To find out the BCR the following formula was used:

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return}}{\text{Total cost of production}}$$

Recorded data on different parameters were analyzed through Analysis of variance using computer software MSTAT-C. Duncan's New Multiple Range Test (DMRT) was performed to determine the significant difference among the means within the parameters (Gomez and Gomez, 1984). Economic analysis was done following Alam et al. (1989).

III. Results

Yield and profitability of Thankuni Shak the field condition

The economic yield of Thankuni was significantly affected by different levels of urea and vermicompost in the field (Figure 01.a). The highest yield of Thankuni (22.37 t ha^{-1}) was found from 75% urea + 25% vermicompost combination (T_2) and the lowest from control (no urea and vermicompost) (9.49 t ha^{-1}) (T_0). Parallel trend was observed in the total cost, gross return, and net return of Thankuni (Table 01). Different levels of urea and vermicompost significantly influenced the production cost, gross profit, net profit and benefit-cost ratio. The maximum cost was recorded from T_2 followed by T_1 and the lowest from T_0. Alike yield, the maximum gross return and net return were obtained from T_2 and the lowest from T_0. Also, the highest benefit-cost ratio was obtained from T_2 (1.37) and the lowest from T_0.

Yield and profitability of Pipil Shak the field condition

The economic yield of *Pipil Shak* was significantly affected by different levels of urea and vermicompost in the field (Figure 01.b). The highest yield of *Pipil Shak* (27.95 t ha^{-1}) was found from 75% urea + 25% vermicompost combination (T_2) and the lowest from control (no urea and vermicompost) (15.73 t ha^{-1}) (T_0). The cost of production, gross return, and net return also found in the same line (Table 02). The production cost, gross profit, net profit and benefit-cost ratio were significantly influenced by different levels of urea and vermicompost. The maximum cost was recorded from T_2 followed by T_1 and the lowest from T_0. Alike yield, the maximum gross and net returns were obtained from T_2 and the lowest from T_0. Also, the highest benefit-cost ratio was obtained from T_2 (1.65) and the lowest from either T_0, or T_1, or T_3, or T_4, or T_5.

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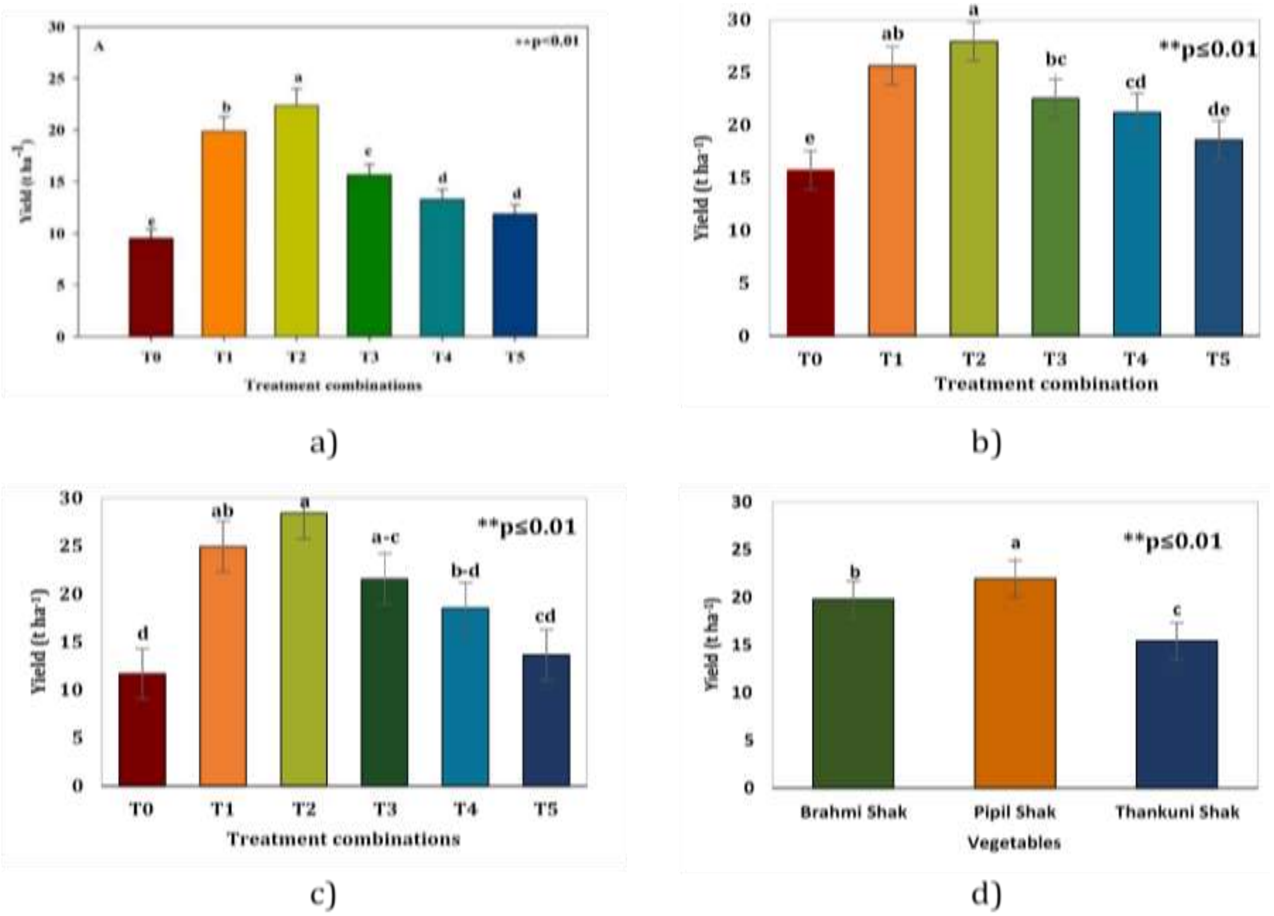
Table 01. Profitability of Thankuni as affected by integrated application of urea and vermicompost in the field condition

Treatment	Total cost	Gross return	Net return	BCR
	('000 Tk. ha^{-1})			
T_0=Control	379 d	474 e	95 d	1.25 b
T_1=50% urea + 50% vermicompost	781 a	993 b	212 b	1.27 b
T_2=75% urea + 25% vermicompost	817 a	1118 a	301 a	1.37 a
T_3=25% urea + 75% vermicompost	618 b	783 c	165 bc	1.27 b
T_4=100 % urea	525 c	665 d	140 cd	1.27 b
T_5=100 % vermicompost	465 c	592 d	127 cd	1.27 b
Levels of Significance	**	**	**	*
LSD Values	30.16	36.60	24.75	0.09

Means with the same letter in each column are not significantly different, while means with different letters are significantly different and are Tukey-Kramer adjusted for multiple comparisons. LS= Level of significance, BCR= benefit-cost ratio. *, **Significant at p<0.05 and p<0.01, respectively.



Note: Bars with the same letter in each graph were not significantly different, while bars with different letters were significantly different, adjusted by Tukey-Kramer for multiple comparisons, with vertical bars as standard errors and p-values indicating significant levels.

Figure 01. Yield of indigenous medicinal leafy vegetables as influenced by the level of urea and vermicompost, a) Thankuni, b) Pipil Shak, c) Brahmi Shak and d) Comparison of yields of three vegetables

Yield and profitability of Brahmi Shak the field condition

The economic yield of *Brahmi Shak* was significantly affected by different levels of urea and vermicompost in the field (Figure 01.c). The highest yield of *Brahmi Shak* (28.43 tha^{-1}) was found from 75% urea + 25% vermicompost combination (T_2) and the lowest from control (no urea and vermicompost) (11.69 tha^{-1}) (T_0). Similar trend was found in the cost of production, gross return, and net return of *Brahmi Shak* (Table 03). The influence of various levels of urea and vermicompost were highly significant for the total cost and gross return, but net return and benefit-cost ratio were

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insignificant. The maximum cost was recorded from T_2 followed by T_1 and the lowest from T_0. Alike yield, the maximum gross and net returns were obtained from T_2 and the lowest from T_0. Also, the highest benefit-cost ratio was found from T_2 (1.39) and the lowest from T_5 (1.17).

Table 01. Profitability of Thankuni as affected by integrated application of urea and vermicompost in the field condition

Treatment	Total cost ('000 Tk. ha^{-1})	Gross return ('000 Tk. ha^{-1})	Net return ('000 Tk. ha^{-1})	BCR
T_0=Control	379 d	474 e	95 d	1.25 b
T_1=50% urea + 50% vermicompost	781 a	993 b	212 b	1.27 b
T_2=75% urea + 25% vermicompost	817 a	1118 a	301 a	1.37 a
T_3=25% urea + 75% vermicompost	618 b	783 c	165 bc	1.27 b
T_4=100 % urea	525 c	665 d	140 cd	1.27 b
T_5=100 % vermicompost	465 c	592 d	127 cd	1.27 b
Levels of Significance	**	**	**	*
LSD Values	30.16	36.60	24.75	0.09

Means with the same letter in each column are not significantly different, while means with different letters are significantly different and are Tukey-Kramer adjusted for multiple comparisons. LS= Level of significance, BCR= benefit-cost ratio. *, **Significant at $p<0.05$ and $p<0.01$, respectively.

Table 02. Profitability of Pipli Shak as affected by integrated application of urea and vermicompost in the field condition

Treatment	Total cost ('000 Tk. ha^{-1})	Gross return ('000 Tk. ha^{-1})	Net return ('000 Tk. ha^{-1})	BCR
T_0=Control	629.33e	629.33e	250.00	1.32b
T_1=50% urea + 50% vermicompost	1026.33ab	1026.33ab	244.80	1.37ab
T_2=75% urea + 25% vermicompost	1117.87a	1117.87a	300.53	1.65a
T_3=25% urea + 75% vermicompost	901.33bc	901.33bc	282.67	1.46ab
T_4=100 % urea	848.00cd	848.00cd	322.67	1.61ab
T_5=100 % vermicompost	743.47de	743.47de	278.13	1.65ab
Level of Significance	**	**	NS	*
LSD	156.52	156.52	-	0.33

Means with the same letter in each column are not significantly different, while means with different letters are significantly different and are Tukey-Kramer adjusted for multiple comparisons. LS= Level of significance, BCR= Benefit cost ratio. *, ** Significant at $p < 0.05$ and $p<0.01$, respectively. NS= Not significant.

Table 03. Profitability of Brahmi Shak as affected by integrated application of urea and vermicompost in the field condition.

Treatment	Total cost ('000 Tk. ha^{-1})	Gross return ('000 Tk. ha^{-1})	Net return ('000 Tk. ha^{-1})	BCR
T_0=Control	379.33 d	467.73 d	88.4	1.25
T_1=50% urea + 50% vermicompost	781.33 a	997.60 ab	162.66	1.28
T_2=75% urea + 25% vermicompost	817.33 a	1137.33 a	320.00	1.39
T_3=25% urea + 75% vermicompost	618.67 b	863.47 a-c	244.80	1.39
T_4=100 % urea	525.33 c	741.33 b-d	216.00	1.41
T_5=100 % vermicompost	465.33 c	545.87 cd	80.53	1.17
Level of Significance	**	**	NS	NS
LSD	603.25	341.78	-	-

Means followed by the same letters within each column do not differ significantly whereas means with dissimilar letters differ significantly and Tukey-Kramer adjustment for multiple comparisons. LS= Level of significance, BCR= Benefit cost ratio. ** Significant at $p<0.01$, respectively. NS= Not significant.

Comparative average yield and profitability of the three indigenous vegetable

The average economic yield among the three indigenous vegetables was significantly affected by different levels of urea and vermicompost in the field (Figure 01.d). The highest yield (19.81 tha^{-1}) was found from Brahmi shak and the lowest from Thankuni Shak (15.42 t ha^{-1}). The production costs, gross and net returns of the vegetables were on the same trend. (Table 04). The gross return, net return, and benefit-cost ratio were observed significant among the three indigenous vegetables, but the cost of

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production remained the same for the vegetables. Similar yield, the maximum gross return and net return were obtained from Brahmi Shak and the lowest from Thankuni Shak. On the other hand, highest benefit-cost ratio was obtained from Pipil Shak (1.37) and the lowest from either Brahmi Shak or Thankuni Shak.

Table 04. Comparative Yield and profitability of the three indigenous vegetables as influenced by combined use of fertilizer and manure

Vegetables	Total cost	Gross return	Net return	BCR
		('000 Tk. ha^{-1})		
Brahmi Shak	398.79	792.22 b	194.33 b	1.31 b
Pipil Shak	398.79	877.69 a	279.80 a	1.50 a
Thankuni Shak	398.79	761.16 b	173.28 b	1.28 b
Level of Significance	NS	**	**	**
LSD	-	58.66	58.66	0.16

Means followed by the same letters within each column do not differ significantly, whereas means having dissimilar letters differ significantly and Tukey-Kramer adjustment for multiple comparison. LS= Level of significance, BCR= Benefit cost ratio. ** Significant at p<0.01, respectively. NS= Not significant.

V. Discussion

Hsu et al. (2000) reported that organic matter in the soil improves the biological activities viz. water retention capacity, infiltration rate, soil aggregate stability and cation- exchange capacity facilitating plant growth and yield. Again, Hossain et al. (2014) and Das et al. (2018) reported that soil fertility was restored by organic matter enhancing vegetative growth, ensuring more yield, which supported the present finding. Organic matter helps to increase the availability of nutrients in the soil and a combination of organic (60%) + inorganic (40%) matter showed better performance for brinjal growth and fruit yield (Ullah et al., 2008), which supports the present finding. The present results suggested that organic matter addition and higher yield need more labor for harvesting, increasing cost of production although gross and net return and BCR were highest from the same treatment due to more yield and more price of Thankuni, Pipil Shak and Brahmi Shak. However, Keskin et al. (2010) informed that high labor costs increased total tomato production cost in turkey that was comparable with this finding. Also, per plant tomato production cost was higher in the organic system over conventional one reported by Santos et al. (2017). Islam et al. (2017), Akther et al. (2019), Farjana et al. (2019), Mondal et al. (2019) and Muqtadir et al. (2019) reported similar findings where they stated that okra, Indian spinach, red amaranth, cabbage, and tomato yield, respectively increased by more organic and less inorganic fertilizer combination. Organic matter fosters the growth of various beneficial microbes that create a proper environment for plant growth and development (Bulluck et al., 2002) which comparable with this study. The combination of organic and inorganic manures and fertilizers may create good soil environment that supplies sufficient plant nutrients for suitable vegetative growth of cabbage and tomato plants, which finally encouraged the size of head and fruits, respectively (Sajib et al., 2015; Adhikary et al., 2016). Das et al. (2018) reported that Indian spinach performed better in organic and inorganic manures and fertilizers combinations than solely using vermicompost or urea, which backs this finding. Vermicompost provides available nutrients used for plant growth and development that helps to increase the number of vigorous leaves and the increase of offsets, eventually increase total biological production.

V. Conclusion

Thankuni, Pipil Shak and Brahmi Shak cultivation with 75% urea (187.5 kgha^{-1}) + 25% vermicompost (3.75 t ha^{-1}) were profitable in terms of maximum benefit-cost ratio (1.37) in open field conditions. Out of six combinations of urea and vermicompost, 75% urea (187.5 kgha^{-1}) + 25% vermicompost (3.75 t ha^{-1}) in field condition was best for the three indigenous leafy and medicinal vegetable plants. Above all, production of Thankuni, Pipil Shak and Brahmi Shak in the open field with a 3:1 ratio of urea and vermicompost for cultivation are prospective and feasible in the Khulna region of Bangladesh even though the ratio could be changed with the types of indigenous vegetables. However, to establish consistency in the feasibility of indigenous leafy vegetables cultivation in the open field in different vegetable growing areas of Bangladesh, extensive research works are recommended.

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