DOI: https://doi.org/10.3329/jbcbm.v10i1.74600 *J. biodivers. conserv. bioresour. manag.* **10**(1), 2024

GROWTH PERFORMANCE OF NEEM (*Azadirachta indica*) SEEDLINGS AS INFLUENCED BY ORGANIC AND INORGANIC FERTILIZERS

Jahan, I.*, S. A. Mina, M. H. Rahman, M. H. R. Shahriar and M. K. Rahman

Department of Soil, Water and Environment, University of Dhaka, Dhaka-1000, Bangladesh

*Corresponding author: isratjahan.du.1998@gmail.com

Abstract

A pot experiment was carried out in the net house of the Department of Soil, Water and Environment, University of Dhaka. The aim of the study was to assess growth and yield performance of Neem seedlings with the different doses of organic and NPK fertilizers. Trichocompost (TC) was used as organic fertilizer. The treatments used in the experiment were: T_1: Control (-OM and -NPK), T_2: TC (10 ton/ha), T_3: TC 5 ton/ha, T_4: NPK 100% RDF, T_5: NPK 80% RDF + TC 5 ton/h, T_6: NPK 60% RDF + TC 5 ton/h, T_7: NPK 40% RDF + TC 5 ton/h, T_8: NPK 80% RDF + TC 10 ton/h, T_9: NPK 60% RDF + TC 10 ton/h, T_{10}: NPK 40% RDF + TC 10 ton/h. Pots were arranged in a Completely Randomized Design (CRD). Plant height and the number of leaves per plant were recorded at a 15-day interval. The tallest plant (78.87 cm) observed with the application of sole Trichocompost 5 ton/ha. Incremental dose of TC and inorganic fertilizer reduces the height of plant. The maximum no. of leaves (51.67) was found with NPK 60% RDF + TC 5 ton/h at the stage of 90 days and the next highest amount of leaves (44.67) with NPK 80% RDF + TC 10 ton/h at 90 days after. The lowest height (12.52 cm) and leaf number/plant (8.33) were recorded in control. Maximum fresh and dry weights (root, bark, and leaf) were 17.19 g/plant and 6.24 g/plant, respectively, found in T_8: (NPK 80% RDF + TC 10 ton/h). The best growth performance of seedlings was observed in T_8: NPK, 80% RDF, and TC 10 ton/h .The research indicated that there was no significant treatment difference on nutrient uptake by the neem seedlings.

Key words: Growth; Neem; NPK-Fertilizers; Trichocompost.

INTRODUCTION

The neem tree, scientifically known as (*Azadirachta indica*) is an adaptable evergreen native to Southeast Asia, including Bangladesh and India. Every component of the neem tree, from the leaves, bark, seeds and seeds oil, has traditionally been used for a various objectives. Due to its multiple of medicinal advantages, the use of neem (*Azadirachta indica*) is very indispensable. Its antibacterial, anti-inflammatory and antiviral properties have been demonstrated in innumerable studies (Gupta *et al.* 2008, Biswas *et al.* 2002). The medicinal potential of neem is enhanced by bioactive components, such as nimbin and azadirachtin, making it a useful resource in traditional medicine and pharmaceutical research. Neem oil, derived from tree seeds, is beneficial for pest control in crop farming (Stephen and Samuel 2022). It enriches soil organic matter reduces nitrogen loss and acts as a nematicide (Alam 1993). Leaves are used for green leaf manure and compost, twigs are exercised as green manure in rice cultivation, with insecticidal properties found in leaf and seed extracts. Neem extracts are applianced as foliar sprays and seed treatments. Powdered bark and roots of neem offer therapeutic benefits, including anti-nematicidal properties, suppressing fleas and sucking pests, and aiding in plant nutrient provision, making it a valuable biofertilizer in agriculture. Seed cake produced from neem is a biodegradable, environmentally friendly, and effective soil conditioner that enhances plant growth, inhibits pests and bacteria, provides essential macronutrients, and increases long-term yield. It is biodegradable, environmentally friendly material that provides essential nutrients to soil and plants, eliminates denitrifying bacteria, and is suitable for both cash crops and food crops. It increases crop yield, reduces fertilizer usage, and has antifeedant properties to reduce insect and pest growth. Overall, the neem tree stands as a valuable botanical resource with applications ranging from traditional medicine to pest control and sustainable agriculture (Biswas *et al.* 2002).

Fertilizer is crucial for crop cultivation, providing necessary nutrition. Inorganic fertilizers are unsustainable as they harm soil health and the environment. Organic manures offer a sustainable alternative, restoring soil organic matter and improving nutrient availability (Qulsum *et al.* 2020). Experiments show that organic manures and compost can increase plant height, tiller number, spike length, and straw/grain yield (Ibrahim *et al.* 2008). They also reduce agrotechnological approaches, increase soil fertility, and minimize phytotoxicity. Organic manures are preferred over chemical fertilizers as they increase the number of nitrogen-fixing bacteria in the rhizosphere, favoring gram-negative bacteria and fungi. Organic fertilizers are particularly beneficial for gram-negative bacteria and fungi (Zhang *et al.* 2012). Poor soil quality and a lack of organic matter hinder agricultural production in Bangladesh. Inorganic farming, defined as non-organic or conventional farming, involves the use of synthetic fertilizers, pesticides, and genetically modified organisms to maximize crop yields. It is mostly practiced for its effectiveness in producing large-scale crops, which helps meet the demands of a growing global population (de Pascual-Teresa and Clifford 2017). But there are some disadvantages to practicing inorganic farming continuously. One disadvantage of inorganic fertilizers is their potential to contribute to environmental pollution. The runoff of nitrogen and phosphorus from fields treated with these fertilizers can contaminate water bodies, leading to issues like algal blooms and aquatic ecosystem disruptions (Matson *et al.* 1997). The disadvantage of inorganic fertilizers have long-term adverse impact on soil health. Continuous use can lead to a decline in soil organic matter and microbial diversity, affecting the overall fertility and sustainability of the soil (Bünemann *et al.* 2018). On the other hand, organic farming is mostly important because it not only helps in promoting biodiversity, enhancing soil fertility, reducing reliance on synthetic pesticides and fertilizers, and contributing to environmental sustainability, but it might also be more cost-effective than other farming systems, and because it has so many positive aspects for prefering organic farming (Ponisio *et al*. 2015). About 7.0 million tons of organic fertilizer are produced annually from household, crop, and animal waste. This creates an opportunity for Bangladesh to use low-cost, sustainable organic fertilizers, reducing the threat of inorganic fertilizers and increasing productivity (Islam 2006).

The Government of Bangladesh has emphasized tree planting in degraded woodlands in order to re green them through a benefit-sharing mechanism with the active involvement of the local community. For the successful completion of this programme, it needs to cooperation and interaction among the governmental institutions, nongovernmental organizations, local government entities, and the participation of mass people (Hossain 2015). Neem seedlings could be planted on the slopes of both sides of the dykes, long road side, in addition to the coastal plantations in the districts of Barguna, Patuakhali, Bhola, Noakhali, Bagerhat, Khulna, Chattogram, and Cox's Bazar, where Neem plant play as a green belt. This would likely offer protection against natural disasters like cyclones and tidal surges, as well as absorb a significant amount of carbon dioxide from the atmosphere. To grow robust, healthy, and lush Neem seedlings, organic manures can be employed in nursery operations. Inorganic NPK fertilizers should be avoided, particularly in the areas of Barishal, Jhalokathi, and Pirojpur. There is not much information about organic agricultural practices in Bangladesh when it comes to cultivating neem seedlings and plantations. These days, neem is grown in Bangladesh's hilly regions to prevent soil degradation and is planted as part of social forestry to establish a nursery (Alam *et al.* 2023, Rifhat *et al.* 2023, Prity *et al.* 2023, Alauddin *et al.* 2021, Rikza *et al.* 2021).

Several crops have been considered for organic cultivation in Bangladesh in recent years (Rifhat *et al.* 2023, Prity *et al.* 2023, Alauddin *et al.* 2022, Rikza *et al.* 2021, Syed *et al.* 2022), but no work has yet been done with the using of organic fertilizer on neem nursery plant in Bangladesh. The objective of the present experiment was to evaluate the growth of Neem seedlings through nutrient management using vermicompost and chemical fertilizers.

MATERIAL AND METHODS

Soil sample collection, processing and analysis

The bulk soil sample was collected to a depth of 15cm from Araihazar upazila, Narayanaganj district, Bangladesh, for setting up the experiment. After collection, the soil was then air dried, cleared of any visible roots or debris, crushed gently to break down large clods, passed through a 2mm sieve, and preserved in labeled plastic bottles properly for further analysis of its physical, chemical, and physico-chemical properties. All the analyses of physical and chemical properties were carried out at the laboratory of the Department of Soil, Water, and Environment, University of Dhaka.

The soil sample was found to be composed of 1.43% sand, 67.27% silt, and 31.30% clay (Bouyoucos 1962), and it was silt loam in texture deduced from the USDA soil texture triangle using the proportion percentages. The particle density of the soil sample was estimated using the pycnometer technique (Huq and Alam 2005) to be 2.62 g/cm3. The matrix color of the soil sample was pale yellow, which was evaluated visually in outdoor sunlight using a Munsell color chart in both dry and moist conditions.

The pH and Electrical Conductivity (EC) of the soil samples were analyzed by taking soil and distilled water in ratios of 1:2.5 and 1:5, respectively (Jackson 1958). The pH of the soil sample was determined to be 7.25 using the HANNA Instrument H12211ph (Orp Meter).

The EC was measured using the EC Eutech CON 700 instrument, which produced a result of 71.1 S/cm. The organic carbon content of the soil sample was determined using Walkley and multiplying the carbon content by the Van Bemmelen factor of 0.42 (Huq and Alam 2005).

The organic carbon and organic matter contents of the soil were 1.17 and 2.072%, respectively. According to fertilizer recommendation guide of BARC (2018), the soil had a low organic matter content. The total N, P, K, and S contents of the soil sample were found to be 0.257, 0.156, 0.490, and 0.215%, respectively. For the analysis of total P, K, and S, the soil sample was digested in nitric acid and perchloric acid (HNO_3:$HClO_4$ = 2:1) (Huq and Alam 2005).

Total soil N was determined by digesting the soil sample separately with concentrated H_2SO_4 and a digestion mixture, then distilled the digest using the Kjeldahl technique (Jackson 1958). Total P was quantified using a spectrophotometer and a colorimetric technique based on the vanadomolybdophosphoric yellow color method (Jackson 1958). A flame photometer was used to assess total K in a sample, and spectrophotometry was used to determine total S after generating turbid solutions with $BaCl_2$ and Tween-80 agents (Huq and Alam 2005).

Pot Experiment

Eight kilograms of grounded soil were taken in each plastic pot (height 21 cm and diameter 22 cm). The pots were arranged in Completely Randomized Design (CRD) having three replications. A total of 10 treatments were used in the experiment. The treatments were as follows:

T_1: Control (-OM & -NPK), T_2: Trichocompost (TC) 10 ton/ha, T_3: Trichocompost (TC) 5 ton/ha, T_4: NPK 100% RDF(20 kg N/ha, 8 kg P/ha, 8 kg K/ha and 6 kg S/ha), T_5: NPK 80% RDF + TC 5 ton/ha, T_6: NPK 60% RDF + TC 5 ton/ha, T_7: NPK 40% RDF + TC 5 ton/ha, T_8: NPK 80% RDF + TC 10 ton/ha, T_9: NPK 60% RDF + TC 10 ton/ha and T_{10}: NPK 40% RDF + TC 10 ton/ha.

The trichocompost used in the experiment was collected from the Garden BD company. The sources of N Pand K were Urea, Triple super phosphate and Muriate of potash, respectively; these were purchased from the local market. The fertilizers were applied as per treatments' design. No fertilizer used in control pot. The manures (Trichocompost) as added to the soil of the pots three weeks prior to planting the plant cuttings. Inorganic fertilizers were incorporated to soil at the date of transplanting.

The experiment was set up in a shady place. The plants were transplanted by propagating the cuttings of neem bought from a local market (Mohammadpur Bazaar, Dhaka). The number of leaves and plant height were recorded at 15-day intervals for 90 days.

a

b

Fig. 1. Pictorial presentation of the experiment: **a**.A general view; and **b.** Neem seedlings growing in a nursery.

Harvesting

After 90 days of transplantation, the plants were harvested. The whole plant was uprooted, and then leaves, roots, and bark were separated. The plant samples were transferred to polybags and then carried to the laboratory. At first these plant samples were washed with tap water and then with distilled water. Fresh weights of the samples were taken. After that, the samples were air-dried at room temperature and then oven-dried at 65°C for 72 hours. The dry weight of the samples was recorded, and the samples were ground with a mechanical grinder. The ground samples were stored in plastic bottles for chemical analysis.

Statistical analysis

Analysis of variance (ANOVA) and Fisher's Least Significant Difference (LSD) tests were carried out with the results obtained. Other statistical analysis was done using Minitab 17 and MS Excel 2010.

RESULTS AND DISCUSSION

Growth performance assessment

Plant growth was assessed in terms of height (Table 1), no. of leaf (Table 2), fresh and dry weights of plant (Table 3). The values of P, N and S uptake by roots, barks and leafs (Table 4) were considered as the indicator to estimate the growth behavior. The nutrient content in post-harvest soil in treated pots also took careful thought to estimate the growth performance (Table 5). The results of the experiments indicated that all the treatments increased the plant growth parameter as compared to the control.

Plant height

Plant height was gradually increased from 15 days to 90 days of transplanting (Table 1). Seedlings were allowed to grow for 90 days and harvested as roots, bark, and leaf. The longest plant was recorded 78.87 cm in T_3 (Trichocompost 5 ton/ha), and the least height found 14.89 cm in T_1: (control-OM and -NPK) on 15 days **(**Table 1). The significant difference in treatments was observed at the stage of 30 days after and continued up to 90 days. In comparison to NPK (15:15:15) fertilizer, Sodimu *et al.* (2020) found that applying cow dung at different doses significantly (P>0.05) improved *Tamarindus indica* seedling quality and growth. The 6 g treatment of cow dung had the highest mean height of 23.65 cm in the eighth week after application, while the NPK treatment recorded the highest height of 20.17 cm in the same period.

Table 1. Effects of manure on the height (cm) of neem plants at fifteen-days interval.

Treatments	Days after planting					
	15 days	**30 days**	**45 days**	**60 days**	**75 days**	**90 days**
T_1: Control (-OM & -NPK)	14.89^{f}	21.90^{f}	31.90^{f}	41.25^{e}	50.04^{ef}	60.62^{de}
T_2: Trichocompst 10 ton/ha	16.75^{de}	22.07^{f}	32.75^{f}	44.58^{d}	56.83^{c}	68.34^{c}
T_3: Trichocompost 5 ton/ha	18.39^{c}	27.85^{b}	39.55^{b}	52.45^{b}	68.04^{a}	78.87^{a}
T_4: NPK 100% RDF	15.54^{f}	21.76^{f}	32.80^{ef}	40.60^{f}	50.30^{e}	60.05^{ef}
T_5: NPK 80% RDF + TC 5 ton/ha	17.41^{d}	24.24^{e}	34.56^{d}	43.35^{de}	50.41^{e}	57.60^{f}
T_6: NPK 60% RDF + TC 5 ton/ha	18.67^{b}	27.21^{c}	37.95^{c}	46.58^{c}	54.01^{d}	61.31^{d}
T_7: NPK 40% RDF + TC 5 ton/ha	17.55^{d}	25.72^{d}	32.89^{e}	41.76^{e}	49.42^{f}	60.67^{de}
T_8: NPK 80% RDF + TC 10 ton/ha	22.44^{a}	31.40^{a}	41.01^{a}	52.84^{a}	60.63^{b}	69.76^{b}
T_9: NPK 60% RDF +TC 10 ton/ha	16.82^{e}	23.80^{e}	32.79^{ef}	40.90^{ef}	49.97^{f}	59.92^{e}
T_{10}: NPK 40% RDF + TC 10 ton/ha	15.21^{f}	22.85^{ef}	32.70^{f}	40.77^{f}	50.00ef	59.30^{e}
LSD at 5%	**0.24**	**0.6**	**0.12**	**0.14**	**0.15**	**0.13**

^{abcdef} Data bearing different superscripts within the same column differ significantly (p≤ 0.05).

Number of leaf

Number of leaf /plant differed with time, although after 90 days the green-treated plant showed the highest number of leaves, 51.67 leaves/plant at T_6 treatment (Table 2). It was observed that T_4 (NPK

100% RDF) had the lowest production of leaves (7.67 leaves per plant). Leaf number/plant increased gradually through 15, 30, 45, 60, 75, and 90 days. After 15 days of transplanting, there was a significant difference between the treatments and the control. The highest number of leaves in Rape plants (*Brassica napus* L.) was recorded in plants amended with 10 kg/m^2 of organic fertilizer, which was significantly ($p<0.05$) higher than the control (Mojeremane *et al*. 2015).

Table 2. Effects of organic and inorganic fertilizers on the no. of neem leaf at fifteen day interval.

Treatments	Days after planting					
	15 days	30 days	45 days	60 days	75 days	90 days
T_1: Control (-OM& -NPK)	8.33^{ef}	12.0^{e}	15.67^{d}	18.33^{e}	21.67^{f}	24.67^{f}
T_2: Trichocompost 10 ton/ha	12.33^{cd}	18.33^{c}	29.00^{a}	33.67^{a}	38.00^{b}	43.67^{bc}
T_3: Trichocompost 5 ton/ha	9.67^{f}	15.00^{d}	24.33^{c}	30.00^{c}	33.33^{c}	40.67^{d}
T_4: NPK 100% RDF	7.67^{f}	14.67^{d}	17.67^{d}	23.33^{d}	27.33^{d}	35.00^{e}
T_5: NPK 80% RDF + TC 5 ton/ha	14.33^{b}	21.0^{ab}	27.67^{ab}	31.0^{bc}	35.00^{c}	41.33^{cd}
T_6: NPK 60% RDF + TC 5 ton/ha	18.67^{a}	22.67^{a}	26.33^{bc}	34.33^{a}	44.67^{a}	51.67^{a}
T_7: NPK 40% RDF + TC 5 ton/ha	11.67^{d}	17.67^{c}	27.67^{ab}	32.67^{ab}	37.33^{b}	44.33^{b}
T_8: NPK 80% RDF + TC 10 ton/ha	13.33^{bc}	19.0^{bc}	24.67^{c}	32.67^{ab}	38.33^{b}	44.67^{b}
T_9: NPK 60% RDF + TC10 ton/ha	13.67^{bc}	18.67^{c}	24.67^{c}	29.67^{c}	34.67^{c}	42.33^{bcd}
T_{10}: NPK 40% RDF + TC 10 ton/ha	8.67^{ef}	15.0^{d}	17.33^{d}	22.33^{d}	26.00^{d}	33.67^{e}
LSD at 5%	**1.5547**	**2.2638**	**2.5830**	**2.6201**	**2.1766**	**2.6385**

^{abcdef} Data bearing different superscripts within the same column differ significantly ($p \leq 0.05$).

Fresh weight and dry weight

The yields of fresh and dry weights of bark, leaf, and root are presented in Table 3. The least dry matter yielded in control (T_1). The highest fresh weight (8.78 g/plant) and dry weight (3.7 g/plant) of bark was recorded in T_8, the highest fresh weight of leaf (4.97 g/plant) and dry weight (0.61 g/plant) achieved with T_2. The fresh weight of the root was 17.19 g/plant and dry weight 6.25 g/plant found maximum with T_8. Similar results, including the maximum fresh weight (37.79 g/plant) and dry weight (9.16 g/plant), were reported in the Supermill treatment during the Mahogany harvesting (Mitu *et al*. 2020). Augmentative root and stem biomass production in Capsicum by the application of different types of vermicompost was found by Alam *et al*. (2023).

Table 3. Effects of organic and inorganic fertilzers on the fresh weight and dry weight of Neem plants (g plant^{-1}).

Treatments	Fresh weight (g/plant)			Dry weight (g/plant)		
	Bark	Leaf	Root	Bark	Leaf	Root
T_1: Control (-OM & –NPK)	4.24^{b}	3.0267^{abc}	6.66^{bc}	1.53^{cd}	0.3167^{abc}	1.85^{cd}
T_2: Trichocompost 10 ton/ha	5.41^{a}	4.79^{a}	12.94^{ab}	1.99^{bc}	0.6067^{a}	4.483^{abc}
T_3: Trichocompost 5 ton/ha	6.813^{a}	4.01^{abc}	12.53^{ab}	2.74^{ab}	0.453^{abc}	4.367^{abc}
T_4: NPK 100% RDF	3.2567^{bc}	3.8767^{abc}	7.43^{bc}	1.28^{cd}	0.4167^{abc}	2.413^{bcd}
T_5: NPK 80% RDF + TC 5 ton/ha	5.563^{c}	4.38^{ab}	9.7933^{abc}	2.263^{bc}	0.523^{abc}	3.1267^{bcd}
T_6: NPK 60% RDF + TC 5 ton/ha	5.6967^{bc}	4.973^{a}	8.32^{bc}	2.31^{bc}	0.5967^{ab}	2.8^{bcd}
T_7: NPK 40% RDF + TC 5 ton/ha	4.99^{c}	2.6^{bc}	13.323^{ab}	2.053^{bc}	0.3067^{abc}	5.05^{ab}
T_8: NPK 80% RDF + TC 10 ton/ha	8.7767^{c}	3.5467^{abc}	17.19^{a}	3.7^{a}	0.33^{abc}	6.2467^{a}
T_9: NPK 60% RDF + TC10 ton/ha	4.8167^{bc}	2.493^{bc}	7.643^{bc}	1.4567^{cd}	0.103^{bc}	1.92^{cd}
T_{10}: NPK 40% RDF + TC 10 ton/ha	1.62^{c}	2.0433^{c}	1.84^{c}	0.653^{d}	0.0767^{c}	0.7767^{d}
LSD at 5%	**2.78**	**2.08**	**8.71**	**1.13**	**0.502**	**2.98**

^{abcd} Data bearing different superscripts within the same column differs significantly ($p \leq 0.05$).

Nutrient content

The concentrations of N, P and S in Root, Leaf and Bark of neem seedlings are presented in table 4. There was no significant difference among the treatments in respect to nutrient content of neem plant. The concentration of N in root, leaf and bark ranged from T_3:0.05% to T_6:0.17%, from T_1:0.01% to T_5:0.07% and from 0.03% to T_2:0.23%; the concentration of P in root, leaf and bark were ranged from T_3:0.05% to T_6:0.17%, from T_1:0.01% to T_5:0.07% and from 0.03% to T_2:0.23%; and the concentration of S in root, leaf and bark ranged from T_4:0.18% to T_{10}:0.55%, from 0.51% to T_6:0.66% and from T_{10}:0.16% to T_9:0.34%, respectively. Treatments T_4, T_5, T_7, T_8, T_9 and T_{10} were statistically similar in the concentration of N and P in leaf and bark. However they showed significantly differences in the concentration of S. Shushupti *et al.* (2021) found the highest N concentration in the Mint plants which was treated with ACI vermicompost, highest P in Alo and highest S in Kazi.

Table 4. Estimation of N, P and S (Conc. %) in different parts of neem seedlings as influenced by Trichocompost and NPK fertilizers.

Treatments	Root			Leaf			Bark		
	N	P	S	N	P	S	N	P	S
T_1: Control (-Om &-NPK)	0.09^{def}	0.09^{def}	0.20^{b}	0.01^{g}	0.01^{g}	0.51^{d}	0.05^{b}	0.05^{b}	0.17^{d}
T_2: Trichocompost 10 ton/ha	0.09^{def}	0.09^{def}	0.21^{b}	0.02^{fg}	0.02^{fg}	0.51^{d}	0.23^{a}	0.23^{a}	0.23^{bc}
T_3: Trichocompost 5 ton/ha	0.05^{f}	0.05^{f}	0.21^{b}	0.02^{f}	0.02^{f}	0.61^{b}	0.22^{a}	0.22^{a}	0.20^{cd}
T_4: NPK 100% RDF	0.15^{abc}	0.15^{abc}	0.18^{b}	0.04^{de}	$0..03^{de}$	0.55^{cd}	0.03^{bc}	0.03^{bc}	0.19^{cd}
T_5: NPK 80% RDF + TC 5 ton/ha	0.10^{cdef}	0.10^{cdef}	0.28^{b}	0.07^{a}	0.07^{a}	0.61^{b}	0.03^{c}	0.03^{c}	0.26^{b}
T_6: NPK 60% RDF + TC 5 ton/ha	0.17^{a}	0.17^{a}	0.24^{b}	0.05^{bc}	0.05^{bc}	0.66^{a}	0.04^{bc}	0.03^{bc}	0.19^{cd}
T_7: NPK 40% RDF + TC 5 ton/ha	0.07^{ef}	0.07^{ef}	0.32^{b}	0.05^{b}	0.05^{b}	0.62^{ab}	0.03^{c}	0.03^{c}	0.23^{bc}
T_8: NPK 80% RDF + TC 10 ton/ha	0.16^{ab}	0.16^{ab}	0.27^{b}	0.04^{d}	0.03^{de}	0.51^{d}	0.03^{c}	0.03^{c}	0.21^{bcd}
T_9: NPK 60% RDF + TC 10 ton/ha	0.13^{abcd}	0.13^{abcd}	0.21^{b}	0.03^{e}	0.03^{ef}	0.58^{bc}	0.04^{bc}	0.04^{bc}	0.34^{a}
T_{10}: NPK 40% RDF + TC 10 ton/ha	0.11^{bcde}	0.11^{bcde}	0.55^{a}	0.04^{cd}	0.004^{cd}	0.58^{bc}	0.03^{c}	0.03^{c}	0.16^{d}
LSD at 5%	**0.05**	**0.05**	**0.15**	**0.009**	**0.009**	**0.05**	**0.01**	**0.018**	**0.05**

^{abcdf} Data bearing different superscripts within the same column differs significantly (p≤ 0.05).

Residual values of the post-harvest soils

Results show that there was no great variation in soil pH with the application of single manure and combined (manure and inorganic) fertilizers (Table 5). The soil pH found in T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9, and T_{10} were 7.84, 7.63, 7.70, 7.73, 7.86, 7.23, 7.98, 7.57, 7.45, and 7.85, respectively (Table 5). The lowest pH value (7.23) of post-harvest soil displayed in T_6, and the highest (7.98) in T_7. This could be due to the fact that the organic manure had a relatively high buffering capacity based on its high organic matter content. The electrical conductivity of post-harvest soil (after 90 days of planting) of T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9, and T_{10} were 38.45 µS, 57.75 µS, 45.55 µS, 42.9 µS, 41.75 µS, 58.7 µS, 59.1 µS, 45.1 µS, 53.1 µS, and 59.7 µS, respectively. Post-harvest soil analyses showed that the soil organic matter were achieved higher than the initial sample. In control, the organic carbon was found 1.46%. The organic carbon increased in T_2 (5.23), T_4 (4.15), T_5 (5.50), and T_8 (4.80) due to addition of manure. It might be quickly release organic substance from manure. Findings of the study revealed that the control (T_1) without fertilizer treatment performed very poor organic carbon content in soil, compare to all the fertilized treated pots.

Table 5. Chemical properties of post-harvest soil due to addition of organic and inorganic fertilizers.

Treatments	Residual values of soil					
	Organic carbon	**pH**	**EC**	**N**	**P**	**S**
T_1: Control	1.46	7.84	38.45	0.14^{bc}	0.14^{bc}	0.25^{cd}
T_2: Trichocompost 10 ton/ha	5.23	7.63	57.75	0.076^{ef}	0.07^{ef}	0.25^{cd}
T_3: Trichocompost 5 ton/ha	3.61	7.7	45.55	0.15^{bc}	0.15^{bc}	0.25^{cd}
T_4: NPK 100% RDF	4.15	7.73	42.9	0.13^{c}	0.12^{c}	0.23^{d}
T_5: NPK 80% RDF + TC 5 ton/ha	3.73	7.86	41.75	0.09^{de}	0.093^{de}	0.31^{abc}
T_6: NPK 60% RDF + TC 5 ton/ha	3.72	7.23	58.7	0.06^{f}	0.061^{f}	0.28^{abcd}
T_7: NPK 40% RDF + TC 5 ton/ha	5.50	7.98	59.1	0.18^{a}	0.18^{a}	0.34^{a}
T_8: NPK 80% RDF + TC 10 ton/ha	4.80	7.57	45.1	0.12^{cd}	0.12^{c}	0.33^{ab}
T_9: NPK 60% RDF +TC 10 ton/ha	3.29	7.45	53.1	0.12^{cd}	0.12^{cd}	0.26^{cd}
T_{10}: NPK 40% RDF + TC 10 ton/ha	3.83	7.85	59.7	0.17^{ab}	0.16^{ab}	0.26^{bcd}
LSD at 5%	---	---	---	**0.029**	**0.029**	**0.029**

^{abcdef} Data bearing different superscripts within the same column differs significantly ($p \leq 0.05$).

Olanikan (2006) noted that the application of organic manure has significant effects on plant height, leaf number, fresh and dry weight of neem plants, the length of roots, branch number, stem girth, and the uptake of nutrients by plants. The presence of organic carbon in the post-harvest soil increases due to the application of organic manure. Thus, applying organic manure to the soil is beneficial for improving soil health and neem production. The highest acquisitions of macroelements N (0.0798%), P (0.0027%), S (0.0084%) were found in the treated post-harvest soil of Spinach plants by Syed *et al*. (2022). This study is expected to provide valuable information to enhance productivity through a balanced use of organic and chemical fertilizers. The findings and information from the study will be helpful for researchers and ultimately for neem growers. The seedlings could be planted in the dyke situated along the sea shore areas as green belt to protect Bangladesh from cyclones, tidal surges *etc*.

REFERENCES

Alam, M. A., M. Alauddin, M. Rahman, M. Rahman, M. S. Rahman, G. M. Mohsin and M. K. Rahman. 2023. Vermicompost induced growth and yield performance of capsicum (*Capsicum anmuum* L.) at sustainable rooftop farming system. *J. Phytol*. **15**: 94-100.

Alam, M. M. 1993. *Bioactivity against phytonematodes in Neem*. Research and Development Society of Pesticide Science, New Delhi, India.

Alauddin, M., A. H. M. Z. Ali and M. K. Rahman. 2021. Effects of poultry litter compost and chemical fertilizers on the growth and yield of field grown sunflower (*Helianthus annuus* L.). *Dhaka Univ. J. Biol. Sci*. **30**(3 CSI): 49-57.

Alauddin, M., M. K. Rahman and A. H. M. Z. Ali. 2022. Interactive effects of poultry litter compost and chemical fertilizers on macronutrients, oil and protein content in sunflower (*Helianthus annuus* L.). *Dhaka Univ. J. Biol. Sci.* **30**(3 CSI): 359-369.

BARC (Bangladesh Agricultural Research Council). 2018. *Fertilizer Recommendation Guide*. Bangladesh Agricultural Research Council (BARC), Dhaka, Bangladesh. 223 pp.

Biswas, K., I. Chattopadhyay, R. K. Banerjee and U. Bandyopadhyay. 2002. Biological activities and medicinal properties of neem (*Azadirachta indica*). *Curr. Sci*. 1336-1345.

Bouyoucos, G. J. 1962. Hydrometer method improved for making particle size analyses of soils 1. *Agron. J.* **54**(5):464-465.

Bünemann, E. K., G. Bongiorno, Z. Bai, R. E. Creamer, G. De Deyn, R. De Goede and L. Brussaard. 2018. Soil quality–A critical review. *Soil Biol. and Biochem*. **120**:105-125.

de Pascual-Teresa, S. and M. N. Clifford. 2017. Advances in polyphenol research: A journal of agricultural and food chemistry virtual issue. *J. Agr. Food Chem.* ***65***(37): 8093-8095.

Gupta, S. C., S. Patchva and B. B. Aggarwal. 2013. Therapeutic roles of curcumin: lessons learned from clinical trials. *The AAPS j.* **15**:195-218.

Hossain, M. K. 2015. *Silviculture of Plantation Trees of Bangladesh.* Arannayk Foundation. Dhaka, Bangladesh. 361 pp.

Huq, S. I. and M. D. Alam. 2005. *A Handbook on Analyses of Soil, Plant and Water*. BACER-DU, University of Dhaka, Bangladesh. 246 pp.

Ibrahim, M., A. Hassan, M. Iqbal and E. E. Valeem. 2008. Response of wheat growth and yield to various levels of compost and organic manure. *Pak. J. Bot*. **40**(5): 2135-2141.

Islam, M. S. 2006. Use of bioslurry as organic fertilizer in Bangladesh agriculture. In: *Prepared for the Presentation at the International Workshop on the Use of Bioslurry Domestic Biogas Programme.* Bangkok, Thailand., pp. 3-16.

Jackson, M. L. 1958. *Soil Chemical Analysis*. Prentice-Hall Inc., New York, USA. 498 pp.

Matson, P. A., W. J. Parton, A. G. Power and M. J. Swift. 1997. Agricultural intensification and ecosystem properties. *Science*. **277**(5325): 504-509.

Mitu, Sk. R. I., R. Rifhat, I. Jahanara, H. B. Murshed and M. K. Rahman. 2020. Raising of Mahogony (*Swietenia mahagoni* L.) seedlings to combat climate change as influenced by organic manures and chemical fertilizers. *J. Biodivers. Conserv. Bioresour. Manag*. **6**(2): 19-26.

Mojeremane, W., M. Motladi, T. Mathowa and G. M. Legwaila. 2015. Effect of Different Application Rates of Organic Fertilizer on Growth, Development and Yield of Rape (*Brassica napus* L.). *Int. J. Inn. Res. Sci. Eng. Tech.* **4**(12): 11680-11688.

Olanikan, P. C. 2006. Organic manures as soil amendment in eroded tropical soil of South Western Nigeria. *J. Trop. Soil*. **5**(3): 11-18.

Ponisio, L. C., L. K. M'Gonigle, K. C. Mace, J. Palomino, P. De Valpine and C. Kremen. 2015. Diversification practices reduce organic to conventional yield gap. *Proceedings of the Royal Society B: Biol. Sci*. **282**(1799): 20141396.

Prity, N. N., M. Syed and M. K. Rahman. 2023. Performance and Nutrient Content of Okra (*Abelmoschus Esculentus* L. *Moench*) Fruits as Influenced by Vermicompost, Nitrogen and Zinc Grown in Soil. *J. Biodivers. Conserv. Bioserv. Manag*. **9**(1): 101-108.

Qulsum, U., F. F. Meem, R. S. Promi, J. R. Zaman, M. F. Ara and M. K. Rahman. 2020. Growth performance of jute (*Corchorus capsularies* L.) as influenced by different organic manures. *J. Biodivers. Conserv. Bioserv. Manag*. **6(**1): 17-24.

Rifhat, R., S. R. I. Mitu, M. Syed and M. K. Rahman. 2023. Utilization of vermicompost and NPK fertilizers on the growth, yield, nutrient and protein content of mung bean (*Vigna radiata* L.). *J. Biodivers. Conserv. Bioserv. Manag*. **9**(1): 29-39.

Rikza, I. J., K. N. Nishi and M. K. Rahman. 2021. Growth and yield performance of green capsicum (*Capsicum annuum* L.) as influenced by vermicompost application grown at rooftop of Chandpur area. *J. Biodivers. Conserv. Bioserv. Manag*. **7**(2): 13-22.

Shushupti, O., R. S. Orpa, T. Tarannum, N. N. Chitra, S. J. H. Suchi and M. K. Rahman. 2021. Influence of various commercially available organic manures on growth, yield and nutrient accumulation in mint plants (*Mentha* sp.). *J. Biodivers. Conserv. Bioresour. Manag.* **7**(1): 73-84.

Sodimu, A. I., M. B. Usman, O. Osunsina and T. A. Awobona. 2020. Effect of Cowdung and NPK Fertilizer on the Early Growth of Tamarindus indica. L in Kaduna Northern Guinea Savanna Eco - Zone of Nigeria. *J. Agric. Sustain.* **13**: 1-14.

Stephen, A. and A. Samuel. 2022. Neem: A Novel Biocide for Pest and Disease Control of Plants. J. *Chemistry*. **2022**(1): 1-12.

Syed, M., K. T. M. Sadi, R. Uddin, A. K. Devnath and M. K. Rahman. 2022. Integrated effects of vermicompost, NPK fertilizers, cadmium and lead on the growth, yield and mineral nutrient accumulation in spinach (*Spinacia oleracea* L.). *J. Biodivers. Conserv. Bioserv. Manag*. **8(**2): 13-24.

Zhang, Q. C., I. H. Shamsi, D.T. Xu, G. H. Wang, X. Y. Lin, G. Jilani and A. N. Chaudhry. 2012. Chemical fertilizer and organic manure inputs in soil exhibit a vice versa pattern of microbial community structure. *App. Soil Ecol*. **57**: 1-8.

(Manuscript received on 12 December, 2023)