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Effect of different doses of NPK fertilizer on the abundance of termite (*Glyptotermes dilatatus*) in tea garden of the north-eastern part of Bangladesh

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Abstract
Tea termite (*Glyptotermes dilatatus*) is a devastating pest of the tea garden. Fertilizer application is considered an important intercultural practice for proper growth and development of tea bushes. In this study, different doses of nitrogen-phosphorus-potassium (NPK) fertilizer were applied as 0 (Control), 10 (NPK10), 20 (NPK20) and 30 (NPK30) g per liter/plant in the Kewachara tea garden of Sylhet, Bangladesh. The abundance of termite and the infestation height were assessed at 0, 5, 10, 15, 20, 25, and 30 days after NPK application. A low number (0.07-0.13) of termite populations were observed with NPK10, NPK20, and NPK30 where there was no significant difference over control. The number was highest at 5 days after application of the dose NPK30. The infestation height was found highest (11 cm) with the doses of NPK20 and NPK30, which showed a significant difference over NPK10 and the control. The infestation height also altered with the days of sample collection. The mineral composition of termite-infested soil in stem and mound was examined, and it was discovered that the concentration of phosphorus (P) in mound soil is higher (45.6 µg/g) than in stem soil (33.4 µg/g). Moreover, sulphur, iron, and magnesium concentrations in mound soil were also recorded higher than in stem soil, which was 10.3 µg/g and 13.4 µg/g and 0.30 meq./100 g, respectively. In contrast, boron and calcium were found higher in stem soil compared with mound soil. However, the concentrations of nitrogen and potassium were similar in both soils; they were 0.04% and 0.13 meq./100g, respectively. Therefore, fertilizer application did not affect the overall termite population, however the infestation height and nutrient concentration of mound and stem soil were altered.

Keywords: Tea termite, abundance, infestation, nitrogen, phosphorus, potassium

Introduction
Tea, *Camellia sinensis* (L.) is one of the most popular beverage drinks worldwide. In Bangladesh, tea is considered as the second largest export oriented cash crop (BBS, 2016). It is a perennial crop which has been produced as a monoculture over huge areas, creating a stable tea habitat for endemic and introduced pests (Mamun *et al.*, 2014) [23]. According to Banerjee 1983, the distribution and abundance of pests is influenced by weather, altitude, pruning, regulation of shade, use of pesticides, and age of plantation. Though tea is long lasting woody perennial and mono-cultural plant, it offers a constant microclimate as well as food supply which is responsible for the prompt growth and development of insects and mites (Mamun and Ahmed, 2011) [21]. These plants are host of 1034 arthropod species and 82 nematode species worldwide (Chen and Chen, 1989) [8]. Insects and mites are the crucial factors infesting tea in Asia (Muraleedharan, 1992) [24]. In Bangladesh, 18 fungal and 1 algal disease, 25 insect species, four mite species, ten nematodes, and 37 dominant weed species are associated with tea plant (Sana, 1989; Ahmed, 2005) [29, 1]. According to Bangladesh Tea Research Institute, insects are one of the reasons for reducing tea production of Sylhet region. The live-wood tea termite (*Glyptotermes dilatatus*) (Blattodea: Kalotermitidae), one of the major insect pests, is currently posing a severe threat to tea productivity in Bangladesh (Mamun, 2012; Gnanapragasam, 2018) [38, 13]. In Sri Lanka, tea termite was recognized as a main pest of tea in 1908 (Sivapalan *et al.*, 1977) [32] and cause a great damage on yield.
On the basis of site of attack, tea termite is known as major root pests of tea (Mamun and Iyengar, 2010) [22].

This pest stays inside the wood and eat, maintaining least or zero connection to the ground at every developmental stage (Danthanarayana and Vitarana, 1987) [10]. According to Mamun and Ahmed (2011), the Economic Threshold Level (ETL) of tea termite is 10% infestation. Damage by this pest causes crop loss, branch death and early death of bushes in 10-15 years after planting (Danthanarayana and Vitarana, 1987) [10]. In Bangladesh, shade trees are planted in association with tea plants (Deka *et al.*, 2006) [11], which provides an appropriate shelter for *Glyptotermes* sp. (Hazarika *et al.*, 2009) [15].

In order to assert the normal physiological metabolism and high-quality leaves of tea, a large amount of fertilizer has to be applied in the soil (Ruan *et al.*, 2010) [28]. Both organic and inorganic fertilizers are often used in tea plantations to regulate yields with high quality products (Ni *et al.*, 2019) [26]. Although nitrogen requirement is higher in tea compared with other crops as N improves both the quality and yield of tea (Han *et al.*, 2008) [14]. The nutrient availability of the topsoil of Bangladesh is low due to heavy rain, erosion and leaching of N and P and decrease of soil microorganisms (Islam *et al.*, 2021; Sultana *et al.*, 2014) [17, 34]. Thus, farmers apply more nitrogen in tea fields. However, increased amount of nitrogenous fertilizer is an impetus for higher insect infestation in plants (Singh and Sarkar, 2021) [31]. According to Bala *et al.* (2018), insect performance was dramatically reduced on unfertilized plants with low nitrogen content. The use of NPK fertilizer significantly enhanced the insect infestation of some plants (Zakka *et al.*, 2016) [36], even though multiply the insect population in many field crops (Yardım and Edwards, 2003). In addition, higher doses of nitrogenous fertilizer are also another reason for accentuating termite infestation in tea (Sivapalan *et al.*, 1977, Sivapalan, 1999, Sudoi *et al.*, 2001) [32, 37].

Nowadays, *G. dilatatus* pose a serious threat to tea production of Bangladesh whereas very few research has been reported on tea termite. Moreover, the effect of fertilizer application in relation with tea termite were also unknown. Therefore, we hypothesized that the application of fertilizer particularly NPK will affect the abundance and infestation height of termite on tea plants.

Materials and methods

Study site

The study was conducted in the tea garden of Kewachara, Sylhet Sadar (24.8917°N 1.8833°E), Sylhet from November to December 2019. The soil of the field was sandy to sandy loam in texture, acidic that had a pH of around 5.3. The mean annual temperature and average relative humidity of December in Sylhet district were 14.9 °C and 71% respectively, without rainfall. For conducting this experiment, termite prone areas were selected. The variety of the tea plant was BT2, and the age of the selected plants were 4 years. The plant to plant, plot to plot, row to row, and block to block distance were 0.3, 0.8, 0.6 and 0.8 m, respectively (Figure 1). The shade trees were not available. Before starting the study, intercultural operations such as weeding, removal of damaged, dead, and diseased branches were done.

Study design and treatments

The study was laid out in a Randomized complete block design with ten replications. Three plants were considered as one replication. Three doses of NPK fertilizer, 10g, 20g, and 30g were mixed with 1 liter of water separately and considered as treatments. Each of the doses of NPK mixture were applied in the root of each plant during early November. After application of fertilizer, the termite number and infested plant height at 5, 10, 15, 20, 25 and 30 days were observed and recorded. All the data were documented in the morning at 9:00 to 12:00 o' clock. The collected data were analysed by using GenStat (VSNI 18th edition). Tukey tests were used to compare the means of termite number and infested height among the treatments. $p<0.05$ was considered as statistically significant.

The nutrients such as nitrogen (N), phosphorus (P), sulphur (S), boron (B), iron (Fe), potassium (K), calcium (Ca) and magnesium (Mg) availability of termite mound and stem soils were analysed in the Soil Research Development Institute (SRDI) of Sylhet, Bangladesh by following the protocol of Sarker *et al.*, 2020 [30].

Results

Termite number

The effect of different doses (0, 10, 20 and 30 g) of the NPK fertilizer on termite number is shown in Figure 2a. The total number of termites in tea plant did not alter (P=0.184) by the doses of NPK fertilizer with a mean of 0.08. However, there was a tendency (P=0.061) for the interaction between treatment and days of sample collection on termite number. Compared to the control, highest number of termite population was found for NPK30 and NPK20 plants at day 5 and day 10, which was on averaged 0.20 (Figure 2b). Similarly, NPK10 plants had the highest termite number at day 10. In contrast, the highest termite number was observed in NPK30 and NPK20 plants compared to NPK10 at day 5.

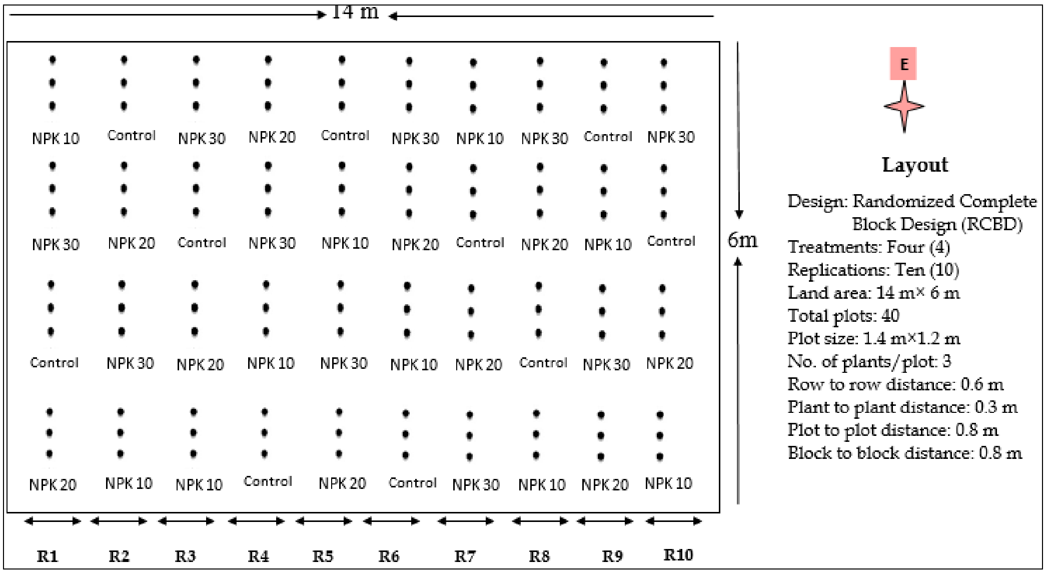

Fig 1: Layout of the experimental field during November to December 2019 in Kewachara tea garden, Sylhet Sadar, Sylhet. The doses of NPK fertilizer were applied as 10 (NPK 10), 20 (NPK 20), and 30 (NPK 30) g per liter/plant and control plot without NPK application.

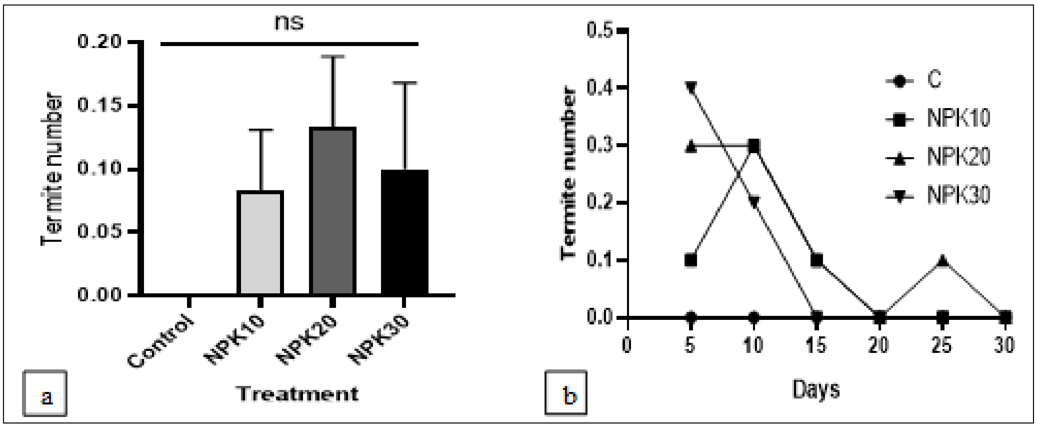

Fig 2: Effect of the different doses (0, 10, 20 and 30 g per liter/plant) of NPK fertilizer on (a) termite number (b) from days 5 to 30 in the month of November 2019 in tea plant of Kewachara tea garden, Sylhet. Pooled SEM = 0.110; treatment, P = 0.184; days, P = 0.671; and treatment × days, P = 0.061.

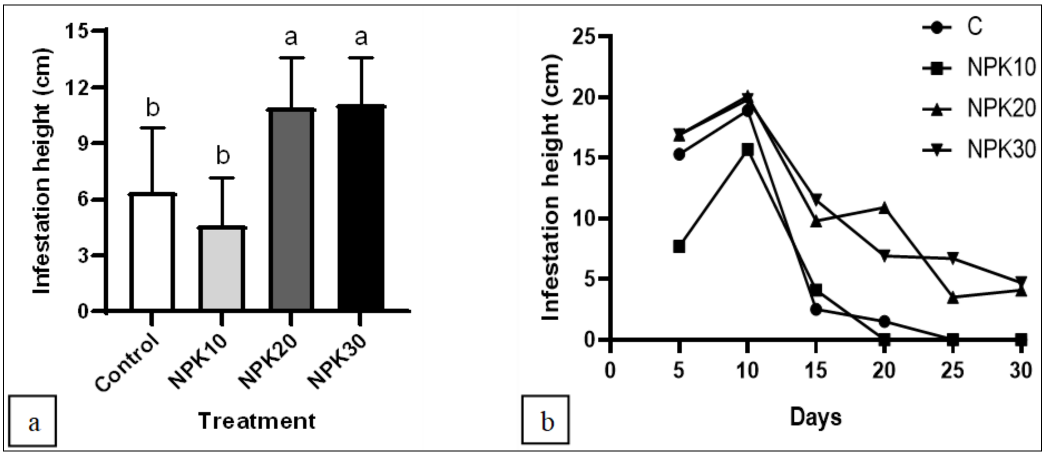

Fig 3: Effect of the different doses (0, 10, 20 and 30 g per liter/plant) of NPK fertilizer on (a) infestation height (b) from days 5 to 30 in the month of November 2021 in tea plant of Kewachara tea garden, Sylhet. Pooled SEM = 2.025; treatment, p< 0.001; days, p< 0.001; and treatment × days, P = 0.346.

Infestation height

Figure 3a shows the effect of different doses (0, 10, 20 and 30 g) of the NPK fertilizer on termite infestation height in tea plants. The height was affected by the NPK fertilizer. The infestation height was similar for NPK30 and NPK20 plants which were on averaged of 11.0 cm, and some of 5.51 cm higher (p<0.001) than NPK10 and control, which had a mean of 5.48 cm. Similarly, the infestation height was altered (p<0.001) by the days of sample collection (Figure 3b). The highest infestation height was observed at day 5 and 10 with a mean of 14.2 and 18.6 cm, respectively which were 12.0 and 16.4 cm higher than the day 30.

Soil composition

The mineral composition of the termite infested soil from stem and mound are shown in Table 1. The concentration of total Nitrogen and Potassium were comparable in both termites infested stem and mound soil, which were on averaged 0.04% and 0.13 meq./100 g. On the other hand, Phosphorus concentration was 12.2 µg/g higher in the termite infested mound soil compared to stem soil. Similarly, termite infested mound soil had the higher concentration of Sulphur, Iron, and Magnesium which were 10.3 and 13.4 µg/g, and 0.30 meq./100 g than the stem soil. In contrast, Boron and Calcium concentration were found to be 0.15 µg/g and 0.32 meq./100 g higher in the termite infested stem soil than the mound soil.

Table 1: The mineral composition of termite infested soil collected from tea plants stem and mound.

Item	Infested soil from stem	Infested soil from mound
Total nitrogen (N; %)	0.04	0.04
Phosphorus (P; µg/g)	33.4	45.6
Sulphur (S; µg/g)	17.6	27.9
Boron (B; µg/g)	0.88	0.73
Iron (Fe; µg/g)	33.6	47.0
Potassium (K; meq./100 g)	0.13	0.13
Calcium (Ca; meq./100 g)	1.38	1.06
Magnesium (Mg; meq./100 g)	0.59	0.89

Discussion

G. dilatatus prefers the tree bush with high amount of nutrient, but in the study plot, NPK fertilizer has been applied generally twice per year which is in early May and mid-August. Lack of nutrient availability in November and December would be one of the reasons of very low number of termite presence. Besides, presence of termite population in control did not show any significant different with treated plots which means there was not major variation of nutrient availability in both plots. Availability of food and water resources, interactions with predators and pathogens affect the population dynamics and nesting and foraging behaviors of termite spatially or temporally (Campora and Grace 2004; Cornelius and Osbrink 2011) [7, 9].

Moreover, temperature and relative humidity in the month of November is generally around 28 ℃ and 79% respectively in the tea plantation in Sylhet, which decline gradually in the month of December. Therefore, the high temperature may cause the termite nest to damage and termite population could not continue to grow because termite is a soft bodied insect and cannot survive with high temperature.

Meanwhile, in the study plot, the gap between tree bushes was high and there was a limited number of shade trees, thus exposing intense sunlight that could damage the termite mound and eventually reduce the number of termite population. In addition, the data was collected at 9:00 to 12:00 in the morning when light intensity was relatively higher, and the termites could be hide themselves from the mound at that time. Furthermore, the tree bushes in the study plots could have been severely infested by termites in the previously, and consequently the lack of enough nutrients for the termite population to infest the tree plants further. Based on our results, we were able to determine that differing fertilizer doses NPK20 and NPK30 affect the infestation height of the termite-infested plants. Besides, the fertilizer dose NPK10 did not influence on the infestation height which is lower than the control.

In case of NPK20 and NPK30, the highest infestation height was found at 5 and 10 days, then gradually decreases. Termites use nutrient-rich saliva and faeces as cementing material for constructing nests in the plant (Holt and Lepage, 2000) [16]. At day 5 and 10, the moisture content of the cementing materials may be more compared to other days.

December is the month of dry winter season in Bangladesh (Alamgir *et al.*, 2015) [2], which is characterized by warm and sunny days. Though the humidity of winter and the moisture content of the air is very low, which may have effect to dry the soil. As a result, the soil in the plant become crispy and loose. In contrast, very few studies have investigated how termites attach their mounds and soil in the plants in order to make them hard-setting and dense (Holt and Lepage, 2000) [16].

The availability of phosphorus (P), sulphur (S), and iron (Fe) were higher in mound soil compared to the stem soil. The stem soil may interact with saliva and lower the nutrient availability. The nutrient enrichment of the mound soil was more as many species construct their mounds using particles from clay rich horizons in the soil profile (Lobry and Conacher, 1990) [19]. Enagbonma *et al.* (2021) [12] also found that termite mound soil has a higher level of nutrients in comparison with adjacent soil. The soil of Sylhet region is strongly acidic (Nazrul and Khan, 2016) [25] and increasing soil acidification can be prevented by applying dolomite (limestone) (Palliyaguru *et al.*, 2013) [27]. The calcium and magnesium availability between mound and stem soil was negligible, this may happen due to lack of dolomite (limestone) Palliyaguru *et al.* (2013) [27] observed that the supplement of dolomite increased the calcium and magnesium concentration of soil compared to control. Besides, the N content of both mound and stem soil are similar as nitrogen fertilizer can lost through leaching and surface run-off. In case of tea garden, the soil moisture is low which causes less leaching and surface run-off. Besides, termites keep soil below (mound) and above (stem) from the soil surface, which may result zero leaching and surface run-off.

Conclusion

The combined effect of N, P, and K fertilizer application in the tea garden on termite abundance, infestation height and nutrient composition in the soils were observed. The overall termite population did not alter but infestation height was varied with the application of NPK fertilizer. The concentration of total N and K was comparable in both stem and mound infested soils whereas the other nutrients were slightly affected with the treatments.

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