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Withdrawal of nutrients by weed biomass aggravates soil nutritional deficiencies in young tea plantations of Sub Himalayan West Bengal

Rubi Samanta[1], Sourav Chakraborty[1], Mainak Mukherjee[2], Malay Bhattacharya[1]*

[1] Molecular Biology and Tissue Culture Laboratory, Department of Tea Science, University of North Bengal, Siliguri, Darjeeling, West Bengal, India

[2] Soil analysis laboratory, Department of Tea Science, University of North Bengal, Siliguri, Darjeeling, West Bengal, India

Abstract
Weed biomass can be used to calibrate the quantity of nutrients absorbed from soil. The current approach proposes a vivid experimental protocol of analyzing edaphological indicators in view of nitrogen, phosphate, and potash (NPK) uptake by weeds. The mean dry weed biomass of tea plantations were recorded to be 256.88g/m^2 while corresponding average NPK withdrawal per hectare (ha) of land was investigated to be 280.8Kg, 1.3Kg, and 21.3Kg respectively. The results precisely imply a positive correlation between weed biomass and amount of NPK withdrawn; which are thus envisaged to be directly proportional to each other, and can be attributed to be a major parameter affecting tea plantation soil fertility. Weed control can effectively reduce soil nutrient drainage.

Keywords: nutrients, soil, tea, weed, withdrawal

Introduction
Biomass is an important parameter to assess the atmospheric carbon harvested from atmosphere by green plants (Kale *et al* 2004) [7]. Similarly, it also can be used as an important feature to quantify the quantity of nutrients withdrawn from soil by weeds. Weeds compete with the main crop for water, nutrients and space (Sit *et al* 2007) [10], and could be attributed to be responsible for in-taking substantial amount of soil nutrients creating serious trouble. Simultaneous abiotic factors such as ground exposure and unscientific use of nitrogenous or organic fertilizer cumulatively aggravate weed growth. In India tea plantations are large holdings covering several hundred hectares of land. Negligence and delayed weeding in tea plantations have already resulted in establishment and maintenance of large scale weed banks (Prematilake 2013) [8]. The weed menace is more deteriorative for soil fertility of this region as plains of sub Himalayan West Bengal receive heavy rainfall favouring luxuriant growth of weeds. Tea plantations of this region face immense problem with weeds and its control is now a second most expensive input, next to fertilizer (Das 2007) [4]. But surprisingly there is no study or report yet, from the stand point of weed nutrient relationship. So the present work is designed to quantify the correlation between weed biomass and nutrient [Nitrogen, phosphate, and potash (NPK)] uptake by corresponding weeds in tea plantations.

Material and Methods
The study was conducted in three consecutive years (2018-2020) at six tea plantations situated in the plains of sub Himalayan West Bengal. Quadrates measuring one square metre area were laid down in twenty different locations in each tea plantation during the first week of August. The weeds within the quadrates were collected along with their roots and preserved in airtight zipper bags for downstream experiments. Aerial height and root length of weeds were measured by steel measuring tape. The average aerial height and root length of all weeds of the quadrates were considered for calculation.

For determination of biomass and moisture content of weeds, the monocotyledonous and dicotyledonous weeds were grouped separately and weighed. Fresh weight (W_f) of each of them were measured and recorded. The individual plant species were air dried in shade condition and after fifteen days their dry weight (W_d) were measured. The moisture percentage of each species were calculated by the formula $[(W_f - W_d)/ W_f] \times 100$.

Quantification of total nitrogen was conducted by Kjeldahl method (Jackson 1973) [6]. Phosphorus and potassium in weed biomass was determined by dry ash method (Baruah and Barthakur 1997) [1]. Phosphorus in the form of phosphate (P_2O_5) in dry plant sample was estimated by spectrophotometric method (Bray and Kurtz 1945; Jackson 1973; Baruah and Barthakur 1997) [2, 6, 1] and potassium in form of potash (K_2O) was conducted by flame photometry (Chapman and Pratt 1961) [3].

Results and Discussion
The sub-Himalayan region receives well distributed annual rainfall throughout the year. The soil is predominantly sandy loam. The soil pH of the study area ranges from 4-5.3. Total nitrogen, phosphorus in form of phosphate and potassium in form of potash are 0.1458%, 17ppm and 191ppm respectively (Table I). In the study area tea bushes were approximately 20 years old and are planted in regular rectangular pattern with 70cm distance between two bushes and 100cm between rows. The average canopy size, height of plucking and collar height of the bushes are 0.81m^2, 0.72m and 0.15-0.20m respectively. Shade plants like *Acacia lenticularis*, *Melia azedarach*, *Derris robusta*, *Albizia chinensis*, *Albizia lebbeck*, *Dalbergia sissoo*, *Leucaena leucocephala* etc. are planted to provide shade to

the tea bushes. Drainage is provided at an interval of 30m. The peripheral drain has a depth of 150cm and the sub drains has a depth of 100cm.

Variable numbers of weeds are reported from the quadrates of the study area. Altogether fifty seven angiosperms and six pteridophytes were reported from the study area. They belonged to three monocotyledonous and twenty seven dicotyledonous families.

Weeds compete with the main plant for sunlight and nutrition. So, determination of aerial height of the weeds as well as the root length of weeds was important. For each weed species average root length of ten weeds were considered for each section. The average root length was 6.31cm and 5.96cm for dicotyledonous and monocotyledonous weeds respectively. The maximum root length was observed in *Desmodium triflorum* (14.51cm) and the least root length was observed in *Youngia japonica* (2.56cm). The weeds were grouped on the basis of recorded root length into two groups. Group I consisted of root lengths up to 15cm while Group II included root lengths exceeding 15cm. In Group I, thirty two dicotyledonous weeds in addition to all monocotyledonous and pteridophytic weeds could be categorised with Group II comprising of the remaining identified six dicotyledonous weeds.

The dry matter content of the weed population is considered as biomass. Calculation of biomass is important because the biomass quantifies the amount of nutrients drawn from the field. The average fresh, dry weight and moisture percentage recorded was 563.46gram/square meter, 256.88gram/square meter and 45.58% respectively. Out of the study quadrates from which weeds were collected, maximum fresh mass observed was 761.6gram/square meter while lowest fresh mass recorded was 208.48gram/square meter. The maximum and minimum moisture percentages recorded was 57.62% and 38.02% respectively.

The quantity of NPK uptake from one square meter is subsequently expressed as quantity of nutrients drawn from one hectare plantation area of tea garden soil. It is estimated that maximum quantity of Nitrogen is absorbed from soil per hectare of tea plantation in comparison to Phosphate and Potash uptake. The quantity of NPK drawn from one ha of plantation area is 280.8Kg, 1.3Kg and 21.3Kg respectively (Table I).

The study region receives more than 4000 mm rainfall that favours weed vegetation (Das 2007; Sit *et al* 2007) [4, 10]. Fifty seven angiosperms and six pteridophytes were reported from the study area. In a similar work on weed diversity in areca nut, coconut and oil palm fields of this region, 44 weeds from 20 angiospermic families were reported by Sit *et al* (2007) [10]. The severity of weed infestation in tea plantations is primarily governed by agro-climatic conditions, cultural practices, general management conditions and specific weed management schedule (Deka and Barua 2015) [5].

Nutrition from soil is withdrawn by weed population. Based on root length analysis all monocotyledons, pteridophytes and a few minute dicotyledonous weeds draw nutrient from the top soil while, all large leaved dicotyledonous weeds with root length beyond 15cm can be inferred to withdraw nutrients from the sub soil. Weeds, especially those with long tap roots collect valuable nutrients from the soil and preserve the corresponding absorbed nutrients in their roots and leaves. To our estimation these explored large leaved dicotyledonous weeds chiefly interfere with the tea plant root system and competes against the available nutrients. Controlling them to a great extent can benefit the plantations.

Calculation of biomass is important because the biomass quantifies the amount of nutrients drawn from the field. The amount of Nitrogen, Phosphorous, and Potassium present in weed biomass was determined by estimating NPK in corresponding weed samples. These elements form the main ingredients of soil nutrients available and are utilized by plants for their regular physiological activities. Weed biomass and quantity of nutrients drawn from the field are observed to be positively correlated and directly proportional to each other; as more the biomass, more is the concerned nutrient uptake. The quantity of nitrogen, phosphorus and potassium available in weeds must have been definitely absorbed from the soil strata and thus, NPK quantification in weeds can provide precise information about the amount of nutrient loss from soil.

Therefore, the quantity of nitrogen absorbed by weeds from the soil stands out as the most important cause in the mechanism of soil nutrient loss; that otherwise could have been potentially utilized by tea plants for their growth and development. Das (2007) [4] estimated that weeds account for about 10-15% crop loss in respect of tea plantations and removes approximately 250Kg soil nitrogen annually from tea field. Puzari *et al* (2010) [9] estimated that weed in tea plantations may cause crop loss to the extent of 10-15% and may remove around 252Kg of soil nitrogen per hectare annually in young tea plantations. Deka and Barua (2015) [5] reported that uncontrolled weed growth can cause a 50-70% loss of tea productivity.

Table 1: Nutrients present in soil and weed biomass/hectare (Mean of three years ± Standard deviation)

Nutrients	Soil	Biomass/hectare
Total Nitrogen	0.1458% (±0.08868)	280.8Kg (±0.12134)
Phosphorus (P_2O_5)	17ppm (±0.03312)	1.3Kg (±0.09689)
Potassium (K_2O)	191ppm (±0.04561)	21.3Kg (±0.11762)

Conclusion

In perspective of large holdings of Indian tea plantations our experimental results confirm huge quantity of nitrogen, phosphorus and potassium drainage from soil via weeds that could have otherwise been utilized by tea bushes. As tea industry is the major pillar of economy of this region, organic and inorganic supplements are constantly added to surmount yield loss. But, these supplements fail to fully replenish tea bushes as some portion of the nutrients are snatched by weeds. This hypothesis deduces a positive correlation between weed biomass and nutrient uptake by corresponding weeds in tea plantations highlighting it as a chief reason for reduction of soil fertility. Therefore, controlling weeds can effectively enhance qualitative parameters of soil and improve plantation outputs.

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