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# Floral Morphology and Impact of Flowering of *Dendrocalamus longispathus* Kurz on Soil Physico-Chemical Properties in Natural Forests of Mizoram, Northeast, India

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## ABSTRACT

Sporadic flowering of *D. longispathus* Kurz clumps located in Mamit District, Mizoram, India was observed to study flowering morphology, phenology and impact of flowering on soil physico-chemical properties during December 2014 to February 2020 from bamboo flowering site and non-flowering site. The species is one of the most common and widely used bamboos in Northeast India and Mizoram in particular. Pollinator type is anemophilous, monoporate pollen grain and protogynous in nature. Ovary is sub-globular, hairy with club shaped stigma. Anthesis of disturbed area shows less completion of flowering. Number of seeds produced by flowering depends on the number and quality of spikelets. Flowering bamboo stand has lower pH and organic carbon as well as Phosphorus, use of phosphatic fertilizers recommended for low P content. Pre-flowering, flowering and post-flowering of bamboos appeared to have caused decreaseor increase of nutrients in the forest ecosystem. During flowering year, anthropogenic activities must be avoided in and around the flowering areas to abtain more floral development, seed production and successful regeneration.

**Keywords** Bamboo flowering, *Dendrocalanus longispathus,* Anthesis, Physico-chemical.

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## INTRODUCTION

*Dendrocalamusl longispathus* is large tufted bamboo. Culms usually 10-18 m high, glaucous green when young, grayish-green on maturity, nodes slightly swollen, often rooting; internodes 25-60 cm long, 6-10 cm diameter, covered by long papery remnants of sheaths and dark-brown pubescence, walls on 1.2 cm thick. Culm-sheatjhs 35-50 cm long and 10-20 cm broad inner surface glabrous and outer surface clothed densely with patches of stiff dark-brown hair; margin light straw-colored in the upper half; ligule broad, much serrate or often long funbriate; auricles usually absent, sometimes very small on one side; blade 25-40 cm long and 2.5-3.5 cm broad, lanceolate-acuminate, recurved. Young shoots spear-shaped. Leaves 10-30 cm long and 2.5-4.5 cm broad, oblong-lanceolate to linear-lanceolate, acuminate, short-stalked margins rough; leaf-sheath ligulate, covered with brown pubescence margin ciliate.

The long-sheath bamboo, *D. longispathus* Kurz occurs in most hill slopes and along streams in the moist fertile loamy soil and particularly shaded fringes of the forest cover. It is distributed in India (Assam, Manipur,Mizoram and Tripura), Bangladesh and Myanmar. It is native to Bangladesh, Myanmar and Thailand. This species has been introduced to Orissa and Western Peninsula. *D. longispathus* found to occur in the South and Southeast Asian countries, where traditionally they used for a variety of purposes and it plays a very important role in rural economy. *D. longispathus* flowere sporadically or intermittently, like other bamboos the bamboo culms die and fall to the ground after the production of flowers and fruits, frequently their rhizomes are exhausted and die. The individual flowers are formed from ears and panicles and measure only a few millimeters. The bamboos normally flower in the last months of a year and seeds mature after fourth and fifth month of the next year. At the start of the rainy season, after the ripening of the seeds, the first new bamboo plants can be seen on the ground. The rhizomes are fully developed, only after many years and can thenproduce culms of the full height and diameter. Flowering has been reported from Bangladesh during the years 1876, 1879, 1880, 1885, 1930 and 1977-79, from Myanmar during 1862, 1871, 1875, 1887, 1891, 1912 and 1913. Flowering was observed in the clumps planted at Nilambur and Wynad (Korala) in 1990. According to Gamble, *D. longispathus* flwered during 1876, 1879-80 in Chittagong (Bangladesh) and during 1871 and 1891 in Myanmar (Gambel 1896). Gupta reported it in flowering from Assam in 1968 and at Mizoram during 1966-67 (Gupta 1972). Sporadic flowering of *D. longispathus* in Tripura during 2014 and the same was observed in the month of January and February 2014 in Mamit and Kolasib Districts, Mizoram (Sinha and Roy 2014).

Sveral studies were made on the impacts of bamboo flowering and death on soil properties. Soil pH tread to decrease, which is in accordance with the lower concentrations of exchangeable Ca and Mg at bamboo flowering sites (Takahashi et al. 2007), Details of the mechanisms behind the decreases in soil pH and exchangeable cations are not apparent but soil moisture and higher water holding capacity at flowering sites is suspect to enhance the leaching of cations from the soil surface especially in the rainy seasons. The organic carbon increased in soils under all the species of bamboo studied (Venkatesh 2005). Flowering and deaths of bamboos appeared to have caused removal of nutrients from the forest ecosystem. This may severely impoverish the soil and may account for the low fertility of the soil after bamboo flowering and death (Lalnunmawia 2008).

Understanding the floral characters along with anthesis and flowering culm par clump were assigned as important studies, where flowering and death of bamboos appeared to have caused removal and or addition of nutrients from the forest ecosystem. This may account for variation in the fertility of the soil after bamboo flowering and death. However, study on the impact of bamboo flowering on the physical and chemical properties of soil is very meager. The biogeochemical role of bamboo in sustaining the productivity of soil in hill areas of Mizoram and the neighboring states of Northeast India cannot be neglected. The present study help us understand the floral development, phenological characters and impacts of bamboo flowering soil characteristics in the hilly areas of Mizoram where bamboo is growing abundantly.

## MATERIALS AND METHODS

### Study site

The study was conducted in Lengte village inside Mamit District, located 33 km North-West of Aizawl, the Capital City of Mizoram, North-East India. The study site is located at disturbed sites N $23.46252^0$, E $092.35481^0$ and undisturbed sites N $23.90063^0$, E $092.65548^0$ of flowering bamboos areas at an elevation of 400 m - 500 m above mean sea level and has a moderate slope. Natural stands of D. longispathus Kurz was selected to study the various parameters where sporadic flowering has been observed in the study site during 2014-2019.

### Phenological characters and floral morphology

The study was done in the natural population of *D. longispathus* Kurz. Three permanent sample plots

of 0.01 ha (which was free from biotic disturbances) was established. Detailed phenologica; records on 30 randomly chosen individulas per culms of the species were made to observe to observe the floral morphology where, different phenological character was studied and measured such as floral characters; culm and clump diversity, which were observed and tabulated accordingly. According to the requirements of the studies, the phenological events were categorized following Opler method of identification (Opten et al. 1980).

***Anthesis***

Anthesis was conducted with some modification by following the technique used by Stephens method of identification (Stephens and Quinby 1934).

**Floral development per clump and per culm**

Randomly selected clump of sporadic flowering was studied by taking three sites each for disturbed area and undisturbed area within 0.001 ha (10 m × 10 m). The number of clump was counted on each study site and then the average number within 0.001 ha was converted into hectare (ha) to calculate the number of possible flowering culm on both the study sites. Also number of inflorescences and spikelets per culm per hectare (ha) was studied along with number of nodes per culm.

For number of flowers of *D.longispathus* Kurz produced per culm; three (3) replicate each on both the study sites were taken by counting the inflorescences as number of inflorescences present per culm and by knowing the average number of flowering nodes is approximately 19 nodes per culm. Three replicates of numbers of 30 bamboo flowering culm were counted and average number of spikelets present in one culm for disturbed and undisturbed areas was noted to obtain average spikelets per culm. Numbers of spikelet per inflorescences were obtained by dividing number of spikelet per culm and number of inflorescences per culm. Numbers of spikelet per nodes were obtained by dividing number of spikelet per culm and number of nodes per culm. The parameters were again analyzed by comparing mean to understand any significant difference between the study sites.

**Soil sampling**

Soil samples were collected from two different sites-bamboo flowering site and non-flowering bamboo site, in triplicates. For each replicates, soil samples were collected using spade from a depth of 0-15 cm, from the soil surface. The soil samples were sun dried, crushed, sieved through finer mesh and subjected to analysis.

**Analysis of soil physico-chemical parameters**

Soil temperature was measured using soil thermometer. The moisture content of soil was determined gravimetrically. The pH of the soil samples was determined by digital pH meter. The organic carbon was estimated by Walkey and Black method (Walkey and Black 1934). The total soil nitrogen (N) was estimated by following Kjeldahl's Digestion and distillation Method. The soil available phosphorus was determined using the method developed by Olsen and others (Olsen et al. 1954). Exchangeable potassium (K) was measured dsing ammonium acetate as an extractant with the help of Flame Photomater.

## RESULTS AND DISCUSSION

**Culm characteristics, loral morphology and phenology**

The flowering *D. longispathus* Kurz clumps and culms attributes i.e. elemp diameter, total number of culms per chump, no, of culms flowered and the height, girth at fifth node, number of nodes and intermodal length of the culms within the clumn were measured during March 2015 (Table 1). The flowering branch pattern was similar to that of a vegetative culm. Numerous floral buds were arranged

**Table 1.** Champ and culm attributes of *Dendrocalanmus longispathus* Kura (± ISD)

| Source | Parameters | Mean |
|---|---|---|
| Clump attributes | Diameter (cm) | 9.5 ± 5.50 |
| | No. of culms | 46.75 ± 12.75 |
| | Beight (m) | 21.01 ± 3.71 |
| | Girth at fifth node (cm) | 25.66 ± 7.26 |
| Culm attributes | Internode length (cm) | 46.66 ± 10.11 |
| | No. of nodes | 34.5 ± 5.30 |

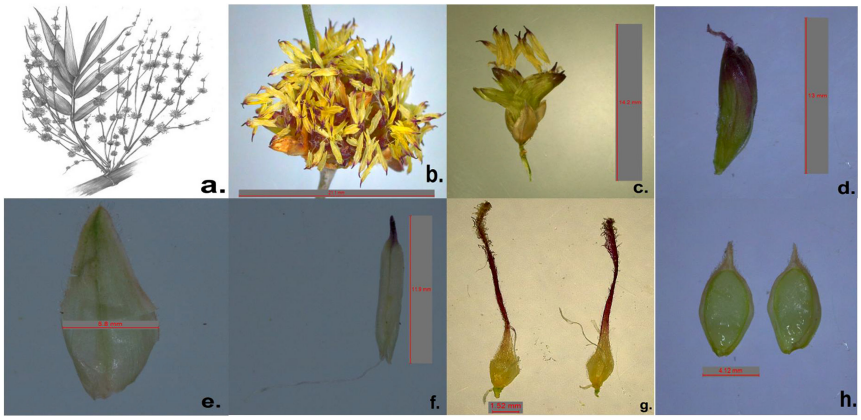


**Fig. 1.** Floral parts and seed of Dendrocalamus longispathus Kurz : a) Sketch of Inflorescence, b) Spikelets, c) Spikelets with glume, Lemma and Pales, d) Young stage of spikelets, e) Lemma, f) Anther, g) Stigma +Style with Ovary, h) TS of seed.

distichously in tight capitates-wise clusters of spikelets at the nodes. Towards the ends of long branches and in shorter ones, spikelets were fewer and loosely arranged compared to the vertical edge of the node.

## Floral morphology

Inflorescence of *D. longispathus* Kurz is a large leafy panicle, with stiff nodose branches bearing large globose heads; rachis dull brown, sparsely pubescent. The spikelets were several in number and arranged capitates wise on nodes. Spikelets were pale green when young and turned dark green on maturity and the exserated yellow anthers gave yellow appearance to heads.

The dimensions of floral parts of D. longispathus Kurz are given in the Table 2 and Fig. 1. Spikelets were dichogamous, protogynous and closed. Maturation of pistil three to five days priod to amther emergence was observed in the field studies indicated the protogynous nature. Presence of young anthers along with matured pistil in the FAA fixed flowers also confirmed the same. Theree to four empty glumes were seen per spikelet, which were basal broadly ovate rounded with ciliate keels. Fertile spikelets were two three and two to three florets per spikelet were observed. Lemma was pale white in color when young and turned pale green on maturity, broad at baseending as needle at top and glabrous. Palea was pale green to white many nerved and shortly bifid. Stamens were six, pale green in color and filaments were narrow, long, apiculate. Anthers and pollens were yellow; pollens were monoporate. Ovary sub-globular, hairy with club shaped stigma.

**Table 2.** Dendrocalamus longispathus Kurz flowering morphology and dimension (ca = circa i.e., approximately).

| Sl. No. | Floral characters | |
|---|---|---|
| 1 | Flowering period | October-January |
| 2 | Flower type | Large panicle |
| 3 | Flower color | Pale green pales with yellow anther |
| 4 | Spikelet with exposed stigma per head | Most of the florets |
| 5 | Spikelet with exposed authers per head | Most of the florets |
| 6 | Stigma type | Wet and papillate |
| 7 | Anther dehiacence mode | Longitudinal |
| 8 | Polien shape | Round and circular/spherical |
| 9 | Number of stigma | One |
| 10 | Number of Pales | 2 |
| 11 | Number of Lemma | 3 |
| 12 | Number of auther | ca 7 to 6 |
| 13 | The number of spikelets per branch | ca 3000 to 4000 |
| 14 | Number of Glume | ca 3 to 2 |
| 15 | Number of spikelet's/florets per head | ca 24 to 5 |
| 16 | Number of glumes | ca 25 to 5 |
| 17 | Width of spike (mm) | ca 5.98 to 5.39 |
| 18 | Width of spike complete flower (mm) | ca 2.75 to 2.42 |

**Table 2.** Continued.

| Sl. No. | Floral characters | |
|---|---|---|
| 19 | Length of the spikelet's (mm) | ca 14.3 to 13.5 |
| 20 | Length and width of Glume (mm) | ca 16.2 to 15.8 and ca 6.1 to 5.8 |
| 21 | Length and width of Lemma (mm) | ca 15.6 to 14.7 and ca 5.8 to 5.2 |
| 22 | Length and width of Palea (mm) | ca 14.8 to 13.4 and ca 5.3 to 4.7 |
| 23 | Length and width of ovary (mm) | ca 15.1 to 11.8 and ca 5.6 to 1.3 |
| 24 | Length of the stigma + style (mm) | ca 13.5 to 13.2 and ca 0.9 to 0.4 |

The present observation on floral morphology agrees with that of the classical and recent description made in Tripura, India (Devi et al. 2014).

## Anthesis

Time of anthesis varied from 6.00 am to 12 noon. Stigma of the flowers emerged out 4-5 days prior to anther emergence. In general, stigma became receptive around 7.00 am to 7.30 am and the viscous fluid secretion indicated the receptivity, where suitable temperature and humidity are at suitable timing on both disturbed and undisturbed area (Fig. 2 and 3). The yellow anthers emerged out around 7.30 am to 8.00 am and they were in the pecping out stage at around 8.00 am to 8.30 am. They exerted out completely after 8.30 am and linearly dehisced to

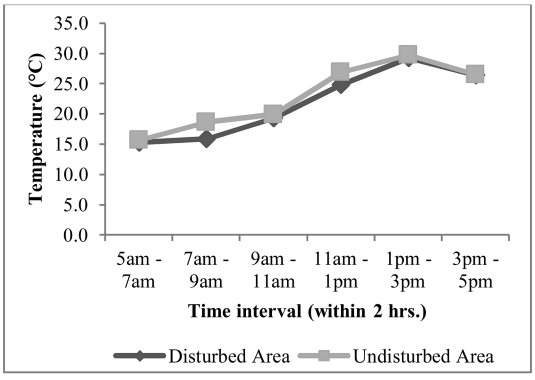


**Fig. 2.** Temperature and humidity during anthesis of *D.longispathus* on the study site.

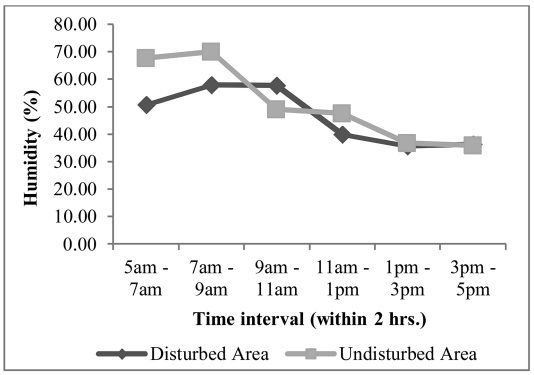


**Fig. 3.** Temperature and humidity during anthesis of *D.longispathus* on the study site.

disperse yellow pollens between 8.30 am and 10.00 am. It was the peak time of pollen dispersal. Gentle breeze and insects shook the anthers to liberate dusty pollen grains in the air. Majority of the anthers curled in the afternoon.

Like many other bamboo species, *D. longispathus* Kurz anemophilous (wind pollinated). Honeybees *Apis florea* and *Apis cerana* visited the flowers from morning till dawn as a frequent floral visitors. They foraged mainly on anthers of flowers. Peak insect visit was observed during 8 am to 3 pm. Presence of large number of pollen grains on the adhesive tapes fixed near flowers also indicated the anemophily.

Amplitude of anthesis was conducted for disturbed and undisturbed sites, the numbers of complete flowering per culm for three days indicated that there are 592 complete flower development on undisturbed study site whereas on disturbed site 518 complete flower development was observed (Table 3). From the grapg (Fig. 4) we can observed that disturbed area has shown less activity for completing its flower, this may be due to lesser inflorescence present on clump and also pollinator which were disturbed by different activity to perform wind pollination compared to undisturbed area. Analysis of variance also stated that there is a significant (F-value = 1281.64 and p-value = 0.00078*) variation between disturbed area and undisturbed area of *D. longispathus* Kurz flowering site.

**Table 3.** Anthesis amplitude of *Dendrocalamus longispathus* Kurz disturbed and undisturbed flowering site (± ISD).

| Disturbed area | Temperature and Humidity | 15.5$^0$C/ 67% | 15.4$^0$C/ 69% | 19.9$^0$C/ 49% | 24.9$^0$C/ 47% | 29.0$^0$C/ 36% | 26.5$^0$C/ 37% | |
|---|---|---|---|---|---|---|---|---|
| | Time | 5 am - 7 am | 7 am - 9 am | 9 am - 11 am | 11 am- 1 am | 1 am- 3 pm | 3 pm - 5 pm | Total flowers opening per day |
| | | | | Number of flowers opening at indicated hours | | | | |
| | Mean (Day 1) | 14.7 | 77.7 | 60.0 | 21.7 | 12.0 | 3.7 | 190 |
| | Mean (Day 2) | 16.0 | 43.3 | 66.3 | 24.0 | 11.7 | 4.3 | 166 |
| | Mean (Day 3) | 13.3 | 42.0 | 55.0 | 29.3 | 17.3 | 6.0 | 163 |
| | Total mean | 14.67 | 54.33 | 60.43 | 25.00 | 13.67 | 4.67 | |
| | | ± 1.35 | ± 20.25 | ± 5.65 | ±3.90 | ±3.15 | ±1.19 | 518 |
| Undistarbed area | Temperature and Humidity | 15.5$^0$C/ 61% | 18.5$^0$C/ 54% | 19.9$^0$C/ 57% | 26.6$^0$C/ 41% | 29.7$^0$C/ 36% | 26.8$^0$C/ 38% | Total flouers opening per day |
| | Time | 5 am - 7 am | 7 am - 9 am | 9 am - 11 am | 11 am - 1 am | 1 am - 3 pm | 3 pm - 5 pm | |
| | | | | Number of flowers opening at indicated hours | | | | |
| | Mean (Day 1) | 22.7 | 53.3 | 82.0 | 33.3 | 16.7 | 6.7 | 215 |
| | Mean (Day 2) | 23.3 | 39.3 | 74.0 | 28.0 | 19.0 | 5.3 | 189 |
| | Mean (Day 3) | 25.7 | 49.3 | 63.7 | 26.0 | 17.7 | 6.3 | 189 |
| | Total mean | 23.90 | 47.30 | 73.23 | 29.10 | 17.80 | 6.10 | |
| | | ± 1.59 | ±7.20 | ± 9.17 | ± 3.77 | ±1.15 | ± 0.72 | 592 |

## Floral development

A study was conducted by selecting an area of 0.001 ha (10 m × 10 m) for disturbed area and disturbed area of the experimental site, where four (4) clump were studied having maximum of 38 culm and minimum of 21 culm on disturbed study site. However, on undisturbed area six (6) clumps were observed within the selected area, the maximum culm per clump was 69 culms and minimum was 14 culm per clump (Table 4), The number of flowering culm per hectare was 13733 culm ha$^{-1}$ on disturbed site and 32667 culm ha-1 on undisturbed site (Fig. 5). The ANOVA analysis also indicated that there was a significant (F-value = 371.687 and p-value = 0.02689*) variation between disturbed and undisturbed area. The studies revealed that disturbed area (13733.3 ha$^{-1}$) show less clump sporadic flowering compared to undisturbed area (32666.7 ha$^{-1}$), this could be due to the practice of jhumming cultivation which was easily explored by human activities and other disturbance that effect the bamboo population.

The number of flowers of *D. longispathus* Kurz produced per culm and the number of flowering bamboo on the two study site was determined as on the table given in Table 5. The average number on flowering nodes was counted as 19 for both the study

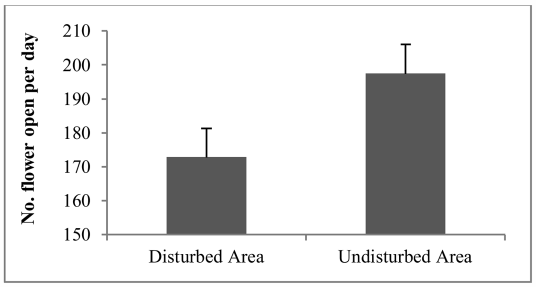


**Fig. 4**. Number of complete flowers formed per culm of *D. longispathus* Kurx.

**Table 4.** *D. longispathus* Kurz with flowering culm per Hectare (ha).

| Clum with flowering on 0.001 ha. i.e., 10 m × 10 m | Disturbed area Mean culm per clump | Undisturbed area Mean culm per clump |
|---|---|---|
| Clump 1 | 37 ± 5.03 | 61 ± 6.56 |
| Clump 2 | 38 ± 3.06 | 69 ± 2.89 |
| Clump 3 | 33 ± 2.09 | 68 ± 4.62 |
| Clump 4 | 21 ±19.43 | 66 ± 7.00 |
| Clump 5 | 0.0 | 56 ± 7.64 |
| Clump 6 | 0.0 | 14 ± 24.83 |

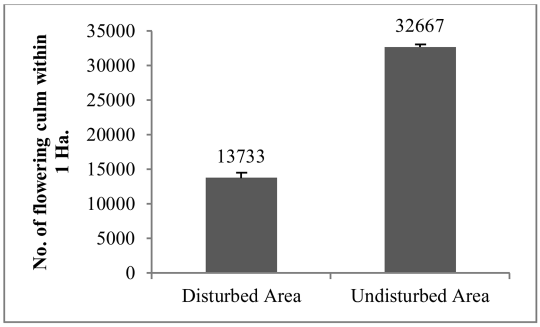


**Fig. 5.** *D. longispathus* Kurz with flowering culm per Hectare (ha).

site. The number of spikelet present per culm was 60790 on disturbed site and 75446 in undisturbed study site. The number of inflorescences present per culm was counted as 114 on disturbed site and 116 on undisturbed site. Hence, the spikelet present per inflorescence was assumed to be 534 on distrubed site and 651 on undisturbed site. Thus, the spikelet per flowering node was assumed to have 3199 at disturbed site and 3971 on undisturbed study site.

One-way Anova analysis showed a significant difference in number of spikelet per culm (F-value = 3457.45 and p-value = 0.00028*), number of spikelets per inflorescence (F-value = 56.363 and p-value = 0.01278*) and number of spikelet per node (F-value = 3470.25 and p-value = 0.00029*). However, there is no significant difference in number inflorescence per culm (F-value = 0.620 and p-value = 0.51347). This indicated that the number of *D. longispathus* Kurz apikelets was successfully developped under natural habitat compared to disturbed area of flowering site.

The number of spikelet per culm, number inflorescence per culm, number of spikelets per

**Table 5.** Number of flowering *D. longispathus* Kurz produced per culm ( ± ISD).

| Parameters | Disturbed area Mean | Undisturbed area Mean |
|---|---|---|
| No. of flowering node/culm | 19 ± 0.58 | 19 ± 0.58 |
| No. of spikelet/culm | 60790 ± 301.35 | 75446 ± 137.37 |
| No. of inflorescences/culm | 114 ± 6.00 | 116 ± 1.53 |
| No. of spikelet/inflorescence | 534 ± 30.01 | 651 ± 10.02 |
| No. of spikelet/flowering node | 319 ± 15.89 | 3971 ± 7.51 |

**Table 6.** Soil moisture, temperature and pH under flowering site and non-flowering site of *D. longispathus* Kurz ± ISE).

| Sl. No. | Solil parameters | Flowering sites | Non-flowering sites |
|---|---|---|---|
| 1 | Mosisteture | 9.17 ± 2.01 | 6.15 ± 0.59 |
| 2 | Temperature | 19.37 ± 0.15 | 20.87 ± 0.42 |
| 3 | pH | 5.2 ± 0.06 | 5.89 ± 0.06 |
| 4 | Organic carbon | 1.887 ± 0.372 | 3.933 ± 0.717 |
| 5 | Nitrogen | 0.027 ± 0.015 | 0.042 ± 0.014 |
| 6 | Phosphorus | 0.005 ± 0.0006 | 0.008 ± 0.001 |
| 7 | Potassium | 0.0007 ± 0.0004 | 0.0006 ± 0.0003 |

inflorescence and number of spikelet per node was well developed and found to be more in production at its natural habitat. Thus the studies reveled that, the nature of seed production is also highly depend upon the pollination and seed developer in natural site wheew there is less or no disturbances.

## Changes in soil characteristic

The sois moisture content was higher in bamboo flowering stand as compared to non-flowering bamboo stands (Table 6). Statistical analysis of data shows that there was significant difference between soil moisture content under the two bamboo stands (Table 7). There was a comparatively thick covering of soil in the bamboo flowering site at the time of data collection, this might have prevented evaporation of moisture from the soil. Different bamboo species require a set of eptimum condition for their growth and development such as temperature, rainfall, humidity, soil structure, sex ture, drainage, soil moisture, soil nutrients, altitude and physiographic features. Soil and climate are the most important factors for growth and development of bamboo (Varmah and Bahadun 1980).

A significant variation was observed on soil temperature of flowering and non- flowering bamboo stands (Table 7).. The average soil temperature was higher in non-flowering compared to flowering bamboo forests (Table 6). Higher soil temperature in bamboo non-flowering site as compared to flowering bamboo site may be due to the utilization of fertilizer, as the local people mingle the study siter with crops cultivation. The soil temperature in the surface layer (0–10 cm) was found to be the predominan controlling the temporal change pattern of the monthly

**Table 7.** ANOVA table for soil moisture, temperature and soil pH of flowering site and non-flowering site of *D. longispathus* Kurz. *Indicates significance at P<0.05. **indicatus significance at p<0.01.

| Objectives | Parameters | F - value | p-value |
|---|---|---|---|
| Soil moisture | Bamboo flowering site X non-flowering site | 8.299 | 0.045* |
| Soil temperature | Bamboo flowering site X non-flowering site | 21.809 | 0.043* |
| Soil pH | Bamboo flowering site X non-flowering site | 199.30 | 0.00015** |
| Organic carbon | Bamboo flowering site X non-flowering site | 0.87 | 0.4033 |
| Nitrogen | Bamboo flowering site X non-flowering site | 1.642857 | 0.269186 |
| Phosphorus | Bamboo flowering site X non-flowering site | 25.00000 | 007490* |
| Potassium | Bamboo flowering site X non-flowering site | 0.890909 | 0.398676 |

soil respiration rate in the *Phyllostachys glauca* and *Phyllostachys praecox* treatments i.e., those without fertilization (Zhang et al. 2020).

A significant variation was observed for soil ph of flowering and non-flowering bamboo stands (Table 7) , The soil pH declined from non-flowering to flowering phase in both the bamboo forests, where higher ph value was recorded in non-flowering bamboo stand (Table 6).Variation in pH has been resulted mainly due to the the variation in precipitation and soil microbial action. Consequently, acid soils incorporate with number of problems, including toxicity of ahuminium, manganese and iron as well as deficiencies of phosphorus, calcium, magnesium, potassium and micronutrients (Schroth and Sinclair 2003). Thus, increase in soil acidity could become an issue for insufficient NPK in the long run (Gazey 2009).

The average organic carbon content was higher in the non-flowering bamboo stand (3.933 mg $g^{-1}$) than the bamboo flowering site (1.887 mg $g^{-1}$) (Table 6). however, statistical analysis of data shows that there was no significant difference in the organic carbon content of the soil in the two stands of *D. longispathus* (Table 7). Bamboo proliferates through rhizome during spring season in which huge sum of soil organic carbon must be utilized. Decomposition of accumulated organic matters resulted in increasing soil organic carbons. According to Takahashi et al. (2007), post-flowering and flowering sites accumulated higher quantity of organic matters especially in these gregarious flowering instances that could be gradually incorporated with soil organic pools. On the other hand, organic carbon recorded in non-flowering sites could be an optimum quantity for the maintenance of their ecosystem, although, factors such as loading of dry leaves, twigs, branches and culms from dying bamboo lead to increase soil organic carbon after initiation of sporadic flowering in bamboo forest.

The total nitrogen content for bamboo flowering site (0.027%) was found to be lower than that of the soil from non-flowering bamboo site (0.024 %). However, the stafistical analysis indicates that there was no significant variation for N content of the soil from ono-flowering and flowering bamboo sites (Table 6). Soil total nitrogen was recorded higher in non-flowering bamboo stand as compared to that of flowering bamboo forests, however, Anova analysis indicates that the difference in N content between the flowering and post-flowering phases was insignificant in both namboo stands (Table 7). Nitrogen loss in flowering phase may be incorporated with denitrification due to higher moisture content in soil and it increases when the soil remains saturated. It also losses during breaking down of organic matters in low oxygen, generally in saturated soil. Leaching is also a major influencing factor for reducing N being a precipitous and hilly region (Berg and Staaf 1980).

Phosphorus content of the soil sample collected from bamboo flowering site were recorded as 0.05 mg $g^{-1}$ while that of non-flowering site of bamboo was 0.08 mg $g^{-1}$ (Table 6). Statistical analysis of data shows that the P content of bamboo flowering site was significantly lower than that of the non-flowering bamboo site (Table 7). This may indicates that P present in the rhizosphere of bamboo clumpmight have been leaching out through the soil after bamboo flowering. Besides, in most environmental conditions P act as limuting element due to smaller concentration in soil against the demand of plants and microbes.

The potassium content of soil collected from bamboo flowering site is higher than that of non--flowering bamboo soil containing 0.0006 mg $g^{-1}$, while while bamboo flowering soil contained 0.0007 mg $g^{-1}$ (Tablr 6). However, the statistical analysis indicates that the difference was insignificant between bamboo flowering site and non-flowering bamboo of the study sites (Table 7). After mass flowering in bamboo a large stock of standing crops died in a short span which is similar to removal of crops, such events moreover influence to depletion in K rapidly by escalating soil compaction, acidity.

## CONCLUSION

The presence of large anthers producing abundant uniform pollen grains which is the characteristic of wind pollinated species also leads to conclusion of the occurrence of anemophily in *D. longispathus* Kurz. Studies of anthesis show that disturbed area has shown less activity for completing its flower.

During the phenomena of gregarious flowering particularly in *D. longispathus* Kurz., primary macronutrients such as NPK in soil were less in bamboo flowering and post-flowering phases. The soil moisture content was higher in hamboo flowering stand as compared to non-flowering bamboo stands, which may be hecause of the increased mulching effect of the litter as the flowering bamboo shed their leaves before flowering. The lower pH in flowerings site indicated that the soil nutrients were utilized more by the flowering bamboo than the non-flowering bamboo stand. after sporadic flowering in bamboo forests, soil increase vulnerability to leaching, which is a major source and one of the most important limiting factors for soil pH in the hilly topography that cause to increase in soil acidification. Thephosphorus levels in soil were not significantly affected in the flowering site Low P availability in the flowering bamboo stand could be link with the uptake of more P during reproductive stage as bamboo for flowering and seeding occurred in mass scale within the clump. Hence, application of fertilizers and manures can be used to supplement the nutrient level in the soil in the bamboo flowering stands. Flowering and death of bamboos appeared to have caused decrease and or increase of nutrients in the forest ecosystem.

The present study has helped us in understanding the floral development,seed production and regeneration of bamboo. Proper awareness among the local inhabitants is necessary for conservation and avoiding anthropogenic activities at the flowering areas during flowering year of *D. longispathus.* The demand of bamboo and their product is ever increasing as a better substitute for other woody species. therefore, proper management of the flowering bamboo stands of the commercially important species such as *D.longispathus* during flowering and post flowering stage is vital for ensuring sufficient and quality seed production in order to raise large-scale plantations for meeting growing market demand. The study is useful for the proper menagement of bamboo (*D. longispathus*) sites in Mizoram.

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