Phenologic Characterization of Perilla [*Perilla frutescens* (L.) Britton] Under the Agro-climatic Conditions in Bangladesh

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Abstract

Perilla frutescens (L.) Britton, a model dicotyledonous plant under Lamiaceae family has been cultivating in the East Asia since ancient times and is now popularly distributed worldwide for her medicinal as well as vegetable (leafy) values. As such, the crop is explored to fit into the existing cropping pattern by comprehensive study on life cycle of the crop plant through seasonal and inter annual variations to agro-climate of Bangladesh. In terms of ecological adaptation to variations in sowing months, the crop grew with diminishing seed yield potential per plant up to November sowing. As sowing time gets closure to onset of the Robi season (15 October to 15 March), vegetative growth of the crop shortens and starts flowering with decreased no. of inflorescences with lower 1000 seed weight and thus yield per plant decreased. Nevertheless, December sown plants showed the maximum yield potential (604g/plant) among the sowing months under study. The crop sown after December, the yield potential starts decreasing up to the middle of February and after that the crop appears with luxuriant vegetative growth with no seed yield due to failure of flowering.

Key Words: Perilla, Phenologic Characterization, Agro-climate

1. Introduction

Perilla is a semi-hardy annual herb native to China belonging to the family Labiatae, and broadly distinguished by the red to green colored species of the crop (Yamazaki and Nishimura, 1992). Within the genus *Perilla*, the taxonomic nomenclature is controversial (Zeevaart, 1969) and the number of the recognized species of this mint family varies from one (Misra and Husain, 1987) to four (Gorshkova, 1954) including many more taxonomic and horticultural varieties (Miller, 1922). On the basis of their morphology and use, the well-known species includes the *Perilla frutescens* (L.) Briton var. *frutescens* and *Perilla frutescens* (L.) Briton var. *crispa* belongs to the categories green leaved *Perilla*, called *Perilla* Green and the purple leaved one, named *Perilla* Red, respectively (Lee *et. al*., 2002). Until now, the *frutescens* (*Perilla* Green) variety is extensively cultivated in Korea for the purpose of oil and leafy vegetable production (Nitta, 2001) although the crop is supposed to be originated in China (Makino, 1961). This short-day annual crop is called "**Ban Tulsi**" in **Bengali**; "**Wild sesame**" in **English**. Including Korea, the crop is an addition to the south-east Asian cuisine. Recently, the development of improved cooking methods with increased consumption of meat, the fresh leaves of the *frutesecens* variant of *Perilla* has become a one of the most important crops in Korea (Lee *et.al*., 2002). In addition to the use of leaves of this variety, as a fresh vegetable and for making pickles, seeds are treated as the most important source of plant oil in Korea.

The seeds of *Perilla* contain about 45% quality oil, which is composed of >90% unsaturated fatty acids like oleic, linoleic and linolenic acids (Park *et.al*., 2000). On the other hand, *Perilla frutescens* var. *crispa* is a Chinese medicine and a fresh vegetable in the Far East with almost disappeared species in many parts of Asia (Nitta *et.al*., 2003). These authors also reported that the cultivation of this variety is still continued in Japan and Vietnam in a large scale for coloring of pickles, but remains only as a relict form in Korea. Nevertheless, Perilla holds two distinct chemo-varietal forms - 'Green Perilla' and 'Purple Perilla' depending upon the availability of anthocyanin pigment therein, as such, it is treated as a nice model plant to investigate molecular mechanism of anthocyanin biosynthesis in these metabolic phenotypes (Saito and Yamazaki, 2002). In addition to those metabolotypes of *Perilla*, weedy plants of both Perilla species are commonly found in such habitats as road sides, waste lands and around farmers' fields in East Asia (Nitta and Ohnishi, 1999). Perilla has been used by plant physiologists to investigate flower induction. The following information is modified from Zeevaart's (1969, 1985) reviews of the effect of day length on Perilla. Long nights induce flowering, which varies with different accessions of the crop. Moreover, plants become photosensitive at the fourth leaf pair stage and flowering starts 18-20 days after starting of long nights. Wada and Totsuka (1982) discovered another environmental influence with continuous lighting by restricting nitrogen availability on the culture media. Perilla plants are easily grown for seeds. They self-pollinate without insect visits and yield well in green house condition. Seed yields ranged from 1020 to 1440 kg/ha in Korean research plots (Choi *et.al*., 1980). The greatest difficulty in Perilla germplasm maintenance is limited seed

viability in storage. In this regard, Cho *et.al*. (1986) reported that the seed viability could be lost in less than a year stored at room temperature, but the storage life in lowered temperature or humidity improves dramatically.

Therefore, the major objective of the study is to explore the optimum cropping season for best fitting up of the proposed crop on the on-going cropping patterns of the Kharif - 2 to the Robi seasons (from July to March) in Bangladesh. The crop induces flowers during the long nights, so the cropping duration would be optimized as per performance of the physiological parameters generated out through the replicated trials on different sowing times during the stipulated period. Moreover, the long-term objective is to acclimatize the crop by growing, in the optimum season as would have been revealed from the investigation, in about 2,68,000 hectares of culturable waste lands in different Agro Ecological Zones (AEZ) of Bangladesh (BBS, 2004).

2. Methodology

Perilla seeds (variety Manbaen) were collected personally from the Republic of Korea (South Korea) in March, 2013 and stored at room temperature condition in Bangladesh. The crop was started growing in pots and field condition. In either of the conditions, seeds were started sowing from July, 2013 and continued the process up to the March, 2014. In each of the months the seeds were sown in sandy loam soil prepared by adding well decomposed compost @ 20% by volume in pot soils and 5cm layer followed by incorporation to approximate depths of 12-15cm depth in field soil. The crop stands were maintained by 50cm X 50cm plant to plant and row to row spacings respectively in field condition. In the case of pot-sowing, up to 5 plants were maintained after discarding the excess plants per pot. Irrigation, intercultural operations and plant protection measures were taken as per need of the crop. As the starting seed material collection was small in quantity (200g) and was stored at room temperature, the viability of seeds was lost up to 90% by 3-4 months also reported by Brenner (1993). So, the destructive samplings from field and pot-sown crops were not possible for growth analysis of the crop cultivated in month-by-month basis. However, the data were taken at the end of each harvest of the crop grown in pots only. The randomly selected 5 plants were considered for recording data on plant height (cm), no. of branches per plant, no. of inflorescence per plant, days to flowering, no. of capsules per branch, 1000 seed weight (g), seed yield per plant (g) and stover yield per plant (g). In addition to those data, the time to 50% germination (T_{50}) was calculated according to Coolbear et al. (1984) modified by Farooq et al. (2005):

$$T_{50} = \frac{t_i + \{ (N/2) - n_i \} (t_i - t_j)}{n_i - n_j}$$

Where N is the final number of germination and n_i, n_j are denoted by the cumulative number of seeds germinated by adjacent counts at times t_i and t_j when $n_i < N/2 < n_j$. The average values (of 5 plants) on the cited parameters were analyzed using MSTAT-C program and the replicated mean values were checked by the standard error values generated through the analysis of variance of the data.

3. Results and discussion

The ecological adaptation of Perilla to variations of sowing months as evaluated by days to 50% germination (**T50**), days to flowering and cropping durations are depicted in Table I.

Table I: Evaluation on days to 50% germination (**T_{50}**), days to flowering and cropping duration of Perilla grown in different months in Bangladesh

Sowing months	T50 value	Days to flowering	Cropping duration
July	3 ± 0.5	56 ± 3.06	70 ± 1.5
August	3 ± 0.5	57 ± 3.06	72 ± 1.4
September	3 ± 0.5	59 ± 3.06	75 ± 2.2
October	3 ± 0.5	38 ± 3.51	55 ± 1.3
November	5 ± 0.5	33 ± 2.51	47 ± 1.6
December	9 ± 0.5	97 ± 3.06	115 ± 2.4
January	9 ± 0.5	100 ± 2.52	120 ± 2.9
February	7 ± 0.5	X	X
March	3 ± 0.5	X	X

- **"X"** indicates no flowering as such the crop failed to complete life cycle.

It showed that the growth period from seeding to harvesting varied with sowing months (from July to January). When the seeds sown in cooler months (December and January), it took longer **T50**, days to flowering and

finally longer time to reach seed maturity comparing to those months, which were comparatively warmer (July to November) in Bangladesh. The crop shortened the vegetative growth to prepare flowering from 38 to 33 days in October and November sowing respectively (Table I). In addition, the crop failed to induce flowering and yielded no seed when sowed in February and March.

These results suggested that mean monthly increase in day length and temperature (Figure I) might have affected on vegetative growth and reproductive phases with maturity of this crop as well.
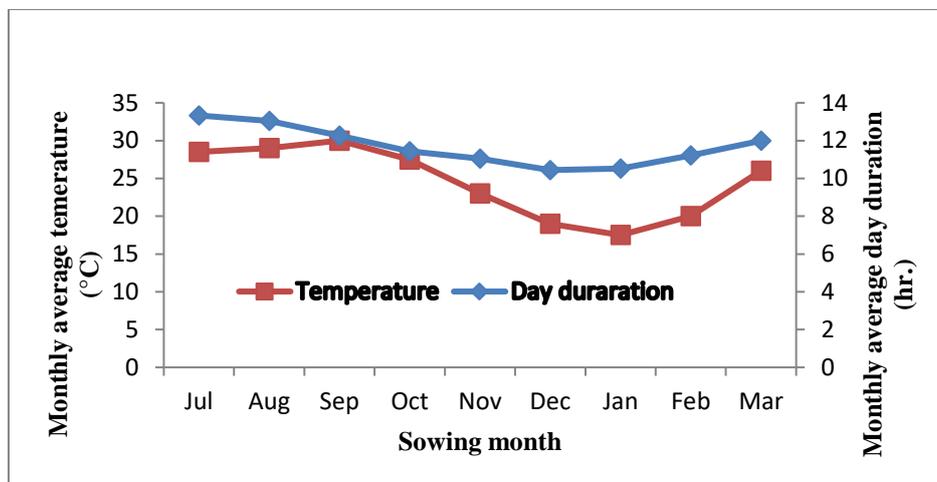
Figure I: Mean monthly air temperature and day duration of Dhaka. The highest and the lowest values of the parameters recorded were considered to calculate the month wise mean values from July 2013 to March 2014 at Sher-e-Bangla Agricultural University farm.

Moreover, the flowering induction by the shortest duration (38 to 33 days) revealed as a short-day nature of the crop. In another study, the sowing time of Perilla was adjusted in long day condition, where it extended the vegetative growth and took 132 days from sowing to maturity but due to shorter days it flowered by 57 days in Korea (Park, 2005). From this study, it confirmed a phenomenon of Perilla that due to long nights it induced flowering as also supported by Lee and Yang (2009). Moreover, the crop grown in different sowing months (July to March) might have substantial requirement of critical night length to bloom and that would be true up to the end of January in Bangladesh. As shown in Figure IIa, Perilla plants elongated like curvilinear fashion. Plants grown in warmer months (Fig. IIa) were shorter compared to those of cooler months as also supported by Lee and Yang (2006).
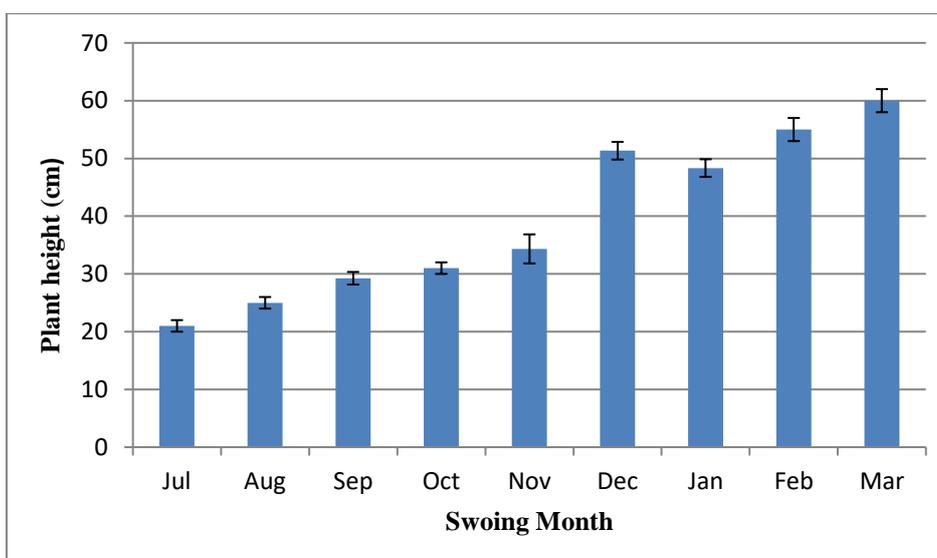

Figure II(a): Variations of average plant height recorded in Perilla cultivated in different months in 2013 and 2014.

In addition, branches per plant were reduced with the lowest number value in October and increased with a linear fashion up to March (Fig. II.b).
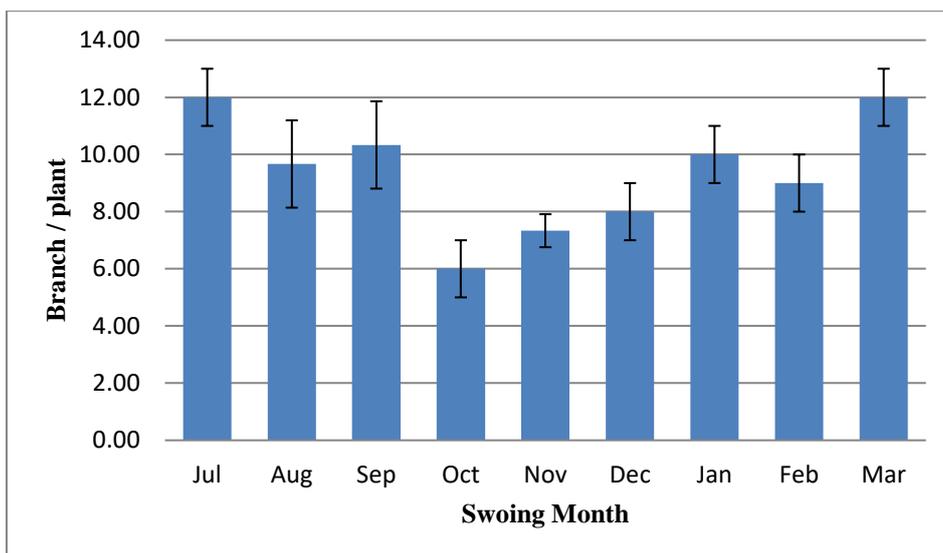
Figure II(b): Variations of branches per plant recorded in Perilla cultivated in different months in 2013 and 2014.

These results might be implied that the photosensitivity of the crop restricted vegetative growth and induced blooming (Brenner, 1993) in October sown batch when mean monthly day duration and temperature starts falling (Figure I) in Bangladesh. In the case of inflorescence numbers / plant, the highest values were recorded in December sown crops (Figure IIIa).
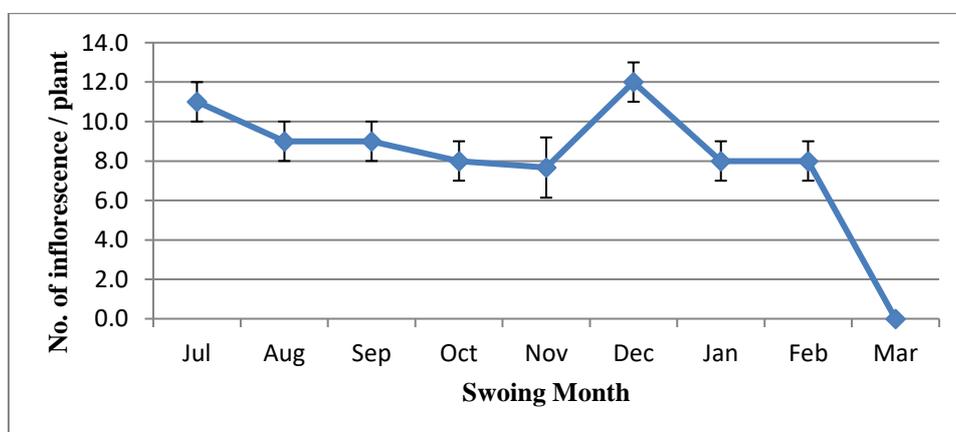

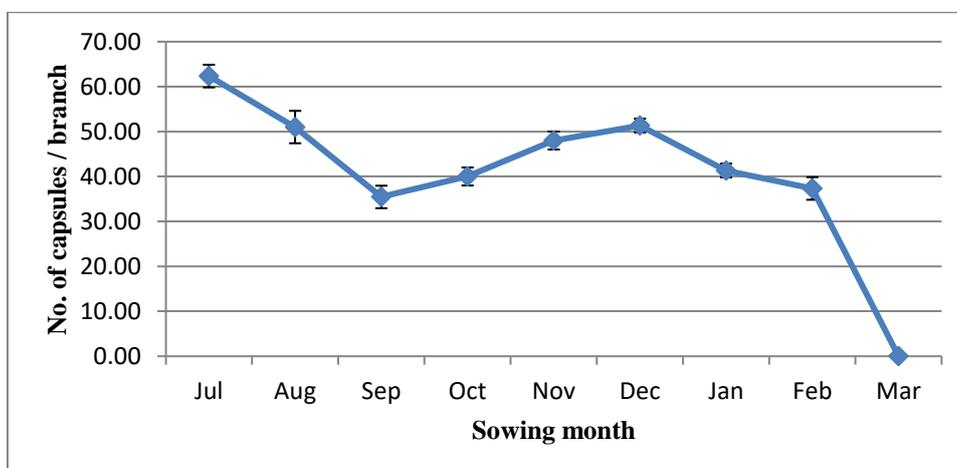Figure III(a): Effect of sowing months on production of inflorescence per plant of Perilla.

Figure III(b): Number of capsules per branch produced in Perilla sown on different months in 2013 and 2014 in Bangladesh.

The productions of capsules / branch were also noted the second highest in August and December after July sown crops (Figure IIIb).

However, the results revealed that decreasing trend of initiating inflorescence and capsules / branch reflected as an evident almost found in rainy and autumn seasons of Bangladesh. Production of larger seeds was found in winter season. In December sown plants, it showed the highest 1000 seed weight values (Figure IV) resulting the highest seed yield per plant (Figure V.)
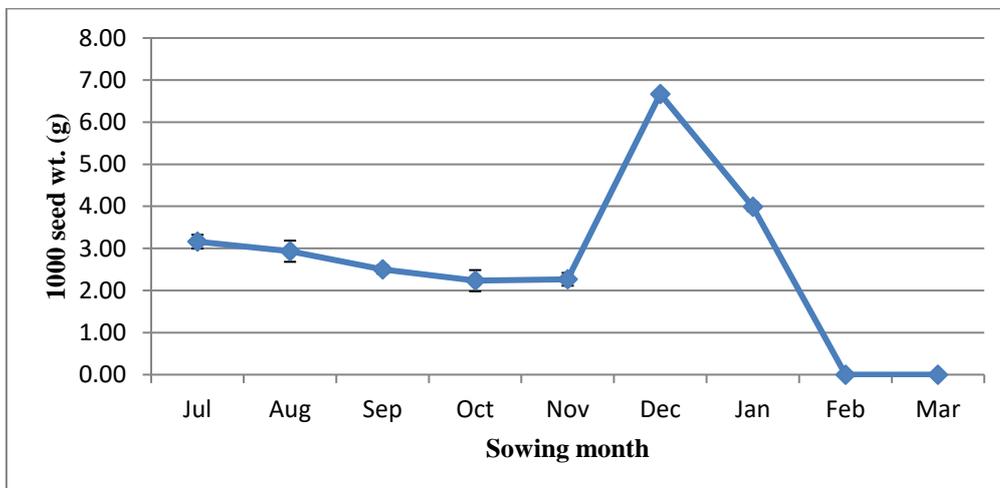
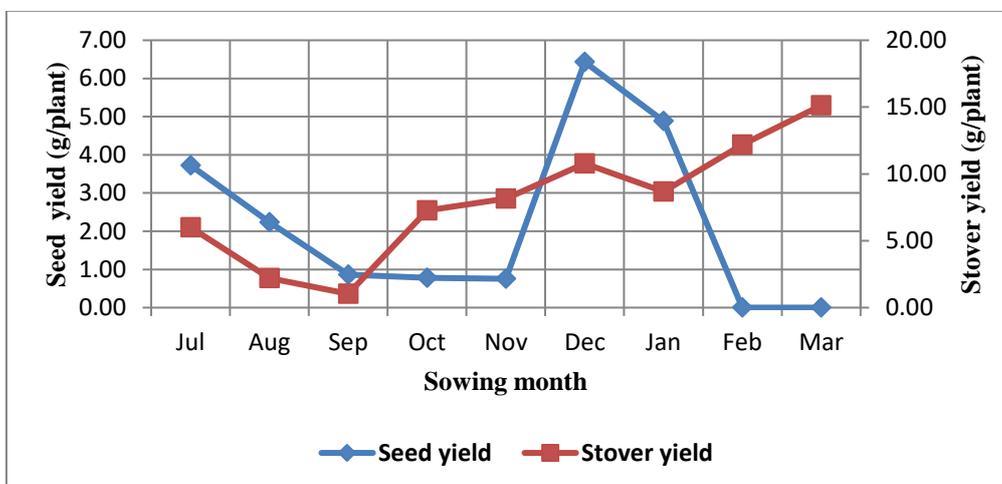Figure IV: Changes of 1000 seed weight of Perilla evaluated through different growing months in Bangladesh.

Figure V: Comparison of changes of seed yields with changes of stover weight of Perilla grown in different months at Sher-e-Bangla Agricultural University farm in years 2013 and 2014.

Sowing months severely affected phonologic stages duration, growth and accumulation of dry matter in Perilla. In this case, stover and seed production followed similar pattern up to January. However, these tendencies were found antagonistic as of the data recorded from February grown plants. Production of dry matter such as stover and seed yield appeared with negative correlation in February and March sown batches of Perilla (Figure 6). At these months, luxuriant vegetative growth of plants occurred towards producing increased dry matter (stover) but attained no floral primordia resulting no seed yield (Figure 6) of the crop.

Figure VI: Growing of Perilla plants in pot soils. A). Perilla at vegetative stage grown in Korean winter season. B). Perilla at flowering stage grown in Korean winter season. C). Perilla at pod setting stage grown in December, 2014 in Bangladesh. D). Perilla at pod flowering stage grown in December, 2015 as extended research in Bangladesh. Seed yield result indicated that maturity duration of seeds varied with growing months and as such the lowest seed yields were harvested in September and that was continued up to November. Apparently, plants grown in hot summer months (July to September) produced less seeds as also reported by Lee and Yang (2009).

4. Conclusion

Perilla was proved as a short-day plant that starts flowering when sown in between July to the end of January. In shorter nights, the crop stimulates vegetative growth but in long night it induces flowering. So, the sowing time of Perilla should be decided after due consideration of the vegetative growth duration desired. The crop appears with productive ecological adaptation when it would be sown in late November to the middle of December for the best seed yield potential in Bangladesh.

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