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Phenology, Thermal Time Requirement, Growth and Yield of Winter Mungbean *(Vigna Radiata)* as Influenced by Sowing Dates in Ganges Tidal Floodplain (AEZ-13) in Bangladesh

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Abstract

A field study was carried out at the Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Rahmatpur, Barishal during the late Rabi season of 2018 in Ganges Tidal floodplain (AEZ-13). The experiment was carried out with four different sowing dates

(i) Sowing at January 15
(ii) Sowing at January 25
(iii) Sowing at February 05
(iv) Sowing at February 15 under randomized complete block design with three replications to study the phenology, thermal time requirement, growth and yield of mungbean.

BARI Mung-6 was used as the variety. The results revealed that mungbean sown on 15 January required the maximum days to reach maturity (87 days) whereas 15 February sown crop required the minimum days to reach maturity (71 days). The lowest accumulated GDD (Growing Degree Days) was observed at sowing on 05 February (1322.4 °C) followed by sowing on 25 January (1355.2 °C) whereas the highest accumulated GDD was observed at sowing at 15 January (1401.85 °C). The highest dry matter production at pod + flower part was sowing at 05 February (7.13g/plant) followed by sowing at 15 February (7.12g/plant) which were statistically identical, sowing at 05 February had produced the highest seed yield (1.73 tha-1) which was statistically identical to sowing at 15 February (1.70 tha-1).

Keywords: Sowing date; Phenology; GDD; Dry Matter Partitioning

Introduction

Mungbean (*Vigna radiata*) is an important component in the intensive crop production system for its short life cycle and is one of the leading pulse crops of Bangladesh. The agroecological condition of Bangladesh is favorable for growing this crop. It is a drought-tolerant crop and can be grown with a minimum supply of nutrients. Cultivation of mungbean can improve the physical, chemical, and biological properties of soil as well as are capable of fixing atmospheric nitrogen by the symbiotic process with the help of microsymbiont (Rhizobium). Mungbean has good digestibility and flavor. Mungbean contains 51% carbohydrate, 26% protein, 10% moisture, 4% minerals and 3% vitamins [1]. In Ganges Tidal Floodplain of Barishal region, 184655 ha areas are under mungbean cultivation and area coverage is increasing every year. Among the mungbean varieties, the major cultivation area is covered by BARI Mung-6 (62%) *e.g.* 115241 ha.

Crop physiological processes dependent on integrated atmospheric parameters in which temperature is an important weather parameter that affects plant growth, development, and yield [2]. Several physiological and morphological changes occur that involve the development of root, shoot and leaves, flowering, and seed formation. Each physiological and morphological characteristic may affect yield in many ways, the net effect of which depends on other characteristics, on environmental conditions, and agronomic practices. Plant morphological characteristics and yield-forming components must be better understood if maximum yields are to be realized and exploited. Sowing time, a non- monetary input, is an important factor to influence yield [3]. Depending on sowing dates crop faces variable temperatures, rainfall, and relative humidity, etc. which affect crop phenology, growth, and yield. Temperature is a major environmental factor that determines the rate of plant development.

The phenological stages of mungbean are mainly related to temperature. Mungbean being a tropical and a sub-tropical crop requires warm temperature regimes (24 to 30°C with average temperature 28 °C) for its growth but can tolerate high temperatures up to 40°C. This temperature requirement for different developmental stages is known as thermal time or growing degree days (GDD). Sowing dates induced temperature variability may change the duration of phenophasic development. The duration of each phenophase determines the accumulation and partitioning of dry matter in different organs as well as grain yield. To understand the physiological basis of yield difference of mungbean, it is essential to quantify the components of growth, and the variation, if any, may be utilized in crop improvement. Climate change has deleterious effects on crop production in terms of the period of maturity and yield. From the last few years, the change in climate has been observed by Swaminathan and Kesavan (2012), which may adversely affect the phenology and production of crops [4]. With a successful study on these thermal indices may provide the information on the crop phenology and approximate date of crop harvest. Therefore, the present investigation was undertaken to evaluate phenological changes, growth, and yield of mungbean under variable sowing dates.

Materials and Methods

Description of the Study Area

The experiment was conducted at the Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Rahmatpur, Barishal at Ganges Tidal Floodplain ecosystem (AEZ-13) during the late Rabi season of 2018. The research station is situated in the southern part of Bangladesh and located at 22º 42″ N Latitude to 90º 23″ E Longitude at an altitude of 4 m from mean sea level (MSL). The climate of the locality is sub-tropical. It has characterized by high temperature, high humidity, and heavy rainfall during the Kharif season (April to September) and low rainfall associated with moderately low temperatures during the rabi season (October to March). The water balance is negative from November to April.

The study area is a piece of well-drained medium high land with even topography. The area belongs to the agro-ecological zone of the Ganges Tidal Floodplain under AEZ-13. The texture of the soil is clay loam in nature with low organic matter content (0.54-2.58) and a pH value of 6.8-7.2. These areas are slightly saline (0.65-1.90 dS/m), with some pockets being non-saline.

Treatments and Experimental Design

The experiment was conducted in a single factor randomized complete block design with three replications. The treatments were as follows: Different sowing dates: (i) sowing at January 15 (ii) sowing at January 25 (iii) sowing at February 05 (iv) sowing on February 15. The unit plot size was 5m x 5m. Initially, the experimental area was divided into three blocks to represent three replications. Each replication contained four plots. Block to block and plot to plot distance was 1m and 0.5m respectively. BARI Mung-6 was selected as the variety. The experimental field was fertilized with 18-30-36-18 NPKS Kg/ha as a basal dose. Yield and different yield contributing characters were measured at harvest.

Collection of Weather data

Weather data of the program was collected by an on-farm meteorological station. Data on maximum and minimum temperature (in degree Celsius), relative humidity (in percentage), and precipitation (in millimeter) during the crop growing period was collected on a daily basis. Average monthly weather data were calculated from daily weather data.

Collection of phenological data

The phenological development stages of mungbean crops were recorded based on visual observations. When the

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seedling emerged from the soil, the number of days taken to emergence was counted. Whenever the first trifoliate leaf emerged, day interval from sowing to first trifoliate leaf emergence was counted. Days required to third trifoliate leaf stage were counted following the same process. Whenever the first flower was observed, the number of days from sowing to flower initiation was counted. When 50% of plants produced flowers, the number of days from sowing to 50% flowering stage was counted. Whenever the first plant with pod was observed, the number of days from sowing to pod initiation was counted. The number of days taken from sowing to maturity was recorded in each plot when about 80% of the pods matured [5].

Calculation of Accumulated Growing Degree Days

The maximum and minimum temperatures were measured through an on-farm meteorological station. Data that were collected on a daily basis were compiled. The maximum and minimum temperatures were calculated by adding them at each phenophase from sowing to harvest e.g. S1: Sowing-Emergence, S2: Emergence- first trifoliate stage, S3: first trifoliate stage-third trifoliate stage, S4: third trifoliate stage- 1st flowering stage, S5: 1st flowering stage- 50% flowering stage, S6: 50% flowering stage-1st pod initiation stage, S7: 1st pod initiation- Maturity stage. The growing degree days per day was calculated by the following formula [6,7]:

Growing degree day (GDD):

$$GDD = \frac{T_{\max} + T_{\min}}{2} - T_b$$

Where,

Tmax = Daily maximum temperature (°C) during a day

Tmin = Daily minimum temperature (°C) during a day

Tb = Minimum base temperature. For mungbean it was taken as 10°C [8]

Accumulated growing degree day (AGDD):

$$AGDD = \sum_{i=1}^{n} GDD$$

Collection of Dry Matter Partitioning Data

For dry matter partitioning data, plants from 50cm × 30cm area were sampled from each plot of each replication at each developmental stage by destructive sampling starting from the first trifoliate stage. Then sampling was done regularly at the third trifoliate stage, first and 50% flowering stage, first pod initiation stage, and maturity stage. The destructive sample collection area was marked with red tape. Yield and yield contributing characters were not measured from these marked areas. The leaves, stems, and reproductive parts (fruit, flower) were separated and dried in an oven at 75 °C temperature for 48 hours. The summation of the dry weight of stem leaves and the reproductive part gave total dry matter accumulation which was then calculated in terms of g/plant [9].

Statistical Analysis

The collected data were analyzed by the statistical software MSTAT-C and the least significant differences were calculated at a 5% level of significance [10].

Results & Discussion

Phenology of Mungbean Affected by Different Sowing Dates

Days required for different development stages of mungbean are represented in Table 1. Significant differences were observed among different sowing dates induced by temperature variation, photoperiod, and solar radiation. Mungbean sown on 15 January required the maximum days (7 days) to emerge. This may be due to the prevailing low air temperature and humidity during the initiation of the experiment. Days required for emergence gradually decreases for other sowing dates. Delayed sowing hastens the emergence of mungbean. Mungbean crop sown on 15 January required the maximum days to reach two-leaf stages (13 days) and trifoliate stage (36 days). Mungbean sown on 15 January required the maximum days (50 days) to reach the first flowering stage whereas the crop sown on 15 February required the lowest (42 days). A similar trend can be observed from days required to 50% flowering. Earlier 50% flowering with delayed sowings has been observed in mungbean [11]. Early sown mungbean demonstrated the maximum days to reach maturity (87 days) whereas the 15 February sown crop exhibited the least (71 days). For maturity, it was observed that delayed sowing shorten the life cycle of mungbean.

Accumulated Growing Degree Days

Accumulated growing degree days (GDD) were calculated for different development events of mungbean at different sowing dates represented in (Table 2). The crop had faced an increased pattern of accumulated growing degree days at the vegetative stage that reached the maximum at the two-leaf stage to the trifoliate stage. At the two-leaf stage to the trifoliate stage, the crop sown on 15 February faced the highest accumulated GDD (297.4 °C) might be a cause of high temperature prevails at the early stage of delayed sowing. At the trifoliate stage to the first flowering stage, accumulated GDD was the maximum at 15 February sown

Table 1: Days required for different development events of mungbean at different sowing dates Means bearing same letter (s) do not differ significantly at 1% level of probability by DMRT.

Date of sowing	Emergence	First trifoliate stage	Third trifoliate stage	First flowering	50% flowering	First pod initiation	Maturity
15 Jan.	7.00 a	13.00 a	36.00 a	50.00 a	56.00 a	59.67 a	86.67 a
25 Jan.	6.33 b	12.67 a	32.00 b	45.00 b	51.00 b	57.00 a	80.00 b
5 Feb.	5.00 c	11.33 b	29.33 c	42.00 c	46.33 c	52.00 b	73.00 c
15 Feb.	5.00 c	11.00 b	28.33 c	41.67 c	45.00 c	49.33 b	71.33 c
$LSD_{(0.05)}$	0.58	0.74	1.76	1.53	1.73	2.69	3.59
CV (%)	4.95	3.11	2.81	1.71	1.75	2.47	2.31

Table 2: Growing degree days (GDD) accumulated for different development events of mungbean at different sowing dates

Note: S1: Sowing-Emergence, S2: Emergence- first trifoliate stage, S3: first trifoliate stage-third trifoliate stage, S4: third trifoliate stage- 1st flowering stage, S5: 1st flowering stage- 50% flowering stage, S6: 50% flowering stage-1st pod initiation stage, S7: 1st pod initiation- Maturity stage

Date of sowing	Growing Degree Days (⁰C)							
	S1	S2	S3	S4	S5	S6	S7	Total
15 Jan.	73.85	70.45	293.8	212.6	99.25	73.2	578.7	1401.85
25 Jan.	77.55	74.45	260.05	205.8	109.45	121.45	506.45	1355.2
5 Feb.	76.35	89.15	263.25	217.5	79.2	128	468.95	1322.4
15 Feb.	61.2	87.65	297.4	267.3	68.7	106.4	487.85	1376.5
SD	7.52	9.37	19.69	28.08	18.54	24.44	47.98	33.65

crop (267.3 °C) and then 217.5 ºC at 05 February sown crop. At first flowering to 50% flowering stage and 50% flowering to the first pod initiation stage, GDD accumulation was declined due to a short interval existed between the stages. At first pod initiation to maturity stage, the maximum GDD was accumulated by the crop sown on 15th January (578.7 °C) and the minimum by 05th February sown crop (469 ºC). The maximum total GDD was accumulated by the mungbean sown on 15 January (1402 °C). Crop sown on 15th February accumulated 1376.5 °C of total GDD and the minimum total requirement was observed at 05th February sown crop (1322.4 °C) (Table 2). Early sown mungbean crop consumed more number of GDD to attain physiological maturity compared to late sown mungbean [12].

Dry Matter Partitioning

The result of the dry matter production of mungbean influenced by sowing date is presented in Figure 1. From the Figure 1, it can be observed that, sowing at 05 February and sowing at 15 February dominated in dry matter production in every developmental stage in different plant organs. At first trifoliate leaf development stage, the crop sown at 15 February had produced the maximum source dry matter into leaves (0.79g/plant). This may be due to high temperature and humidity enhances rapid dry matter accumulation, the higher rate of photosynthesis, and hence

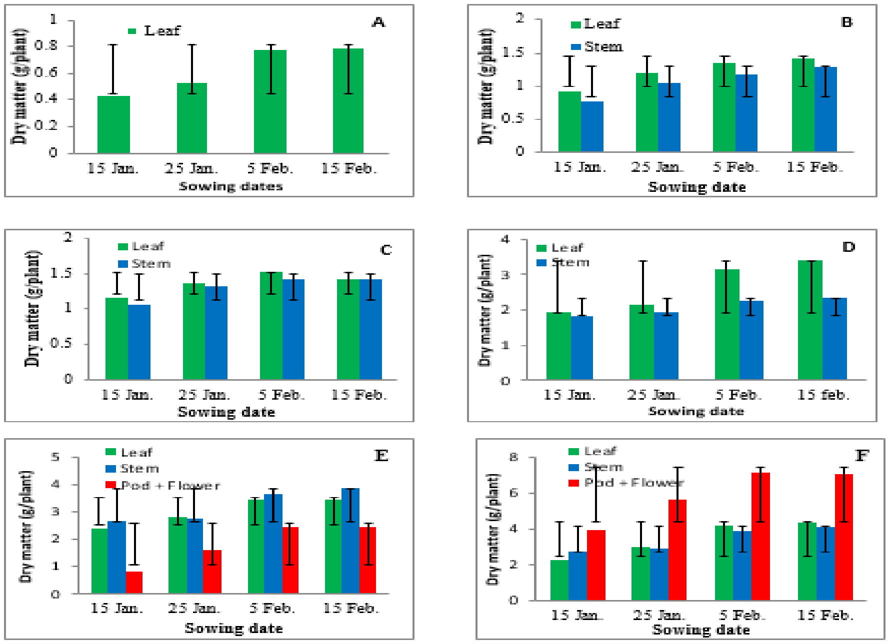

Figure 1: Dry matter production of mungbean (A. first trifoliate stage B. third trifoliate stage C. first flowering D. 50% flowering E. first pod initiation F. maturity stage) at different sowing dates (All the data were statistically significant).

growth. Among other sowing dates, the crop sown on 05 February had produced 0.77g/plant dry matter. The crop sown on 25 January had produced 0.53 g/plant dry matter at the first trifoliate leaf development stage and 15 January sowing had produced the least (0.43 g/plant) (Figure 1).

At the third trifoliate leaf development stage, mungbean sown on 15 February had produced the maximum dry matter into leaves (1.42 g/plant) and stems (1.29 g/plant). The crop was sown on 05 February also had produced statistically identical dry matter production into leaves. The least dry matter had been produced by the crop sown on 15 January into leaves (0.9 g/plant) and stem (0.78 g/plant) (Figure 1B). At first and 50% flowering stage, mungbean sowed on 05 February and 15 February significantly produced the statistically identical maximum dry matter into source whereas sowing on 15 January had produced the least (Figure 1C), D)]. At the first pod initiation stage, likewise, other developmental stages the maximum dry matter production can be observed from 05 February and 15 February sown crop into leaves (3.4 g/plant) and stems (3.8 g/plant). Consequently, they also translocate the maximum dry matter into the sink (pod + flower) (About 2.45 g/plant). Mungbean sown on 15 January had translocated the least amount of dry matter into pod + flower (0.82 g/plant) (Figure 1E). This may be due to lower dry matter accumulation into the source at the early sown crop. At the maturity stage, the maximum dry matter production can be observed from 05 February and 15 February sown mungbean crop. Sowing on 05 February had produced the maximum dry matter in the reproductive part (7.13 g/plant) which was statistically similar to 15 February sown crop (7.12 g/plant). The minimum dry matter in the reproductive part was accumulated by sowing on 15 January (3.93 g/plant) (Figure 1F).

Yield and yield contributing attributes

Significant differences can be observed from yield and yield contributing characters of mungbean influenced by different sowing dates except for plant population/m2, pod length, and the number of pods/plant characters. The number of seed/pods differs significantly among the sowing dates. The maximum number of seeds/pods can be observed from the crop sown on 05 February (12.67) which were statistically identical to 15 February sown crop (12.10) [Table 2]. The minimum number of seeds/pods can be observed from sowing on 15 January (8.53). Thousand seed weight differs significantly among different sowing dates. The heaviest thousand-grain weight was exhibited by the crop sown on 05 February (46.4 gm) which is statistically identical to 15 February sown mungbean (45.6 gm). Consequently, the lightest thousand-grain weight can be observed from 15 January sown mungbean (34.4 gm). This may be due to lower dry matter accumulation in the reproductive part as a consequence of early sowing and higher GDD accumulation (Table 3). The highest seed yield

Table 3: Yield and yield contributing characters of mungbean at different sowing dates.

Date of sowing	Plant height at harvest (cm)	Plant population/m²	Pod length (cm)	Pods/ plant (no.)	Seeds/pod (no.)	1000-seed weight (g)	Seed Yield (t/ ha)
15-Jan.	38.55 b	34.00	10.00	8.07	8.53 b	34.4 c	0.93c
25-Jan.	40.97 ab	33.60	10.37	8.07	9.60 b	39.8 b	1.20 b
05-Feb.	47.50 a	29.30	10.83	13.07	12.67 a	46.4 a	1.73 a
15-Feb.	42.67 ab	25.20	10.57	12.13	12.10 a	45. 6 a	1.70 a
$LSD_{(0.05)}$	7.32	ns	1.04	6.21	1.17	1.09	0.24
CV (%)	8.64	3.87	5.00	30.09	5.45	6.06	8.64

can be observed from the crop sown on 05 February (1.73 t/ha) which is statistically identical to the crop sown on 15 February (1.70 t/ha). Mungbean sown on 15 January exhibited the lowest seed yield (0.93 t/ha) (Table 3).

Conclusion and Recommendations

From the above study following conclusions and recommendations can be drawn out-

i) Early sown mungbean demonstrated the maximum days to reach maturity (87 days) whereas delayed sown crop exhibited the least (71 days). Delayed sowing shortens the life cycle of mungbean.

ii) The maximum dry matter production in the reproductive part (7.23 g/plant and 7.12 g/plant) can be observed from late sown (05 February and 15 February, respectively) mungbean. The minimum dry matter in the reproductive part was accumulated by early sown crop (3.93 g/plant).

iii) The highest seed yield can be observed from the crop sown on 05 February (1.73 t/ha) which is statistically identical to the crop sown on 15 February (1.70 t/ha). Early sown mungbean exhibited the lowest seed yield (0.93 t/ha) (Figure 2).

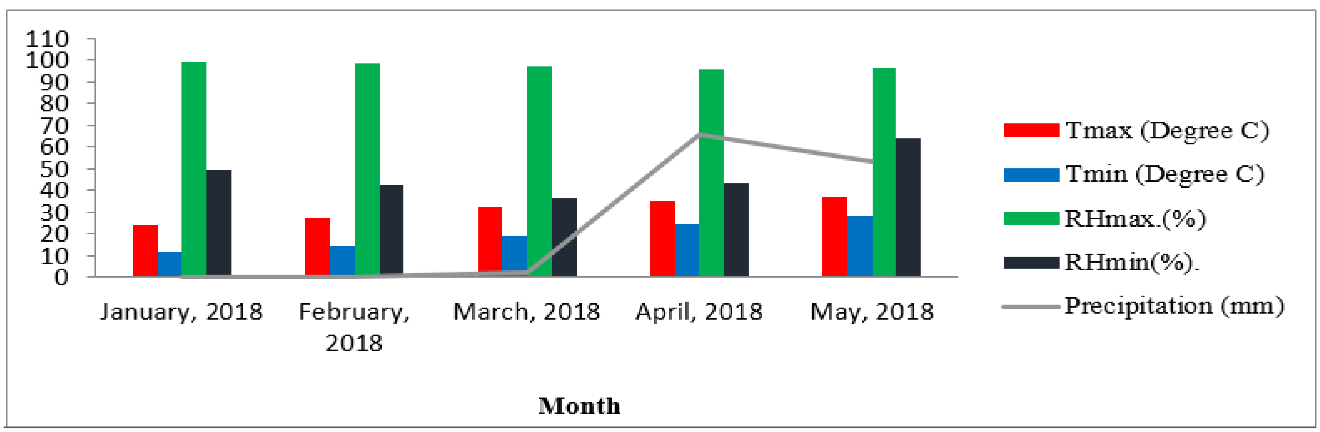

Figure 2: Monthly average maximum and minimum temperature, relative humidity and precipitation during the crop growth period.

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