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Response to phenological manipulation through planting time for productivity of banana (*Musa* AAA, Grand Naine) under subtropics

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ABSTRACT

The present study was carried out to standardize the ideal planting time in response to phenological changes in banana (*Musa* AAA, Grand Naine) for better yield and quality under subtropical conditions during 2017–19 at first block of ICAR-CISH, Rehmankhera, Lucknow. The tissue cultured banana cv. Grand Naine were planted at monthly intervals w.e.f 15 June 2017 to 15 May 2018 in the experimental field at 1.8 m × 1.5 m spacing. The banana planted during 15th June and 15 July had the highest pseudostem circumference, leaf area, leaf area index and fruit yield, respectively. Pseudostem height and leaf number were highest in banana planted during 15 November. The Growing Degree Days (GDD) from planting to shooting were calculated and found to be optimum and duration from planting to shooting was also minimum when planted during 15 June and 15 July. There were no leaf emergence during winter month especially December, January and February due to low temperature irrespective of planting dates in banana under subtropics. Quality parameters such as bunch weight, number of hands, total fingers, and weight and number of fingers in 2nd hand were recorded in banana planted on 15 of July. The TSS content was higher when planted on 15 June and acidity when planted on 15 October. The ideal time for planting of banana in present study was 15 June and 15 July for better yield and quality under subtropical conditions.

Keywords: Banana, GDD, Fruit yield, Phenological manipulation, Planting time

Banana (*Musa* AAA, Grand Naine) is one of the important fruit crops of tropical and subtropical region of the country. India is the largest producer in the world contributing 29.19% to the global production with a total production of 30.8 million tonnes from 0.88 mha area. In Uttar Pradesh, it is cultivated in over 69380 ha area with annual production of 31.72 million tonnes and productivity is 45.72 t/ha (Anonymous 2018). The banana cultivar Grand Naine (AAA) is well known for excellent taste and quality. The productivity and profitability is highly variable due to lack of appropriate technological and research support under subtropical conditions where the crop is subjected to severe cold injury in winter and dry hot wind in summer.

The cultivar Grand Naine is most remunerative among banana varieties in the region. Thorough knowledge of phenological cycle in a particular area is needed so that the farmers can intensify the level of management like plan the planting date and harvest with the market demand for banana (Robinson and Sauco 2010). The planting time differ from region to region, in south India, it is planted throughout the year because of favourable climatic conditions and in north India, planting is done during rainy season only. In Kerala, optimum planting time for banana is February (Bindhu and Girijadevi 2016) and in Odisha during rainy season (Kumar and Pandey 2008). Planting time for better yield and quality depends on cultivars and prevailing climatic conditions in the region (Abd-Allah *et al*. 2011). The fruit size and quality play an important role and quality preference though consumer acceptability in banana (Bauri *et al*. 2014). Input use efficiency improves yield and quality in banana (Pramanik *et al*. 2016, Kumar *et al*. 2020). For each planting date, the GDD from planting to shooting is expected to be the same (Turner *et al*. 2007). However, Turner and Hunt (1987) pointed out the GDD not the same for the different planting dates in banana cultivar Williams (AAA Cavendish subgroup). Therefore, the present investigations were under taken with the objective to improve fruit yield and quality by standardizing planting time under subtropical conditions.

MATERIALS AND METHODS

The experiment was conducted at Research Farm of ICAR-Central Institute for Subtropical Horticulture, First block, Rehmanhkera, Lucknow (26° 54' N latitude, 80° 45' E longitude and 127 m amsl) during 2017–19. The experimental soil had 7.1 *p*H and 0.28 dS/m electrical conductivity, respectively. The initial levels of organic carbon content was 0.41-0.49 % with available P and K

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content ranging between 16.5-24.2 and 62.5-68.4 mg/kg, respectively and soil showed optimum range of fertility status. Bulk density and particle density ranged between 1.35-1.54 g/cm^3 and 2.38–2.72 g/cm^3, respectively. The soil of the experimental site is taxonomically classified as mixed hyperthermic, Typic Ustocrept and derived from Indo-Gangetic alluvium with sandy-loam texture. The climate is typically subtropical with hot dry summer and cold in winter month. The mean maximum temperature was 39.1°C in April and minimum 5.1°C in January and average annual precipitation 861.5 mm received during the study period. The planting material of banana cv. Grand Naine (AAA) consisting of one-month old tissue cultured plants were planted at 1.8 m × 1.5 m spacing at monthly intervals w.e.f 15 June 2017 to 15 May 2018. A buffer strip of 2 m was maintained between the planting row. The pit dimension of 0.5 × 0.5 × 0.5 m dug and mixed well with decomposed farmyard manure @ 8-10 kg including phosphorus before planting. The nitrogen and potash were applied in equal split at 3, 5, 9 and 11 month after planting. Recommended standard agronomical practices were followed uniformly to all plants during study period.

Pseudostem height was measured from the base of the plant to the top and pseudostem circumference was measured at 15 cm above ground level using meter tape. Time interval between successive leaf emergence was recorded in days taken into consideration the emergence day of proceeding leaf. Number of leaves per plant at harvest was counted in each plant. Leaf length and width was measured by using measuring tape. The leaf area was estimated as non-destructive method by multiplying the length and breath of the leaf and multiplied by the factor 0.8 and expressed in m^2/plant. The leaf area index of functional leaves was obtained by leaf area per plant divided by ground area occupied by the plant. At harvest stage, total crop duration (planting to harvest) was recorded and expressed in days.

Bunches were harvested at physiological maturity stage and bunch weight was taken using digital field balance and expressed in kg. The number of hands per bunch was recorded after counting hands in each bunch. Observations on finger characteristics were recorded from D finger of D hand. The second hand from the top of the bunch is regarded as D hand and the middle finger in the top row of the second hand is designated as D finger. The quality attributes of D finger were analysed. The total soluble solids were estimated using hand refractometer and expressed in degree brix and acidity was determined using titration procedure. Data related to each character were analysed by applying the analysis of variance techniques. The minimum and maximum temperature data recorded at ICAR-CISH, Rehmankhera, Lucknow observatory during the study period, i.e. from June 2017 to April 2019 (Fig 1).

RESULTS AND DISCUSSION

Data (Table 1) indicated that plant growth characters, viz. pseudostem height, pseudostem circumference, number of functional leaves, leaf area and leaf area index were significantly influenced by different planting dates. The banana planted on 15 November had highest pseudo stem height (2.25 m). Maximum pseudostem circumference (61.90 cm), number of functional leaves (12), leaf area (9.76 m^2) and leaf area index (3.61) were recorded in 15 July planted banana, closely followed by 15 June planting (pseudostem circumference 61.5 cm; number of functional leaves 12; leaf area 8.14 m^2 and LAI 3.01) which is significantly superior over other dates of planting. There were declined trends after July planting and again increased in 15 November and 15 December. The June and July planted banana had 9.46 and 10.18% in pseudo stem circumference; 33.3% in functional leaf; 17.12 and 40.43% in leaf area and 17.12 and 40.46% in leaf area index higher over 15 October planted banana cultivar Grand Naine. The overall better performance of banana planted during June and July might be due to favourable climatic conditions (temperature, humidity and

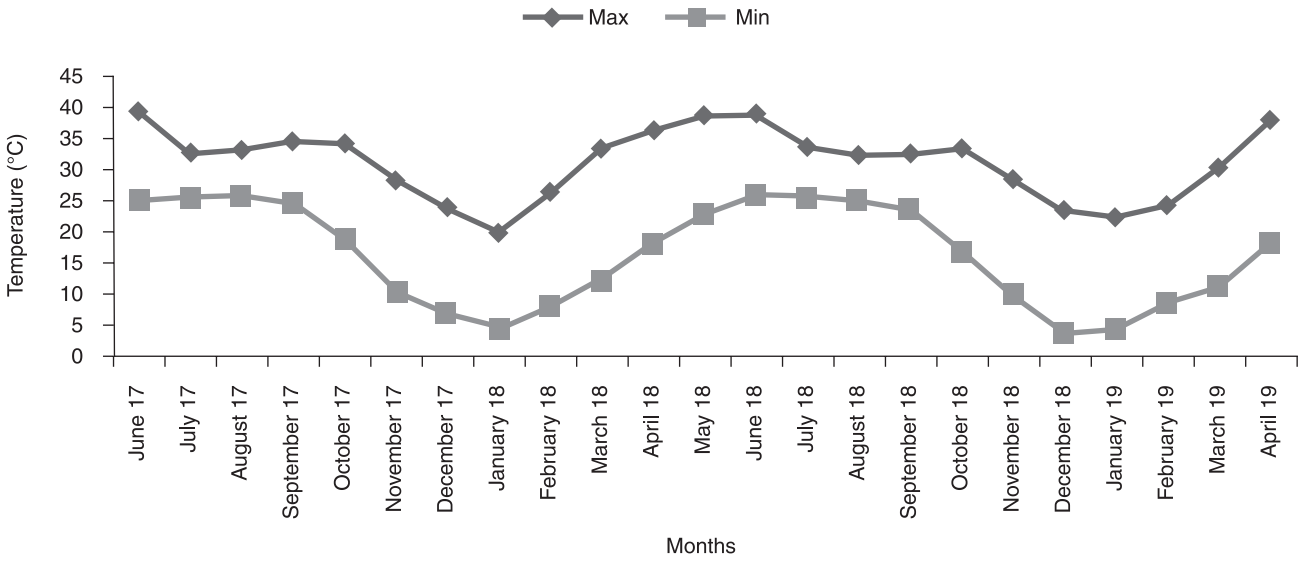

Fig 1 Minimum and maximum temperature during crop growth period of banana.

Table 1 Effect of date of planting on vegetative growth, flowering, harvesting and GDD of banana cultivar Grand Naine

Planting date	Pseudostem height (m)	Pseudo stem circumference (cm)	Functional leaf (number)	Leaf area (m^2)	Leaf area index	Days from planting to shooting	Days from shooting to harvesting	Days from planting to harvesting	GDD (From planting to shooting)
15 June	1.92^{c}	61.50^{ab}	12^{a}	8.14^{bc}	3.01^{bc}	367de	108^{d}	475^{f}	5260^{d}
15 July	2.10^{b}	61.90^{a}	12^{a}	9.76^{a}	3.61^{a}	365^{e}	112^{d}	477^{f}	5240^{d}
15 August	1.85^{cd}	60.12^{abc}	11^{ab}	7.54^{cd}	2.79^{cd}	371de	120^{c}	491^{e}	5363^{cd}
15 September	1.80^{d}	58.12^{cd}	10^{bc}	7.12^{d}	2.64^{d}	375^{d}	149^{a}	524^{c}	5396^{c}
15 October	1.75^{d}	56.18^{d}	9^{c}	6.95^{d}	2.57^{d}	387^{c}	127^{bc}	514^{d}	5450^{c}
15 November	2.25^{a}	59.18^{bc}	10^{bc}	8.75^{bc}	3.24^{b}	514^{a}	132^{b}	648^{a}	6261^{a}
15 December	2.18^{ab}	58.75^{cd}	10^{bc}	8.30^{b}	3.07^{b}	488^{b}	135^{b}	623^{b}	6102^{b}

Value indicates mean of four replicates. Different letters in the same column indicate significant differences at P≤0.05 (Duncan's Multiple Range Test).

rainfall) which improve photosynthetic activity that leads to optimum growth of banana. Similar observations have been reported by Yadav *et al*. (2011) indicating that June planted banana performed better in respect to vegetative growth.

Data (Table 1) indicated that earliest shooting was noticed in banana planted on 15 June and 15 July took 367 and 365 days for shooting and differences were non-significant. However, banana planted during 15 November and 15 December took maximum days (514 and 488 days) for shooting. The banana planted on 15 August and 15 September took 371 and 375 days for shooting. It took 108 to 149 days from shooting to harvesting under different planting dates. Banana planted on 15 June and 15 July took 108 and 112 days from shooting to harvesting and the differences were non-significant. The banana planted on 15 September took maximum days (149 days) from shooting to harvesting. The growing degree days was calculated from planting to shooting and found that banana planted on 15 June and 15 July took 5260 and 5240 growing degree days (GDD) for shooting under subtropical conditions. The banana planted during 15 November took maximum 6261 GDD in banana. Earliest flowering and fruiting was observed when banana planted during 15 June and 15 July under subtropical conditions which might be due to favourable optimum weather conditions especially temperature, humidity and photoperiod for vegetative growth and shooting. Retention of optimum number of leaves at harvest as most reliable predictor for bunch weight in banana (Baiyeri 2008). These results are in agreement with the findings as the optimum planting time improves the fruit yield and quality in banana (Abd-Allah *et al*. 2011, Karuna and Rao 2015).

Data on banana leaf emergence at periodical intervals as influenced by planting dates (Fig 2). Number of leaves emerged per month were recorded and counted total number of leaves produced till shooting stage. The banana planted during 15 June produced total 32 number of leaves, 15 July (32 leaves), 15 August (33 leaves), 15 September (33 leaves), 15 October (33 leaves), 15 November (40 leaves) and 15 December (40 leaves) before shooting. There were no leaf emergence during winter season especially December, January and February month due to low temperature irrespective of planting dates in banana under subtropics. The minimum temperature (7.0, 4.4 and 8.0 °C) was observed

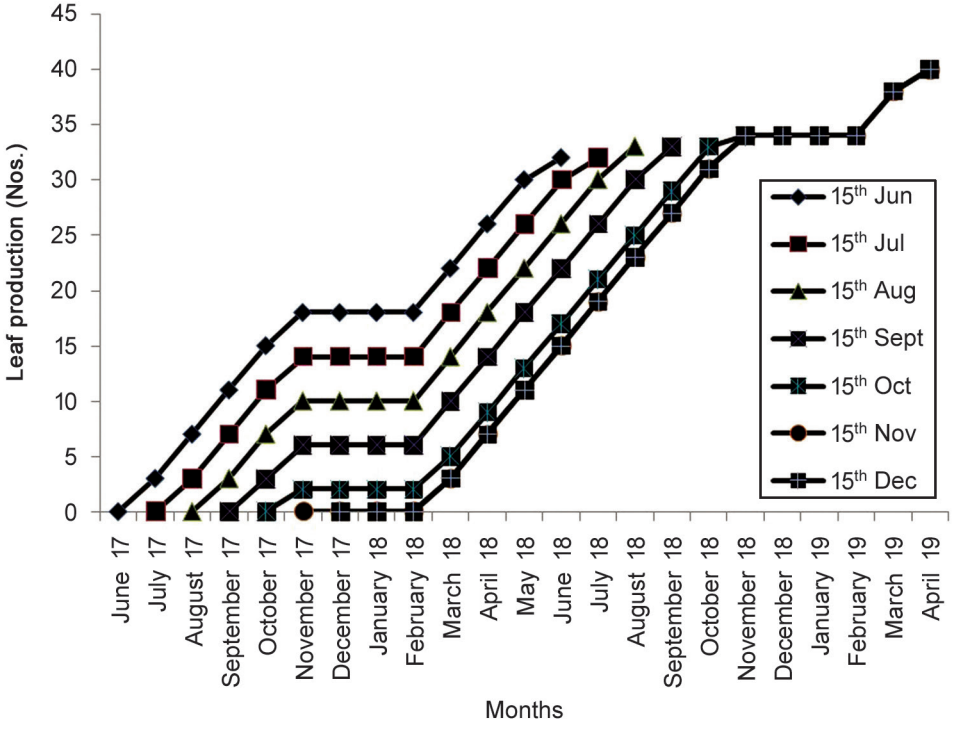

Fig 2 Effect of date of planting on banana leaf emergence at periodical intervals.

Table 2 Effect of date of planting on bunch characters of banana cv. Grand Naine

Planting date	Bunch weight (kg)	Number of hands	Total fingers	Weight of 2nd hand (kg)	Number of fingers in 2nd hand	TSS (°Brix)	Acidity (%)
15 June	19.5^{ab}	11^{a}	118^{a}	1.92^{a}	16^{a}	21.5^{a}	042^{bc}
15 July	20.2^{a}	11^{a}	120^{a}	2.02^{a}	16^{a}	20.7^{b}	0.45^{b}
15 August	16.5^{d}	10^{a}	101^{b}	1.61^{b}	14^{b}	19.5^{c}	0.47^{ab}
15 September	15.2^{e}	10^{a}	98^{b}	1.34^{c}	12^{c}	18.9^{d}	0.48^{ab}
15 October	5.2^{f}	8^{b}	72^{c}	0.90^{d}	12^{c}	15.4^{e}	0.51^{a}
15 November	18.4^{c}	10^{a}	115^{a}	1.95^{a}	16^{a}	20.8^{b}	0.44^{bc}
15 December	18.9^{bc}	10^{a}	118^{a}	1.99^{a}	16^{a}	20.7^{b}	0.42^{c}

Value indicates mean of four replicates. Different letters in the same column indicate significant differences at $P \leq 0.05$ (Duncan's Multiple Range Test).

during December 2017, January 2018 and February 2018 and similar low temperature (3.7, 4.6 and 8.5°C) was also noticed during December 2018, January 2019 and February 2019 for banana cultivar Grand Naine during study period (Fig 2). The temperature in the region plays an important role in production of leaf in banana. Optimum temperature produces 3-4 leaf per month depending upon the season. Similar findings were reported by Kumar *et al*. (2019) while working on banana.

A perusal of data on bunch weight, number of hands, total number of fingers, weight of 2nd hand, number of fingers in 2nd hand and fruit quality as influenced by different dates of planting is predicted in Table 2. The bunch weight ranged from 5.2 to 20.2 kg, number of hands from 8 to 11 and total number of fingers from 72 to 120 in banana cultivar Grand Naine. Maximum bunch weight (20.2 kg) was recorded in banana planted during 15 July followed by 15 June (19.5 kg), 15 of August (16.5 kg), 15 of September (15.2 kg), 15 October (5.2 kg), 15 November(18.4 kg) and 15 December (18.9 kg), respectively. Maximum number of hands and fingers per bunch (11 and 120) were recorded in banana planted on 15 of July closely followed by 15 June (11 and 118), 15 August (10 and 101) and 15 September (10 and 98), respectively. For quality analysis, 2nd hand of bunch was considered and counted number of fingers, hand weight and quality parameters like TSS and acidity. Maximum hand weight and number of fingers (2.02 kg and 16 numbers) were recorded in banana planted on 15 July. Whereas, maximum TSS (21.5 °Brix) was estimated in banana planted on 15 June. The bunch and finger characters like number of hands per bunch, weight of D hand, length and weight of D fingers are considered as yield determinants (Stover and Simmonds 1987).

Data on fruit yield as influenced by different date of planting in banana, maximum fruit yield (74.74 t/ha) was recorded in the treatment of banana planted on 15 July closely followed by 15 June (72.15 t/ha) and the variations were non-significant. Whereas, banana planted during 15 October had yielded minimum (19.24 t/ha). The low fruit yield during October planted banana might be due to the fact that shooting takes place during November and after that low temperature inhibits the fruit growth and development. The low temperature damaged the leaves which finally turned yellow affecting photosynthesis activity leading to poor growth and development of banana bunch particularly fingers. Similar findings were reported by Yadav *et al*. (2011) while working on banana. It may be concluded that banana planted during 15 June and 15 July performed better in respect to fruit yield and quality. The Growing Degree Days were also recorded and found optimum in these months from planting to shooting in banana under subtropical conditions.

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