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Determination of Time Period of Fruit-Bud-Differentiation and the Associated Histological and Biochemical Changes in Mango Hybrids

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ABSTRACT

The present study was carried to find out the time period of fruit bud differentiation of mango hybrids namely Amatrapali, Mallika and Pusa Arunima and the associated morphological and biochemical changes during last week of September to the last week of December for the 2003-04 and 2004-05 under Delhi condition. The fruit-bud-initiation process was started from 15th October in all the hybrids. The initiation and differentiation of progressively increased from 15th October to 15th November maximum number of fruit buds differentiated. The differentiation continued and the buds reached their advance stage of differentiation by 15th December. Four stages of fruit bud could distinctly be identified in the process of fruit-bud-differentiation. The first stage was represented by the emergence of broad conical protuberances in the axis of scales of fruit bud. In the second stage, the buds became plump by 15th November; histotlogically the main axis of fruit bud protruded conically and came out from the scales. Histologically, the main axis elongated and became multi-lobed due to development of primary branches of flower panicle. In third stage, the main axis further elongated. Whereas, the primary and secondary branches showed lobing. In fourth stage, the scales started loosening, which indicted the 'bud break'. Further elongation of the axis and the loosening of scales made the bud enter into the 'bud break' stage which was the most advance stage of fruit-bud-differentiation. The vegetative bud showed hardly any difference between the different stages of development. While studying the biochemical factors associated with fruit-bud-differentiation it was found that the total sugars, total phenols have been found increasing during the process of fruit-bud-differentiation in all the hybrids during the study period. The total carbohydrates, total nitrogen and the ratio of total carbohydrates to total nitrogen have been found decreasing during fruit-bud-differentiation.

Key words: Fruit bud differentiation, Fruit bud, stages of fruit bud, mango hybrids, Vegetative bud

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INTRODUCTION

Mango (*Mangifera indica* L.) is one of the most popular fruit in India. It is considered to be the choicest fruit among all the fruits grown in India. The knowledge of the time period of fruit-bud-differentiation under a particular set of climatic conditions for a given variety would enable the orchardist to schedule the manuring, irrigation and other cultural operations to have better yield. The time period of fruit-bud-differentiation is a crucial event in the growth and development of mango, as it reveals the proper partitioning of metabolites between the vegetative (source) and reproductive organs (sink) which is governed by the growth hormones. The time of fruit-bud-differentiation in mango is known to be governed by local weather conditions, which varies from place to place and to some extend varies with varieties grown under the same climatic conditions. The newly developed hybrids/varieties provide excellent material for the study of fruit-bud-differentiation as the time period of fruit bid differentiation is not established for these newly developed hybrids. Present study was carried to find out the time period of fruit bud differentiation of mango hybrids under Delhi condition and the associated histological and biochemical changes during the time period of fruit bud differentiation.

MATERIALS AND METHODS

The present investigations were carried out at the experimental orchard of the Division of Fruits and Horticultural Technology, Indian Agricultural Research Institute, New Delhi during 2003-04 and 2004-05. Matured healthy trees present in the orchard were chosen for the present experiment. All the mango trees were uniformly fertilized and received other recommended cultural practices.

Time period of fruit bud differentiation

Plant materials

For the determination of time period of fruit bud differentiation, three hybrids namely Amarapali, Mallika and Pusa Arunima were selected .Five trees were selected from each hybrid and from each hybrid plant 15 shoots were tagged in the month of August. From these each tagged shoots 12 buds were selected randomly for the bud dissection study.

Bud sampling and slide preparation for bud dissection study

The buds and/or shoots sampling and dissection methods were slightly modified from the procedure reported by Mustard and Lynch [1]. The bud samples were collected from two to three month-old-healthy-shoot with the help of secateur without injuring the buds and / or shoots during August (last week) to December (last week), for two years (2003 to 2005). These collected buds and / or shoots were killed and preserved in the Formalin Aceto Alcohol (FAA) and the preserved buds were subjected microtome cutting to get thin bud sections. Permanent

slides were prepared using this thin bud section mounted on Canada balsam. The permanent slides were observed under microscope (10X) for the categorization of buds and also the stages of bud development also observed. From this data, percentage of fruit, vegetative and undifferentiated buds was calculated by dividing the number of fruit/vegetative/undifferentiated buds by the total number of buds x 100. The percentage of fruit, vegetative and undifferentiated buds was used to find out the time of fruit-bud-differentiation of all the three hybrids. The data on fruit-bud-differentiation analyzed statically in Factorial CRD and the mean values were tabulated. Bud sections were also observed under microscope for the identification of different developmental stages of fruit and vegetative bud.

Changes in biochemical factors during the time period of fruit bud differentiation
Sampling procedure

For the biochemical studies, three trees from three hybrids were labeled randomly. From these tagged trees the five centimeter apical shoot sample with terminal leaves and buds were collected at fortnight interval from 8 A.M. to 10 A.M. A composite sample consisting of 12 shoots was collected and immediately brought to the laboratory. After cleaning, the shoot samples were chopped separately for stems and leaf portions. Thirty gram of the above samples containing equal portion of stem and leaves were weighed and stored in the deep freeze for subsequent extraction to estimate the biochemical parameters.

Estimation of soluble carbohydrate fractions

The alcohol free extract of fresh shoot sample was passed through ion exchange (Dowex-50) resin column (H+) by the method followed by Rao et al [2] and the effluent was used for the estimation of soluble carbohydrate fraction. The total sugars in this fraction were estimated A.O.A.C [3]

Estimation of insoluble carbohydrate fraction and the total carbohydrate

The residue obtained after alcoholic extraction of shoot sample, was dried and a known amount of it was hydrolyzed for three hours with an ml of concentrated hydrochloric acid. The hydrolyzed fraction of carbohydrate was estimated as reducing sugars. The amount of starch was computed by multiplying the value of this fraction by 0.9 factor.

Estimation of total nitrogen

Dried and powdered shoot samples (0.5 gm each) were taken to estimate the total nitrogen by micro-kjeldahal method. The evolved ammonia was absorbed into boric and it was titrated with standard sulphuric acid by using a mixed indicator of bromo-cresol green and methyl red Jackson [4]

Estimation of total carbohydrate and C: N ratio

The amount of total sugars and the insoluble carbohydrates were taken as the amount of total carbohydrate on dry weight basis. The C: N ratio was calculated as the ratio of total carbohydrate to total nitrogen content of the samples by dividing total carbohydrate with total nitrogen.

Changes in phenol content during the period of fruit-bud-differentiation

The buds and / or shoots samples (approx. 0.5 g) was homogenized in a pestle and mortar by adding ten ml of 80 percent ethanol. Then, it was centrifuged at 10,000 rpm for 20 minutes. The supernatant was filtered using Whatman No. 42 filter paper. The residue was re-extracted (five times) with 80% ethanol and the supernatant collected was evaporated to dryness. The residue was dissolved in five ml water, from which about 0.2 ml was taken. The total fresh Folin-ciocalteau reagent (0.5 ml) was added. After three minutes, two ml of Na2CO3 solution was added, mixed thoroughly and placed in hot water bath (58˚C) exactly for one minute. Then, it was cooled to room temperature and the absorbance (650 nm) was measured against blank (catechol) Mallik and Singh [5]. The contents were expressed as mg per gramme fresh weight.

Statistical analysis

The experiments were laid out in factorial completely randomized design with five replications and the data (2003-2004 and 2004-2005) were analyzed

RESULTS AND DISCUSSION

Time period of fruit-bud-differentiation

Experiments were started from 30th August and continued to 30th December during the study period. From the Table 1 it can be assumed that the process of initiation of the fruit buds started from 15th October and the period from 15th November to the end of November may be considered as critical period for fruit-bud-differentiation under Delhi conditions. The advanced stage of fruit-bud-differentiation, which was observed in mid December, may be considered as the end of the fruit-bud-differentiation process. The period from 15th October to the 15th December may be considered as the total period of fruit-bud-differentiation for all the three hybrids namely, Amrapali, Pusa Arunima and Mallika during study period. From Table 2, it is clear that the percentage of fruit buds obtained were maximum during this critical period of fruit bud differentiation for all the three hybrids. The above mentioned period is certainly very much crucial under north Indian conditions, which may differ by a month or two depending on the variety. The fruit-bud-differentiation starts 5 to 6 months before the actual flowering for which one season old shoots differentiates. Several workers have reported the fruit-bud-differentiation to occur from October to December Sen and Mallick [6]; Singh [7]; Sen et al [8]

and Mussahib-ud-din[9]. However, the period of fruit-bud-differentiation was observed from August to the end of October by Khan [10]. Keeping these findings in mind, the bud and / or shoot.

Morphological and histological changes of bud

There were four developmental stages of dissected fruit bud were observed under microscope during the experimentation period There were no differentiated fruit buds from the end of August to the end of September during the study period in all the hybrids. The undifferentiated buds were green, partially covered by dried scales with brownish tips as per the morphological appearance during the above period. Furthermore, undifferentiated buds were inactive plate 1 (Fig 1) Prior to fruit-bud-differentiation, the main axis in the fruit bud elongated slightly and rounded off assuming a dome shape appearance accompanied by broadening scales. Whereas, the main axis became conical shaped in vegetative bud

The origin of broad axial protuberances represented the fruit bud initiation, which is marked with high meristematic activity. It may be considered as the first stage of fruit-bud-differentiation plate 2 (Fig 2). In the second stage of fruit-bud-differentiation, the main axis elongated and became multi-lobed due to development of primary branches of flower panicle plate 3 (Fig 3) In third stage, main axis elongated, primary and secondary branches showed lobbing, which was necessary to form flower cluster plate 4 (Fig 4). Further elongation and loosening of scales made the bud to enter the 'bud burst' stage, which was the most advance stage of fruit-bud-differentiation and was considered as fourth developmental stage of fruit bud plate 5 (Fig 5).Ravishanker et al[11] also observed these four developmental stages of fruit-bud-differentiation in mango in Karnataka.

Histologically, the vegetative bud showed hardly and difference between the different stages of its development in comparison to the fruit bud. However, the main axis was slightly elongated in a fruit bud prior to fruit-bud-differentiation. The fruit bud rounded off and assumed a dome shape, which was accompanied by broadening scales. Whereas, the main axis had conical shape prior to the vegetative-bud-differentiation. At latter stage the main axis got elongated and thickened. Furthermore, the old scales at the basal end were separated and dried up. More whirls of young and active scales surrounded the growing apex of the vegetative bud plate 6 (Fig 6) Similar developmental pattern of vegetative-bud-differentiation was observed by Singh [12] at Saharanpur.

Biochemical changes

The biochemical changes in respect of carbohydrate fractions, total nitrogen and phenols were studied from the last week of August to the last week of December during the study period.

Changes in the level of total sugars

Data on the total sugars during the study period is presented in Table 3. As far as the mean values are concerned, the maximum total sugars (7.36 mg/g on fresh weight basis) were recorded on 30th December and the minimum total sugars (5.43 mg/g on fresh weight basis) were found on 15th September. The total sugar contents varied from 5.20 to 7.90 mg/g on fresh weight basis. It was quite interesting to note that the average of total sugar content gradually increased from 15th September to 30th December during the study period (Table3) It was also observed that the average of the total sugar contents gradually increased that the average of the total sugar contents gradually increased from 15th September to 30th December. The change in the level of total sugar contents might be due to the increasing levels of the reducing sugars and conversion of insoluble fractions of carbohydrates into soluble fractions during fruit-bud-differentiation. It is obvious that the bio-chemical changes in the tissues lead to the production of soluble form of carbohydrates, which are required for the meristematic activities. Flowering has been reported to be regulated by carbohydrates: nitrogen ratio with high levels being conductive for flowering Kraus and Kraybill [13].

Changes in the level of insoluble carbohydrate fractions

No consistent trend was noticed in the levels of insoluble carbohydrate fractions and it differed from hybrid to hybrid during the study period. The maximum Insoluble carbohydrate fractions (46.2 mg/g on fresh weight basis) were recorded on 30 September, and the minimum insoluble carbohydrate fractions (30.1 mg/g on fresh weight basis) were available on 15th December in Amrapali. However, the maximum insoluble carbohydrate fraction (50.5 mg/g on fresh weight basis) were found on 15th October, and the minimum insoluble carbohydrate fraction (29.3 mg/g on fresh weight basis) were found on 15th December in Pusa Arunima. Contrary to this, Mallika had the maximum insoluble carbohydrate fractions (52.6 mg/g on fresh weight basis) on 30th August itself – the date of first sampling. The variations among the hybrids might be due to their different genetic constituents having different parents and their combinations. It was further observed that the insoluble carbohydrates gradually decreased from 15th October to 15th December during the study period, which might be due to the conversion of insoluble carbohydrates into soluble carbohydrates particularly for the production of reducing sugars. The minimum carbohydrate fractions (32.6 mg/g on fresh weight basis) were recorded on 15th December like other two hybrids Table 4. It was further observed that the mean values of insoluble carbohydrate fractions gradually declined from 15th October to 15th December during both the years.

Changes in the level of total carbohydrates

The total carbohydrate contents of the shoot and / or bud varied considerably during the total period of experimentation during both the years (Table 5). The maximum total carbohydrates (51.4 mg/g on fresh weight basis) were recorded on 30th September, in Amrapali. Whereas, the total carbohydrates were the maximum (56.0 mg/g on fresh weight

basis) on 15th October in Pusa Arunima. Furthermore, the total carbohydrate contents were the maximum (58.5 mg/g on fresh weight basis) at the start of experiments i.e. 30th August, in Mallika (Table 5). The total carbohydrate contents were found decreasing from 15th October to 15th December in Pusa Arunima and Mallika. Whereas, the decline in the total carbohydrate contents was observed from the end of September to the mid December in Amrapali during the study period. (Table 5)

The total carbohydrates contents of the shoot and / or bud varied considerably during the total period of experimentation. The total carbohydrates contents were found decreasing from 15th October to 15th December in Pusa Arunima and Mallika. Whereas, the decline in the total carbohydrates contents was observed from the end of September to mid December in Amrapali. However, the total carbohydrates started decreasing from 15th October to 15th December as per their mean values. After it, there was considerable increase in total carbohydrates, which almost increased equal to the contents of total carbohydrates available on the first date of sampling. Therefore, it seems that the fruit-bud-differentiation process has been completed by 15th December in all the hybrids during the study period. Unfortunately, no reference could be traced out to agree or disagree with the above findings, which were inconsistent by themselves in the present study too.

Changes in the level of total nitrogen

The data of total nitrogen contents in shoot and / or bud in all the hybrids were inconsistent. However, the maximum total nitrogen (2.50 mg/g on fresh weight basis) was observed on 15th October during the study period and the minimum total nitrogen (1.89 mg/g on fresh weight basis) was recorded on 30th December as per the mean values Table 6. It was interesting to not that the highest values of total nitrogen (2.60, and 2.31 mg/g on fresh weight basis) were recorded in Amrapali. Pusa Arunima and Mallika respectively on 15th October, Table 6. However the minimum values were 1.90 and 1.88 mg/g on fresh weight basis on 15th December.

The total nitrogen contents in shoot and / or bud in all the hybrids were marginally inconsistent like total carbohydrates discussed in the foregoing paragraph. However, the maximum total nitrogen was noted on 15th October and the minimum total nitrogen was recorded on 30th December, according to their means. As expected, the nitrogen contents reduced from the start of the experiment, which continued up to 30th December in all the hybrids baring some minor differences between different dates of sampling. Chacko [14] reported that the total nitrogen contents were higher in the stem and leaves of trees, which were expected to initiate flower bud irrespective of the cultivars. Furthermore, nitrogen is known to have more vegetative growth, if it crosses the critical limit required for fruit-bud-differentiation.

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Changes in the ratio of the total carbohydrates to the total nitrogen

The change in the ratio of the total carbohydrates to the total nitrogen in the shoot and / or bud varied significantly with in the hybrids. The mean value was the highest (27.6) on 30th December**,** Table 7. The mean values started declining from 30th September and declining trend continued up to 15th December. The highest ratio was recorded on 30th December in all the three hybrids namely, Amrapali (29.0), Mallika (27.7) and Pusa Arunima (26.1). while, the lowest ratio was observed in Amrapali (17.9) and Pusa Arunima (17.1) on 30th August while in Mallika (20.4) on 15th December Table 7. It was interesting to note that the ratio started reducing from 15th October and continued up to 15th December in both the years in all the hybrids. After that it increased abruptly. The ratio of the total carbohydrates to the total nitrogen in the shoot and/or bud varied significantly between the hybrids. The highest ratio was recorded on 30th December in all the three hybrids. The declining trend was observed from 30th September to 15th December. It might be due to change of insoluble carbohydrates into soluble carbohydrates and their subsequent utilization in energy production processes during fruit-bud-differentiation. Furthermore, on 30th December the ratio had increased abruptly. It might be due to the fact that by 15th December the process of fruit-bud-differentiation was completed as stated above.

Changes in the level of the total phenols

It was quite interesting to note that the total phenol contents were the maximum on 15th December, in all the hybrids including the mean of sampling dates during the study period. Whereas, the minimum phenol contents were found on 15th September, in all the hybrids including the mean of sampling dates (Table 8). The phenol contents started increasing from 15th September to 15th December during experimentation. After that the values decreased significantly in all the hybrids including the averages. Furthermore, the phenol levels were in between 4.64 to 6.64 in Amrapali, 4.42 to 6.57 in Pusa Arunima and 5.47 to 7.83 mg/g on fresh weight basis in Mallika.

The total phenol contents were the minimum on 15th September in all the hybrids, which progressively increased up to 15th December during both the years in all the hybrids. It seems that the process of phenol synthesis was accelerated much more before the process of fruit-bud-differentiation. It might be due to the fact that the activity of polyphenol oxidase is more during the fruit-bud-differentiation. Similar findings were reported by Patil et al [15]. They estimated the total phenol and polyphenol oxidase activity in different types of fruit buds of 'Alphonso' during fruit-bud-differentiation and found that the phenolic contents of the fruit buds increased steadily with the advancement of fruit bud- differentiation but remained stable in undifferentiated buds

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Table 1.Number of differentiated fruit buds during the last week of August to the last week of December (pooled)

Interval	No. of bud Samples	No. of differentiated fruit buds			
		Amrapali	Pusa	Mallika Mean	Arunima
August, 30	60	0	0	0	0
September, 15	60	0	0	0	0
September, 30	60	0	0	0	0
October, 15	60	18.0	20.0	20.0	19.3
October, 30	60	36.0	40.0	40.0	36.7
November, 15	60	42.0	40.0	40.0	41.3
November, 30	60	42.0	40.0	42.0	41.4
December, 15	60	36.0	38.0	36.0	36.5
December, 30	60	36.0	36.0	34.0	35.3

	SEM±	CD at 5%	CD at 1%
Hybrid (H)	0.219	0.630	0.841
Interval (I)	0.380	1.091	1.456
H x I	0.658	1.890	2.522

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Table 2. Percentage of differentiated fruit buds during the last week of August to the last week of December (pooled)

Interval	No. of bud Samples	Percentage of differentiated fruit buds			
		Amrapali	Pusa	Mallika Mean	Arunima
August, 30	60	0	0	0	0
September, 15	60	0	0	0	0
September, 30	60	0	0	0	0
October, 15	60	30.0	33.3	33.3	32.2
October, 30	60	60.0	66.7	66.7	64.4
November, 15	60	70.0	66.7	66.7	67.8
November, 30	60	70.0	66.7	70.0	68.9
December, 15	60	60.0	63.0	60.0	61.1
December, 30	60	60.0	60.0	56.7	58.9

	SEM±	CD at 5%	CD at 1%
Hybrid (H)	0.305	0.875	1.168
Interval (I)	0.528	1.516	2.022
H x I	0.914	2.625	3.503

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Table 3. Changes in the level of total soluble sugars in the shoot and / or bud during the last week of August to the last week of December (pooled)

Interval	Total sugars (mg/g fresh weight)				
	Amrapali	Pusa	Mallika	Mean	Arunima
August, 30	6.00	6.50	5.93		6.14
September, 15	5.20	6.00	5.09		5.43
September, 30	5.20	6.00	5.19		5.46
October, 15	6.10	5.50	5.30		5.63
October, 30	6.40	5.75	5.43		5.86
November, 15	6.50	5.83	5.55		5.96
November, 30	6.54	5.87	5.63		6.03
December, 15	7.20	5.92	5.73		6.28
December, 30	7.90	7.15	7.02		7.36

	SEM±	CD at 5%	CD at 1%
Hybrid (H)	0.045	0.129	0.173
Interval (I)	0.078	0.224	0.299
H x I	0.135	0.388	0.518

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Table 4.Changes in the level of insoluble carbohydrate fractions in the shoot and / or bud during the last week of August to the last week of December (pooled)

Interval	Insoluble carbohydrates (mg/g fresh weight)				
	Amrapali	Pusa	Mallika	Mean	Arunima
August, 30	39.2	37.1	52.6		43.0
September, 15	40.0	37.1	38.3		38.5
September, 30	46.2	45.6	45.1		45.7
October, 15	45.0	50.5	46.7		47.1
October, 30	44.2	48.2	42.2		44.9
November, 15	38.2	39.5	39.7		39.1
November, 30	34.5	33.3	35.8		34.5
December, 15	30.1	29.3	32.6		30.7
December, 30	43.0	45.6	46.2		44.9

	SEM±	CD at 5%	CD at 1%
Hybrid (H)	0.281	0.806	1.076
Interval (I)	0.486	1.396	1.863
H x I	0.842	2.418	3.227

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Table 5 Changes in the level of total carbohydrates in the in the shoot and / or bud during the last week of August to the last week of December. (pooled)

Interval	Total carbohydrates (mg/g fresh weight)				
	Amrapali	Pusa	Mallika	Mean	Arunima
August, 30	45.2	43.6	58.5		49.1
September, 15	45.2	43.1	43.4		43.9
September, 30	51.4	51.6	50.3		51.1
October, 15	50.6	56.0	52.0		52.9
October, 30	50.2	54.0	47.7		50.6
November, 15	43.7	45.4	45.2		44.8
November, 30	41.0	39.2	41.5		40.6
December, 15	37.3	35.2	38.3		36.9
December, 30	48.9	52.7	53.2		51.6

	SEM±	CD at 5%	CD at 1%
Hybrid (H)	0.343	0.984	1.313
Interval (I)	0.593	1.704	2.274
H x I	1.028	2.951	3.938

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Table 6. Changes in the level of total nitrogen in the shoot and / or bud during the last week of August to the last week of December (pooled)

Interval	Total nitrogen (mg/g fresh weight)				
	Amrapali	Pusa	Mallika	Mean	Arunima
August, 30	2.52	2.55	2.12		2.40
September, 15	2.12	2.15	1.85		2.04
September, 30	2.52	2.11	2.30		2.31
October, 15	2.60	2.60	2.31		2.50
October, 30	2.45	2.54	2.23		2.38
November, 15	2.30	2.25	2.14		2.23
November, 30	2.15	2.11	2.00		2.08
December, 15	2.00	1.90	1.88		1.92
December, 30	1.72	2.02	1.92		1.89

	SEM±	CD at 5%	CD at 1%
Hybrid (H)	0.016	0.047	0.062
Interval (I)	0.028	0.081	0.108
H x I	0.049	0.140	0.187

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Table 7. Changes in the ratio of the total carbohydrates to the total nitrogen in the shoot and / or bud during the last week of August to the last week of December (pooled)

Interval	Ratio of the insoluble carbohydrates to the total nitrogen			
	Amrapali	Pusa Arunima	Mallika	Mean
August, 30	17.9	17.1	27.6	20.9
September, 15	21.3	20.1	23.5	21.6
September, 30	20.4	24.5	21.9	22.2
October, 15	20.1	22.0	22.5	21.5
October, 30	19.5	20.5	22.3	20.7
November, 15	19.2	18.2	22.1	19.8
November, 30	19.1	17.7	20.7	19.2
December, 15	18.7	17.4	20.4	18.8
December, 30	29.0	26.1	27.7	27.6

	SEM±	CD at 5%	CD at 1%
Hybrid (H)	0.135	0.387	0.517
Interval (I)	0.234	0.671	0.895
H x I	0.405	1.162	1.551

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Table 8 Changes in the level of phenols in the shoot and / or bud during the last week of August to the last week of December (pooled)

Interval	Phenols (mg/g fresh weight)				
	Amrapali	Pusa	Mallika	Mean	Arunima
August, 30	6.34	6.15	7.33		6.61
September, 15	4.64	4.42	5.47		4.84
September, 30	5.45	5.32	6.00		5.59
October, 15	6.00	5.98	6.11		60.3
October, 30	6.22	6.11	7.32		6.55
November, 15	6.32	6.30	7.43		6.68
November, 30	6.44	6.38	7.53		6.78
December, 15	6.64	6.57	7.83		7.03
December, 30	5.58	5.43	6.18		5.73

	SEM±	CD at 5%	CD at 1%
Hybrid (H)	0.046	0.132	0.176
Interval (I)	0.080	0.229	0.305
H x I	0.138	0.396	0.529

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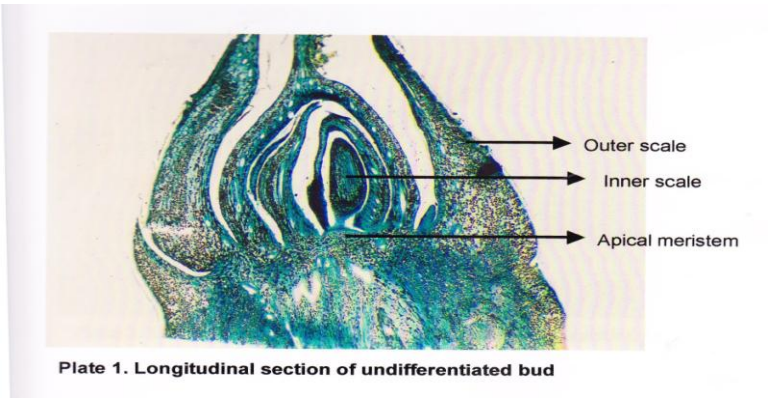

Plate 1. Longitudinal section of undifferentiated bud

Figure 1

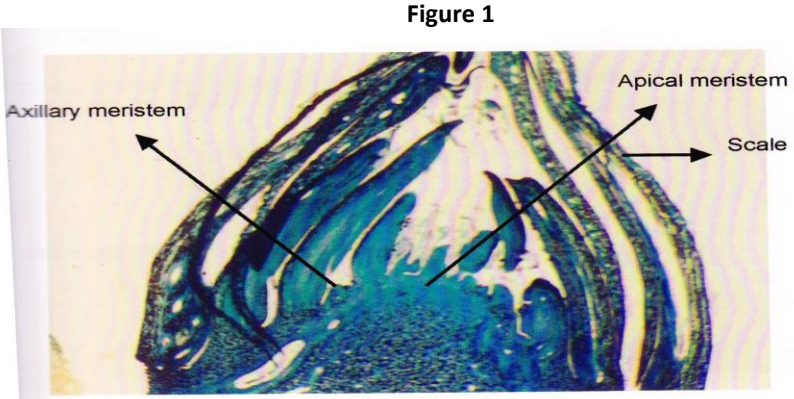

Plate 2. Longitudinal section of bud in fruit-bud-initiation stage (Stage-I)

Figure 2

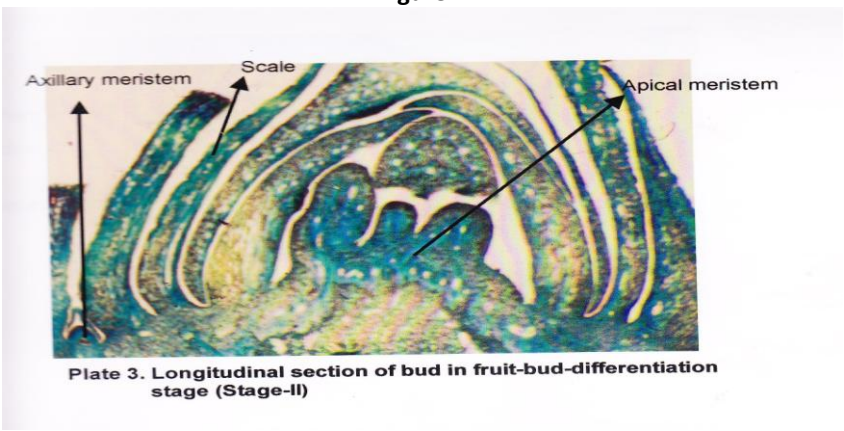

Plate 3. Longitudinal section of bud in fruit-bud-differentiation stage (Stage-II)

Figure 3

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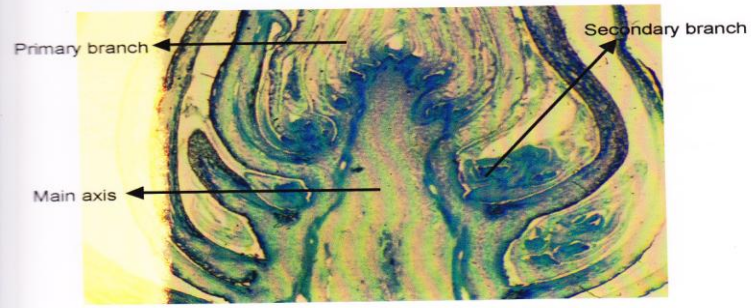

Plate 4. Longitudinal section of bud in fruit-bud-differentiation stage (Stage-III)

Figure 4

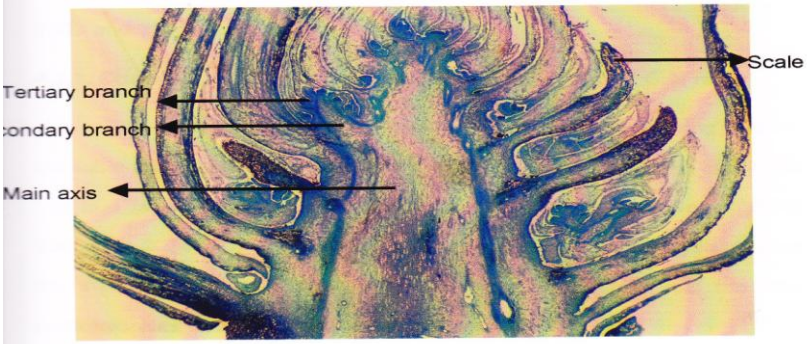

Plate 5. Longitudinal section of bud in fruit-bud-differentiation stage (Stage-IV)

Figure 5

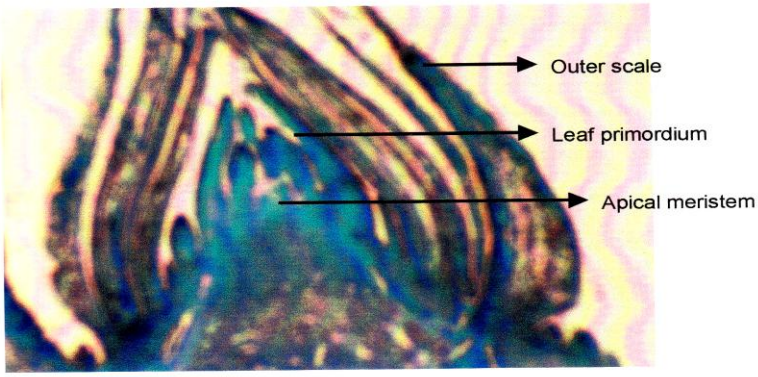

Plate 6. Longitudinal section of differentiated vegetative bud

Figure 6

Figure 1 Longitudinal section of undifferentiated bud.
Figure 2 Longitudinal section of bud in fruit bud initiation stage (Stage I)
Figure 3 Longitudinal section of bud in fruit bud differentiation stage (Stage II)
Figure 4 Longitudinal section of bud in fruit bud differentiation stage (Stage III)
Figure 5 Longitudinal section of bud in fruit bud differentiation stage (Stage IV)
Figure 6 Longitudinal section of differentiated vegetative bud.

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CONCLUSION

The morphological studies and histological changes pertaining to the fruit and vegetative buds, time of fruit-bud-differentiation and the biochemical changes have been monitored under Delhi conditions. Based on the microscopic observation of dissected buds the following findings were made regarding the time period of fruit bud differentiation. Fruit bud initiation process was started on 15th October and peak time of fruit bud differentiation was observed between October to November and process completed by December 15th study period. During this time period of fruit bud differentiation the buds were categorized into undifferentiated, vegetative and fruit bud. Four developmental stages were observed for the fruit bud but no such stages were observed for the vegetative bud. The total sugars, total phenols have been found increasing during the process of fruit-bud-differentiation in all the mango hybrids. Total carbohydrates, total nitrogen, ratio of total carbohydrates to total nitrogen have been found decreasing during fruit-bud-differentiation period.

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REFERENCES

[1] Mustard MJ and Lynch SJ. Bot Gaz 1946; 108: 136-40.
[2] Rao MM, Pandey RM and Singh RN. Indian J Hort 1975; 33: 14-18.
[3] A.O.A.C. 1970. Official Methods of Analysis. Association of Official Analytical Chemists. 11th ed., Washington, D.C.
[4] Jackson ML. Orissa J Hort 1958;1: 33-44.
[5] Mallik PC and Singh MB. 1980. In: part Enzymol. Histoenzymology. Kalyani Publishers, New Delhi. 286 p.
[6] Sen PC and Mallik PC. Indian J Agric Sci 1941; 11: 74-81
[7] Singh RN. Hort Adv 1959; 3: 28-49.
[8] Sen PK, Singh SK and Guha D. Indian Agric 1963; 1: 187-88.
[9] Mussahib-ud-din. Punjab Fruit J 1946;10: 30-31.
[10] Khan AA. Punjab Fruit J 1960; 23: 151-58
[11] Ravishankar H, Rao MM and KM Bojappa. Scientia Hort 1979;10(1): 95-99.
[12] Singh RN. Hort Adv 1958; 5: 96-106.
[13] Kraus EJ and Kraybill HR. Bull Oregon Agric Exp Stn 1918:149.
[14] Chacko EK. 1968. Studies on the physiology of flowering and fruit growth in

Mango (*Mangifera indica* L.). Ph.D. thesis submitted to P. G. School of IARI.
[15] Patil PB, Rao MM. Sriniivasan CN, Basarkar PW and Nalwadi VG. Karnataka J Agric Sci 1992; 5(4): 338-42.