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Influence of season affecting flowering and physiological parameters in mango

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A field experiment was conducted at State Horticultural Farm, Kanyakumari District undertaken by the Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam during the year 2010 to 2012. In general, mango flowering is considered as a complex phenomenon. Besides, favorable climate conditions that favours off-season flowering, genetic potential of the varieties, physiological and biochemical variations and better management interventions could also play the vital role in promoting off season flowering. The environmental variables play a key and vital role in induction of mango flowering. The result was revealed by the Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam during the year 2010 to 2012. The number of inflorescence m^{-2} (32.10 and 26.40), hermaphrodite flower per cent (37.95 and 33.25), male flower per cent (47.97 and 52.60) and fruit set per cent (0.67 and 0.63) were higher in cv. Neelum during main season and off–season respectively. With regard to physiological parameters, the highest soluble protein (12.55 and 11.94 mg100 g^{-1}) and total phenols (3.510 and 3.250 mg100 g^{-1}) and the lowest of IAA oxidase activity (169.85 and 178.20 µg g^{-1}) and Gibberellic acid content (1.05 and 1.06 µg g^{-1}) were recorded in cv. Neelum during main season and off–season respectively.

Key words: Flowering, physiological parameters, mango cultivars, season.

INTRODUCTION

Mango (*Mangifera indica* L.) belonging to the family Anacardiaceae occupies a predominant place among the fruit crops grown in India and christened as the 'King of fruits' owing to its delicious flavour and taste. In India, mango is cultivated extensively in about 2.3 million hectares with the production of 15.27 million metric tonnes (Anonymous, 2011). The national average productivity of mango in India is 6.6 tonnes per hectare. In Tamil Nadu, mango is grown in an area of about 1,048,000 ha with the production of 823,000 MT of fruits and the productivity is about 5.60 MT per hectare (Anonymous, 2011). Normally mango flowering occurs during the month of December-January and fruiting takes place during April-May in Indian conditions. However, in certain pockets of Southern Tamil Nadu *viz.,* Tenkasi and Senkottai blocks of Thirunelveli district and Agasteeswaram block of Kanyakumari district, mango produces off-season, bearing and flowering occurs during July-August, and fruiting commences during November-December. This peculiar phenomenon of flowering and fruiting in mango is known as off-season bearing. The number of flushes varied greatly depending upon the variety, age of the tree, climatic conditions and the amount of crop borne in the previous season. They also reported that although flowering in mango trees generally took place during short days in the areas that fall nearer to the equator, the very fact that off-season cropping was possible at Kanyakumari Thirunelvelli district in South

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India suggested that flowering in mango is certainly under the environmental control, most probably photoperiod. They also reported that mango trees responded to temperature variations more critically than to photoperiods as evidenced by the different times of flowering at different places in India (Palanisamy et al., 2011). As a consequence of efforts to elucidate the mechanisms of this critical biological event in mango and other model plant systems, many of the important details are becoming clearer at the molecular, biochemical, and physiological levels resulting in a better understanding of how to manage flowering in the field. A conceptual flowering model has been described to explain the interaction of internal and external factors regulating vegetative and reproductive shoot initiation and induction in mango trees growing in tropical and subtropical environments (Davenport and Nunez-Elisea, 1997). The present study was undertaken to influence of season affecting flowering and physiological parameters in mango.

MATERIALS AND METHODS

The present investigation was conducted at State Horticultural Farm, Kanyakumari District and undertaken by the Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam during the year 2010 to 2012. The experimental design was laid out in a Factorial Randomized Block Design (FRBD), with two seasons and ten varieties and replicated twice. Ten year old trees of mango cultivars were selected for this study. Mango cultivars selected for this study are Alphonso, Bangalora, Kalepad, Himayuddin, Sendura, Mulgoa, Neelum, Rumani, Banganapalli and Swarnarekha and seasons are main and off-season. The weather parameters *viz.*, maximum and minimum temperature, relative humidity, average rainfall and rainy days in Kanyakumari, were recorded in experimental location.

Number of inflorescence per metre square

Number of inflorescence m^{-2} was counted in a square metre area of four different places in a tree with the help of wooden frame of 1 m × 1 m dimension and the mean was obtained.

Male flowers percent

The percentage of male flowers was calculated from the randomly selected ten panicles $tree^{-1}$ employing the following formula and expressed in percentage.

$$Percentage\ of\ male\ flower = \frac{number\ of\ male\ flowers}{total\ number\ of\ flowers}\ X\ 100$$

Hermaphrodite flowers per cent

The percentage of hermaphrodite flowers was calculated from the randomly selected ten panicles $tree^{-1}$ using the following formula and expressed in percentage.

$$\text{Percentage of Hermaphrodite flower} = \frac{number\ of\ hermaphrodite\ flowers}{total\ number\ of\ flowers}\ X\ 100$$

Fruit set (pepper stage) per cent

The fruit set was recorded at pepper stage in twenty tagged panicles in all the selected trees and the mean values were expressed in percentage (Sharma and Singh, 1969).

$$\text{Fruit set percentage} = \frac{number\ of\ fruits}{total\ number\ of\ flowers}\ X\ 100$$

Total phenol content

The total phenol content of the leaves was estimated by adopting the method of Bray and Thorpe (1954) and the mean values were expressed in mg 100 g^{-1}.

Soluble protein content

The soluble protein content was extracted with phosphate buffer and estimated as per the method described by Lowry et al. (1951) and the mean values were expressed in mg g^{-1} of fresh weight.

Chlorophyll content

The leaf chlorophyll content was estimated through Simple Portable Diagnostic (Minolta SPAD – 502) and expressed as simple portable diagnostic value.

IAA oxidase

The estimation of indole acetic acid oxidase was done as per the method suggested by Parthasarathy et al. (1970) and values were expressed as µg g^{-1}.

Gibberellic acid bio assay

The gibberellic acid content of leaf samples was estimated as per the method of Holbrook et al. (1961) method and the mean values were expressed in µg g^{-1}.

RESULTS AND DISCUSSION

The present study revealed that the environmental factors played very effective role to induce flowering and fruiting. With regard to flowering characters, the highest values in number of inflorescence per metre square, hermaphrodite flower percentage and fruit set percentage; and the lowest male flower percentage were registered by Neelum during main season and followed by cv. Kalepad during main season (Table.1). This is in agreement with the findings of Kulkarni (1988), and Robbertsen and Stassen (2004). Similar results were also reported in different mango cultivars of Australia (Winston, 1992), Indonesia (Voon et al., 1991; Tongumpai et al., 1991). This might be attributed due to

Table 1. Influence of season on flowering characters in mango cultivars.

Varieties	Number of inflorescences per metre square		Hermaphrodite flower (%)		Male flower (%)		Fruit set (%)	
Seasons	**Main season**	**Off season**	**Main season**	**Off season**	**Main season**	**Off season**	**Main season**	**Off season**
Alphonso	17.32	14.55	19.60	16.05	70.76	74.77	0.32	0.26
Bangalora	18.90	13.40	22.85	19.10	66.80	74.59	0.50	0.40
Kalepad	23.40	17.25	31.30	26.25	53.10	57.55	0.58	0.54
Himayuddin	14.75	10.80	17.67	15.65	78.95	78.06	0.28	0.23
Sendura	18.45	14.05	20.47	17.45	71.92	76.39	0.31	0.26
Mulgoa	12.05	9.00	16.27	13.45	83.05	85.87	0.28	0.24
Neelum	32.10	26.40	37.95	33.25	47.97	52.60	0.67	0.63
Rumani	15.65	12.75	13.22	9.55	84.91	86.06	0.27	0.24
Banganapalli	20.15	16.20	19.90	15.85	78.10	77.23	0.38	0.30
Swarnarekha	11.60	8.45	16.12	13.05	78.95	77.94	0.23	0.20
SEd	0.04305		0.05035		0.07256		0.00138	
CD (0.5%)	0.08708		0.10184		0.14678		0.00280	

Table 2. Influence of season on physiological parameters in mango cultivars.

Varieties	IAA oxidase activity (µg g^{-1})		Gibberellic acid content (µg g^{-1})		Soluble protein (mg100g^{-1})		Total phenols (mg100g^{-1})	
Seasons	**Main season**	**Off season**	**Main season**	**Off season**	**Main season**	**Off season**	**Main season**	**Off season**
Alphonso	216.55	238.40	1.15	1.21	9.27	8.95	1.647	1.450
Bangalora	202.95	215.30	1.01	1.08	8.85	8.57	2.417	2.200
Kalepad	178.10	192.70	1.07	1.10	10.05	9.60	3.100	2.900
Himayuddin	222.35	235.80	1.27	1.28	7.62	7.23	1.725	1.515
Sendura	220.95	225.50	1.10	1.17	8.40	8.10	2.137	1.762
Mulgoa	233.60	240.45	1.31	1.28	8.05	7.84	1.385	1.152
Neelum	169.85	178.20	1.05	1.06	12.55	11.94	3.510	3.250
Rumani	214.50	217.95	1.40	1.43	7.07	6.76	2.667	2.425
Banganapalli	230.60	235.60	1.07	1.11	8.50	8.35	1.957	1.737
Swarnarekha	275.35	282.60	1.25	1.29	8.26	7.39	1.700	1.582
SEd	0.18354		0.00080		0.00942		0.00904	
CD (0.5%)	0.37124		0.00162		0.01904		0.01211	

high leaf N level in the month of February (flowering stage) which exhibited a clear and positive correlation with percentage of hermaphrodite flower per cent. These results confirmed the earlier studies (Anonymous, 1982) and revealed that per cent hermaphrodite flowers increased when the nitrogen level was increased from leaf and same observations were also made by Rajput and Tiwari (1975) and reported that high N level improved the hermaphrodite flower percentage and in term fruit set per cent in mango. Increased N level of leaves during flowering resulted with more production of hermaphrodite flowers, that is, 63% of total flowers per mango panicle.

Flowering and fruit set of the different cultivars and seasons were associated with the reduced vegetative growth, often induced by lower level of gibberellin (Voon et al., 1991). The lowest IAA oxidase activity level was observed within the present study. Reduction of vegetative growth required physiological changes, which resulted in higher in terms of flowering. Following the reduction in vegetative growth parameters, there was a higher chlorophyll content, carbohydrate content and carbohydrate-nitrogen ratio in leaves and shoots at three phases of growth and development viz., vegetative, flowering and harvesting (Table 2). A higher accumulation of required reserves in the current year or main season shoots before flowering was also observed by Stassen (1997). The hormonal content of flowering in mango implies that the cyclic synthesis of floral stimulus in the leaves and the difference between two such cycles would determine the flowering behaviour of mango cultivars (Kulkarni, 1988). The development of hermaphrodite flowers needed more reserves from the tree than male flowers. The number of inflorescence per

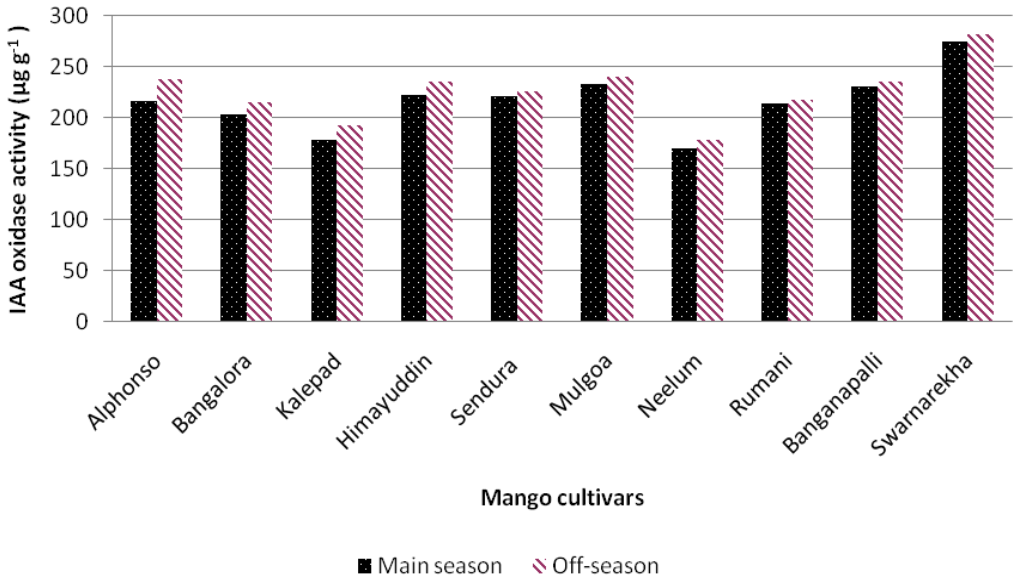

Figure 1. IAA oxidase activity (µg/g^{-1}) of mango.

metre square, the percentage of hermaphrodite flowers and fruit set percentage had the favourable environmental factors which resulted in higher reserves, that is, carbon-nitrogen ratio (Vijayalakshmi and Srinivasan, 2002). The high humidity and rain prevalence at the time of bloom or late rain appeared to influence flower bud differentiation and fruit set development. Shanmugavelu et al. (1987) opined that wide (1.25 to 70%) ratio of hermaphrodite to male flower was observed in varieties with the highest number of inflorescence per metre square particularly in Neelum. Sex expression in mango was influenced by temperature, where higher temperature seems conducive for production of more perfect flowers (Singh, 1990). Thimmappaiah and Suman (1987) stated that among 13 different cultivars, evaluated maximum percentage of hermaphrodite flowers was found in Neelum. The significant differences in sex ratio noticed among the cultivars studied may be due to their genetic makeup, time of flower, response to prevailing environmental conditions and the level of endogenous growth hormones.

In the present study, indications of physiological parameter, the highest values for total phenol content, soluble protein content and lowest IAA oxidase activity and gibberellic acid content were registered by Neelum during main season followed in Kalepad during main season (Table 2, Figures 1, 2, 3 and 4). Pal and Ram (1978) opined that the activity of gibberellin (GA) like substances was found to be greater in the 'off' year and postulated that high levels of gibberellin inhibit flowering in mango. The similar results suggested that Chandler (1950) proposed a hypothesis that flower induction in mango could occur only when the cell division had started and that a flower inducing hormone played no part in the initiation of growth; but when presented with insufficient amount at the beginning of growth, it determined the course of differentiation of tissue in the axillary buds. He also proposed that if a hormone induced flowering in plants and the source of hormone was the leaf or some precursor formed in the leaf, then the leaf surface rather than the accumulation of carbohydrates might have the dominant influence on flowering. This might be due to environmental factors that influence the accumulation of total phenol, and it might be due to the excess production of hydrogen peroxide by increased respiration (Farkas and Kiraly, 1962) or due to the activation of hexose mono phosphate (HMP) shunt pathway, acetate pathway and release of bound total phenols by hydrolitic enzymes. A reverse trend was observed in respect to IAA oxidase activity which was lower in the flowering shoots than in the vegetative shoots, thus indicating higher content of ascorbic acid, RNA and total phenolics. Lower IAA oxidase activity, may have a positive association in the flowering of mango. Besides, a lower level of gibberellin-like substances and higher levels of cytokinin-like substances, growth inhibitors and ethylene have been indicated to be the prime factors favourable for induction of flowering in mango (Tekchand, 1980).

The depletion in sugar level was found to be responsible for the accumulation of total phenols since the sugars are utilized for the synthesis of total phenols. Total phenol exhibited the highest levels during flower bud differentiation. The results are in conformity with the findings of Misra and Dhillon (1981). Total phenols and soluble protein content were reportedly increased during the period of fruit bud differentiation (Patel et al., 1992). Del Rio et al. (1978) confirmed that the above results nitrogen content in the leaves could enhance the soluble protein synthesis throughout the growth phase of the

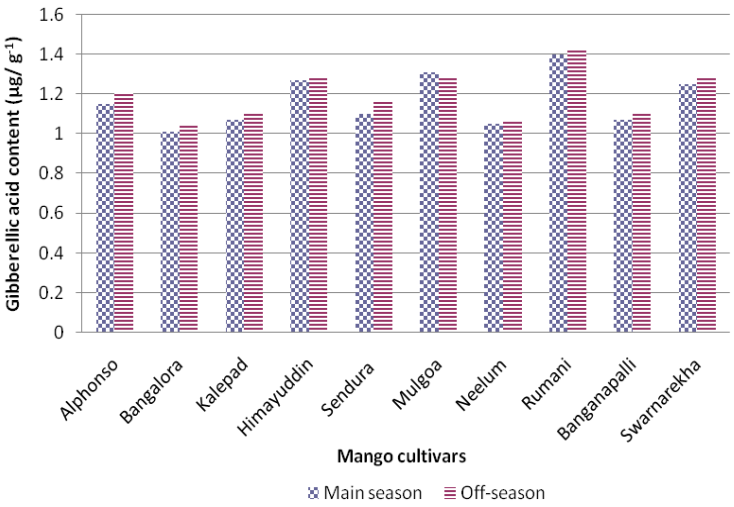

Figure 2. Gibberellic acid content (µg/g^{-1}) of mango.

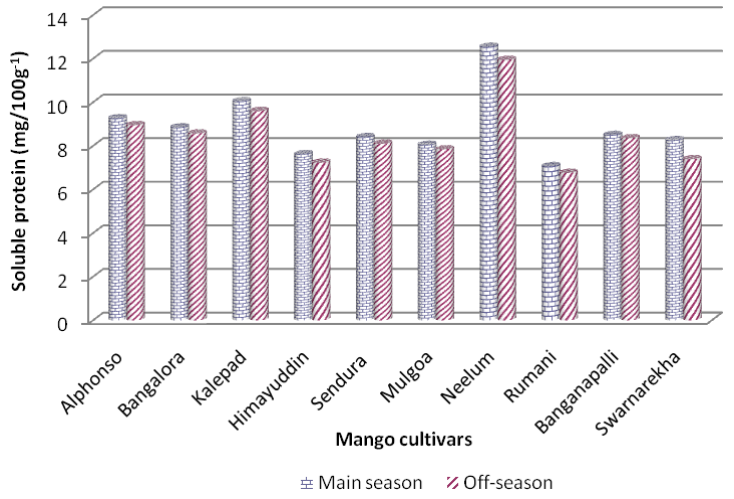

Figure 3. Soluble protein (mg/100 g^{-1}) of mango.

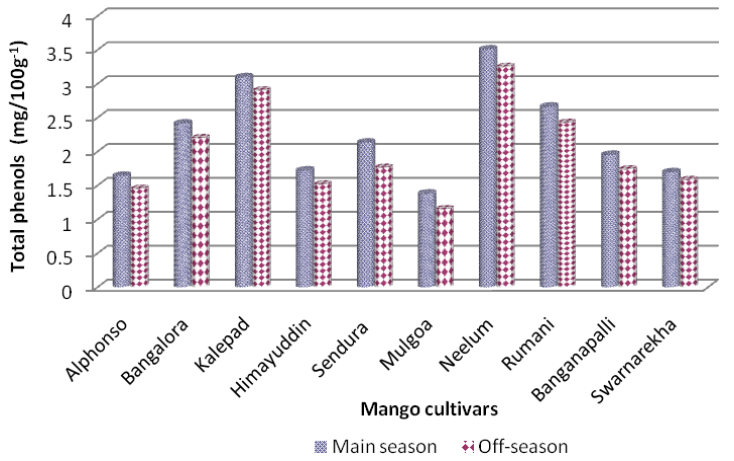

Figure 4. Total phenols (mg/100 g^{-1}) of mango.

plant by direct participation as an essential constituent of soluble protein. At flowering stage, there was a low rate of IAA oxidase activity which might have resulted in greater amount of auxins in the leaves (Vijayakumar, 2001). It was also revealed that high yielding plants had favourable auxin balance through IAA oxidative degradation. The present results corroborate with the findings of Reece et al. (1949). The hormonal studies on the mango varieties showed lower levels of IAA oxidase activity and of gibberellin favour flowering (Chacko et al., 1970). The shoot tip of Dashehari contained during flower bud differentiation several fold higher auxin in the “on” year than the “off” year. This is in conformity with the earlier findings of Lal and Ram (1977). The auxin concentration was greater in the buds of Langra during its “on” year than “off” year at flowering stage. This was in corroboration with the findings of Upreti and Murti (1993). Singh (1961) reported that newly emerged leaves in the shoot of regular bearing cultivars such as Neelum was capable of synthesizing flower inducing hormone. During floral induction period, the apical bud of an on year tree attracted photosynthates. Photosynthates moved basipetally to the main stem and root system during branches; movement was towards the developing sink in fruit (Chacko, 1984). The shoots from Dashehari “on” year and Totapuri “on” year had higher levels of growth promoting substances during the period of flower bud differentiation. This was in conformity with the findings of Chacko (1968). Studies so far have shown that during both the preceding period and floral initiation of mango shoot, leaves or xylem sap contain higher levels of auxins, abscisic acid, cytokinins and steroids when compared to non-flowering trees.

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