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Environmental Influence under Off-season Production on Yield and Quality Attributes of Mango

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A B S T R A C T

An experiment was conducted at the State Horticulture Farm Kanyakumari in eighteen regular off-season bearing varieties where flowering is observed during August, September, October, November months with the fruiting period during December-January were selected for this study. The off-season bearing varieties are Neelum, Kalepad, Bangalora, Banganapalli, Himayuddin, Nadan, Panchavarnam, Rumani, Dilpasand, Kalkachi, Jehangir, Pairi, Panikanadan, Khudadad, Athimathuram, Mulgoa, Alphonso and Surangudi. The off-season flowering is a peculiar phenomenon in Tamilnadu because continuous flowering, fruiting and vegetative production can be seen simultaneously in Kanyakumari. The off-season flowering is usually observed during July-August and harvesting of fruits is usually done during December-January. While most of the varieties shows some peculiar characters in fruit yield and quality attributes it plays a vital role in post harvest self- life in preserving quality. The highest yield was recorded in Bangalora (520.80 Kg/tree). It recorded maximum fruit length (22.60 cm), fruit girth (33.30 cm), fruit volume (469.50 ml), fruit weight (471.50 g) and number of fruits per tree (560.00). Bangalora recorded the highest TSS (20.50° Brix), total sugars (18.16 %), reducing sugars (7.83 %), non reducing sugars (10.34 %), carotene content (60.25 mg/kg), titrable acidity (0.49 %) and ascorbic acid content (37.18 mg/100g). The maximum temperature (29.9 to 32.9°C), diurnal variation (6.9°C), relative humidity (76.6 %), rainfall (159.53 mm), wind velocity (6.13 kmph) and sunshine hours (437.05) were highly conducive for off-season flowering in Kanyakumari.

Introduction

The mango (*Mangifera indica* L. Anacardiacea) is one of the choicest fruit crops of tropical and sub-tropical regions of the world, especially in Asia. Its popularity and importance can easily be realized by the fact that it is often referred as 'King of fruits' in the tropical world (Singh, 1996). The production of off-season cropping in mango which coincides with November-December months should be properly considered for

quality aspects also as fruit development during rainy/cool season months will be of generally inferior in quality because of prevalence of lower quantum of heat units (Ananthanarayan and Anchanam Alagia Pillai, 1968). Whereas flowering is the first of several events that set the stage for mango production each year off-season cropping of certain tracts of Tamil Nadu.

Besides the normal crop that matures from May to August, the trees of certain varieties also mature an off-season crop from October to January. Neelum, Bangalora, Calcutta or Bengal Barasmasi, Kintalvanipeta, and Ali Pasand have been mentioned as varieties bearing two or more crops in succession during certain years and extend their bearing period almost till December and sometimes throughout the year. This has been attributed to the peculiar seasonal conditions and the fairly well distributed rainfall of the area (Chacko and Randhawa, 1971) (Sundararaj *et al.*, 1972). In a study to find out the cause of differential flowering in mango in the island ecosystem by Damodaran *et al.*, (2006) reported that the specific bands obtained were responsible for genes associated with differential flowering behaviour and is due to introgression of genes during hybridization. At Coimbatore, the varieties Peter and Baneshan have been reported as flowering in the off-season. At Kodur, the variety Ambalavi produced five blossom crops between September and the following may except Neelum, Kintalvanipeta, Manoranjan and Willard produced three crops of blossoms. The clonal progeny of an off-season bearing tree at Tenali was found to behave tree at Tenali was found to behave like the parent tree. These facts suggested that the off-season bearing, though a varietal character, was induced by favourable seasonal and climatic conditions. Climate change has emerged as a major challenge influencing agricultural production in the country. Mango crops, being perennial in nature, have to face the impact of climate change even during a single generation or in a standing crop. Hence it is important that the impact of climate change is understood well. Mangoes are grown in ecologically sensitive areas such as coastal belts, hilly areas and areas with high rainfall and high humidity. This crop is of high economic value contributing substantially to the agricultural exports at global and national levels. These are grown in large areas in Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, West Bengal and Assam. The mango crops provide sustenance to the millions of people. Weather variables such rainfall, evapotranspiration, temperature, solar radiation, sunshine hours, relative humidity and wind velocity influence the yield potential of mango. The present study was undertaken for the seasonal effect of climatic condition under off-season production in yield and quality attributes of mango.

Materials and Methods

The present experiment was conducted at the State Horticulture Farm Kanyakumari, Tamil Nadu Investigation on off-season flowering, fruiting behaviour, effect of growth, physiological changes, yield and yield attributes of eighteen mango varieties was under taken during the period between August 2010 and January 2011. The off-season bearing varieties are Neelum, Kalepad, Bangalora, Banganapalli, Himayuddin, Nadan, Panchavarnam, Rumani, Dilpasand, Kalkachi, Jehangir, Pairi, Panikanadan, Khudadad, Athimathuram, Mulgoa, Alphonso and Surangudi. Experiments were arranged in randomized block design replicated three times. Five trees were used in each variety for replication 25 years old trees were chosen for the study. From each tree, 20-30 samples were taken at monthly intervals and quality analysis was carried out to assess the fruit

quality by adopting the standard procedures five fruits from each treatment were harvested at uniform maturity and allowed to ripe naturally in the room temperature. At edible ripening stage, the fruits were cut and the pulp were mixed together for performing the quality analysis. Observations on yield attributes, quality attributes and weather parameters were recorded.

Assessment of fruit yield characters on off-season mango

Off-season fruits were assessed for determining the following yield parameters. Fruit length and grith were determined by the means of expressed in centimeter. Fruit volume was determined by the means of expressed in milliliter. The number of fruits harvested per tree was counted and the total was expressed as number of fruits per tree. Fruit weight, Peel weight, Pulp Weight and Stone Weight were randomly selected from each tree and the average weight of the pulp was calculated and expressed in gram. The ratio of Stone to pulp was calculated based on the analysis of total stone and total pulp. Total weight of the fruits harvested per tree was recorded and expressed in kilograms (Kg/tree). Specific gravity of fruit was calculated as (Density of mango fruit/ Density of water), Density was calculated as (mass/volume). The number of days to ripen after harvest of fruits was recorded and expressed in number.

Estimation of important quality attributes on off-season mango

Fully matured representative figures were allowed for natural and uniform ripening in the room temperature. These fruits were assessed for determined the following quality parameters. The total soluble solids were determined by using Carl-Zeiss hand refractrometer and expressed as degree Brix. The total sugars, reducing and non-reducing sugars were estimated as per the methods suggested by Somogyi (1952**)** and expressed as percentage. The carotenoid content of the fruit was estimated by adopting the A.O.A.C. (1975) method and expressed as Milligrams/ Kilogram. Titrable acidity of the fruit was estimated by adopting the method of A.O.A.C. (1975) by titrating against N/10 KOH using phenolphthalein indicator and expressed in terms of percentage of citric acid. Ascorbic acid content was estimated by A.O.A.C. (1975) by using 2, 6-dichlorophenol indophenols dye and the value was expressed as milligrams/100gram.

Meteorological Parameters from flowering to maturity

Monthly maximum temperature °C and Monthly minimum temperature °C were expressed in terms of (Celsius). Relative humidity was expressed in terms of percentage. Rainfall was expressed in terms of mille meter. Wind velocity was expressed in kilo meters per hour. Sunshine hours were short day and long day hours. Day and night temperature was calculated as Diurnal variation (Maximum temperature – Minimum temperature).

Results and Discussion

Effect of seasonal difference on off-season fruiting yield parameters of mango

The maximum fruit length (22.60 cm), fruit girth (33.30 cm), fruit volume (469.50 ml), fruit weight (471.50 g) and pulp weight (365.00 g) were recorded in Bangalora. Nadan recorded maximum peel weight (79.50 g) and Athimathuram recorded the maximum stone: pulp ratio of 10.84 (Table 1). Due to seasonal and varietal variation of fruit characters in post-harvest study were recorded in Bangalora, Neelum, Himayuddin followed

by Kalepad were influenced by different seasonal effects on climatic changes and biological wonders in Kanyakumari reported by (Kennedy *et al.*, 2009a) (Kennedy *et al.*, 2009b) and (Parthiban *et al.*, 2009). Maximum yield performance of Bangalora was due to their prolific nature and adaptability to Kanyakumari regions of Tamil Nadu. Similar variations in yield in the off-season bearing nature of mango varieties were recorded at Erode (Sundaram, 2007) and at Sangareddy (Lakshminarayanareddy *et al.*, 2009). Bangalora recorded the maximum number of fruits per tree (560.00) and fruit yield per tree (520.80). Similar variation in fruit yield per tree had also been reported by Kumar and Kavino (2009).

Effect of seasonal difference on off-season fruiting quality parameters of mango

The maximum total soluble solids (20.50º brix), total sugars (18.16 %), reducing sugars (7.83 %), non reducing sugars (10.34 %), carotene (60.25 mg/kg) and ascorbic acid content (37.18 mg/100g) were recorded in Bangalora. The available photosynthates required for fruit development are diverted to improve the TSS. Similar finding was reported by Hassan *et al.*, 2004; Khattab *et al.*, 2006 and Shaban, 2009. The maximum titrable acidity content was recorded in Surangudi (0.49 %) (Table 2). Srinivasan and Shanmugavelu (1971) reported that Low acidity of the fruits is one of the desirable qualities in mango. In mango, the quality is mainly judged by total soluble solids (TSS), total sugars, titrable acidity and total carotenoid content in fruits.

Effect on off-season environmental changes in meteorological parameters

The location of the experiment site might play a critical role in induction of off- season flowering as experiences have shown that off-season flowering cannot be seen as a uniform phenomenon in all mango growing regions. In the present case, it is surrounded by hills on three sides presenting a different microclimate, favouring off-season cropping than the other neighboring parts. The fluctuation between the maximum and minimum relative humidity was found to be wide during the main season, while it was narrow during the off-season. Ananthanarayanan and Pillai (1968) while studying the off-season bearers at Kanyakumari also opined that high humidity and rainfall prevailed during the off-season than the main season.

Monthly maximum temperature during August to January 2010-2011 ranged from (29.9°C to 32.9°C). While, the monthly minimum temperature ranged from (23.5°C to 25.2°C) in the experimental location. These temperature regimes might be probably conducive for flowering and fruit setting during the off-season. Another important factor is the absence of very heavy rain during these months as rains, fogs or cloudy weather at the time of flowering prevents the setting of fruits and favour the development of pests and diseases similar finding was reported by Gangolly *et al.*, 1957 and Gandhi, 1959. Relative humidity ranged between (71.6 to 80.6 %). There are many schools of thoughts ascribed to this phenomenon and it has observed by the mango research that a high relative humidity of 90%; low night temperature during south west monsoon; a well distributed monsoon rains may be responsible for residual food reserve conversion into flower primordial even in young shoots also (Richard Kennedy *et al.*, 2009a). The per cent soil moisture was also high during off-season because of high rainfall. The location receives nearly (400.9 mm) of rain fall during the off-season flowering period and which is followed by low rainfall (29.5) during subsequent months

that favours better fruit setting Naik (1949) reported that dry and relatively rainless summer evidently helped the shoot to get the desired rest period for successful initiation of flower buds. Cloudy weather and rains during blossoming period reduced the crop indirectly by creating favourable conditions for pest and disease (Singh, 1957). Fairly well distributed rainfall may be the desirable feature for the production of a regular off-season crop in Kanyakumari (Lysander and Pillai 1957; Velappan and Shankar, 2001).

Table.1 Effect of seasonal difference on off-season fruiting yield parameters of mango

S. No	Varieties	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Peel weight (g)	Stone: Pulp ratio	Number of fruits/tree	Fruit yield (Kg/tree
1	**Neelum**	13.60	25.05	272.00	42.50	3.46	549.00	149.33
2	**Kalepad**	12.80	24.10	258.50	44.00	3.66	540.00	139.59
3	**Bangalora**	22.60	33.30	471.50	46.00	6.03	560.00	520.80
4	**Banganapalli**	15.10	33.30	463.50	42.50	6.33	448.50	194.70
5	**Himayuddin**	14.10	23.75	305.00	51.00	3.54	396.50	120.93
6	**Nadan**	13.75	30.05	385.50	79.50	2.45	272.50	105.05
7	**Panchavarnam**	12.75	24.25	267.50	33.00	2.26	517.50	138.44
8	**Rumani**	12.75	24.55	203.50	45.50	3.00	437.50	89.04
9	**Dilpasand**	13.45	22.10	229.00	43.50	2.78	186.50	42.71
10	**Kalkachi**	13.20	27.50	402.50	43.00	4.94	129.00	51.92
11	**Jehangir**	16.20	26.95	396.00	74.00	3.67	114.50	45.34
12	**Pairi**	12.65	23.95	243.00	48.00	2.86	82.50	20.05
13	**Panikanadan**	15.85	26.10	432.50	37.00	5.63	50.00	21.63
14	**Khudadad**	15.45	26.25	316.50	60.00	3.71	137.50	43.51
15	**Athimathuram**	15.05	31.45	460.00	64.00	10.84	252.50	116.15
16	**Mulgoa**	14.80	26.00	224.00	45.00	2.62	183.50	43.90
17	**Alphonso**	11.95	22.00	176.00	37.00	2.11	67.50	11.89
18	**Surangudi**	12.15	22.15	152.00	31.50	2.49	410.00	62.38
	SEd	**0.577***	**0.444***	**5.381***	**3.318***	**0.387***	**3.316***	**6.516***
	CD(P=0.05)	**1.21**	**0.93**	**11.35**	**7.001**	**0.81**	**6.99**	**13.74**

Table.2 Effect of seasonal difference on off-season fruiting quality parameters of mango

S. No	Varieties	TSS (ºBrix)	Total sugars (%)	Reducing sugars (%)	Non Reducing sugars (%)	Carotene content (mg/kg)	Titrable acidity (%)	Ascorbic acid content (mg/100g)
1	**Neelum**	17.50	14.31	4.70	9.61	59.75	0.39	33.62
2	**Kalepad**	16.50	12.98	3.45	9.53	58.63	0.39	33.61
3	**Bangalora**	20.50	18.16	7.83	10.34	60.25	0.37	37.18
4	**Banganapalli**	13.50	10.21	2.06	10.34	54.35	0.44	31.17
5	**Himayuddin**	14.50	11.04	2.40	8.64	54.75	0.43	31.20
6	**Nadan**	11.50	7.90	1.60	6.30	51.30	0.46	29.20
7	**Panchavarnam**	14.50	11.02	2.40	8.63	54.75	0.43	31.17
8	**Rumani**	8.50	5.14	1.03	4.11	49.48	0.49	26.48
9	**Dilpasand**	9.50	5.58	1.10	4.48	49.98	0.48	26.98
10	**Kalkachi**	14.50	11.02	2.39	8.63	54.75	0.43	31.20
11	**Jehangir**	11.50	7.66	1.58	6.08	52.08	0.46	29.48
12	**Pairi**	14.50	11.01	2.39	8.62	54.74	0.43	31.20
13	**Panikanadan**	12.50	8.90	1.81	7.10	52.98	0.45	30.20
14	**Khudadad**	9.50	5.51	1.08	4.43	50.20	0.48	26.98
15	**Athimathuram**	10.50	6.70	1.40	5.31	51.10	0.47	29.20
16	**Mulgoa**	12.50	8.90	1.81	7.10	52.97	0.45	30.20
17	**Alphonso**	10.50	6.74	1.40	5.36	51.07	0.47	29.19
18	**Surangudi**	8.50	5.03	1.08	3.96	49.40	0.49	26.00
	SEd	**0.333****	**0.659***	**0.368***	**0.456***	**0.259***	**0.003***	**0.237***
	CD(P=0.05)	**0.70**	**1.39**	**0.77**	**0.96**	**0.54**	**0.007**	**0.49**

Table.3 Effect on off-season environmental changes in meteorological parameters

S.No	Months	Monthly max temp°C	Monthly mini temp°C	Relative Humidity (%)	Rainfall (mm)	Wind velocity (kmph)	Sunshine hours	Diurnal variation
1	August-2010	31.9	25.2	74.8	34.5	6.97	398.65	6.7
2	September-2010	32.6	25.3	75.1	29.5	5.80	487.71	7.3
3	October-2010	31.2	24.6	79.8	166.0	5.28	469.51	6.6
4	November-2010	32.9	25.0	80.6	400.9	5.01	491.42	7.9
5	December-2010	29.9	23.7	77.7	174.1	7.61	346.61	6.2
6	January-2011	30.6	23.5	71.6	152.2	6.08	428.39	7.1

Sunshine hours ranged from (346.61 to 491.42). Although flower bud initiation in mango takes place during short days in the fall, off-season flowering during June is also observed near equator. Hence, it is difficult to call this species a short/long day plant. The

climatic mystery is also twisted by the varietal differences as varieties like 'Neelum' flowers twice in Kanyakumari but once in north India. This effect is also found to be seen in this species as the trees which are grown in the eastern side of an orchard flowers a few days ahead of others. It clearly indicated that the trees found on the eastern side are found to receive longer hours of sunlight in fruits. Wind velocity ranged between (5.01 and 7.61 kmph). The State Horticultural Farm Kanyakumari which depicts that the diurnal variation in temperature is low with a range of (6.2 to 7.9°C) (Table 3) during the flowering months of June – August for off-season bearing. This is also supported by the prevalence of low night temperatures during that period when compared to other months. Ravishankar *et al.,* (1979) reported that flower bud initiation in 'Alphonso' commenced in early October and reached a peak by mid November. The marked drop in the night temperature and relative humidity appeared to be favourable for fruit bud differentiation.

Many cultivars flower erratically in the low latitude tropics, providing continuously warm temperature with high soil and atmospheric moisture (Davenport, 2003). Researchers in Thailand had revealed that mango trees were in need of dry period for flower bud formation and flowering occured naturally after the dry and cool season (Rajan, 2009).

In conclusion, among the eighteen varieties Bangalora performance well in off-season mango production under Kanyakumari condition. While most of varieties which have shown preponderance of crop in the off-season can at best be termed only as mediocre from the stand point of quality, it is interesting to note that some trees of varieties in commercial cultivation such as Bangalora, Neelum, Kalepad, Banganapalli and Himayuddin etc. The possibility of stabilizing off-season cropping in commercial production of mango in certain tracts of south Tamil Nadu belt for off-season production. Whereas highly conducive environmental condition for off-season flowering and fruiting in Kanyakumari.

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