Journal of Agrometeorology 14 (1) : 91-94 (June 2012)

Short Communication

Impact of meteorological variables on postbloom fruit dropping in kinnow mandarin

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Kinnow mandarin is predominantly produced in Northern States of India. It occupies a significant place on the fruit map of Rajasthan by covering 14,620 ha area with production and productivity of 95,600 tonnes and 12.5-15.0 tonnes/ha respectively (Anonymous, 2010). Post bloom fruit drop (PFD) influenced by pathological factors (*Botryodiplodia theobromae* Patouillard*, Colletotrichum gloeosporioides* (Penzig) Saccardo) and physiological factors (nutritional deficiency), is a major constraint in kinnow production (Sharma, 2007). This disease causes variable fruit yield losses depending on the weather conditions (Santos and Garza, 1986; Feichtenberger, 1994). The fungi infect citrus flowers producing orange-brown necrotic spots or affecting the entire petal. Fruit lets on affected inflorescences do not develop or abscise, but the calyx and floral discs remain attached to the peduncle. These persistent calyces, commonly called buttons, are diagnostic for the pathological fruit dropping and may persist for many months after flowering.

Environmental factors like temperature, humidity and rainfall influence the PFD to the great extent in citrus (Timmer and Zitko, 1993). Study on relationship between weather parameters and PFD in kinnow is urgently needed thereby congenial period of PFD during the crop season can be find out which would be used to formulate schedule for fungicidal/ nutritional applications. Application of fungicides/nutrition according to the model increased fruit counts 30 to 60 per cent and use of the model prevented unnecessary fungicidal/ nutrional applications (Timmer and Zitko, 1996). Therefore, here an effort has been made to investigate the impact of weather variables on PFD in kinnow to predict the most congenial period of PFD and ultimately to formulate schedule for fungicidal/nutrional applications in Nort-West part (Zone 1b) of Rajasthan.

To assess the fruit dropping caused by pathological (biotic) and physiological (abiotic) factors and its correlation with meteorological variables, three locations (Agricultural Research Station, Layalpur orchard and Vishnu garden) of kinnow orchards in Sriganganagar district were selected for two consecutive years (2007-08 to 2008-09). Twenty plants at each location were randomly selected. Surveys were conducted at these locations at weekly intervals from August to till harvest during 2007-08 and from May to till harvest during 2008-09. Dropped fruits were collected and brought to the laboratory at each visit. The dropped fruits were cut and examined individually for biotic or abiotic causal agent of dropping and assigned into different categories (pathological/ physiological) accordingly. The percentage of fruits dropped due to each cause was calculated on the basis of total number of fruits borne, which was worked out by adding number of dropped fruits with number of fruits retained on plants till harvest as, fruit dropping (%)= [Number of dropped fruits/ Total number of fruits observed] x 100.

Pathological fruit dropping: Fruit dropping of this category was calculated on the basis of dropped fruits showing typical rotting symptoms on distal end and on fruit rind.

Physiological fruit dropping: Fruit dropping of this category was calculated on the basis of dropped fruits devoid of pathological disease symptoms.

These observations recorded on pathological, physiological and total fruit dropping from different orchards were correlated with meteorological factors viz., temperature (maximum, minimum, average, difference), relative humidity (maximum, minimum, average, difference) and total rainfall. The data of two years were pooled to draw conclusion with regards to effect of climatic changes on fruit dropping in kinnow mandarin.

The results of two years (2007-08 and 2008-09) indicated that minimum pathological fruit dropping of 0.66 per cent was recorded during June month when the maximum and minimum temperature was 40.3 and 27.7 ^{o}C respectively, The pathological fruit dropping showed fast increase till October month. During this period fruit dropping increased from 0.66 to 3.88 per cent. Thereafter decreased showly during October – January fruit dropping from 3.88 to 2.68 percent.

The study of correlation of the individual weather

Table 1 : Meteorological factors in relation to pre-mature fruit dropping in kinnow orchards in Sriganganagar district (Mean of 2007-08 & 2008-09)

	Fruit dropping (%)			Meteorological factors (Mean of 2007-08 & 2008-09)								
Month	Pathological	Physiological	Total(Avg.	Temperature (°C)				Relative humidity (%)				Total
	Avg.	Avg.	of Path. +Physio.)	Max	Min	Avg.	Difference	Max	Min	Avg.	Difference	rainfall (mm)
June	0.66	1.38	2.04	40.3	27.7	34.0	12.5	66.9	51	58	15	105.4
July	1.52	1.33	2.85	39.9	28.9	34.4	11.0	66.5	48	57	18	73.4
August	1.90	1.09	2.99	38.2	27.3	32.7	10.8	70.4	56	63	13	48.2
September	3.50	1.85	5.35	36.9	24.2	30.5	12.7	71.7	56	63	15	60.9
October	3.88	2.58	6.46	36.1	17.3	26.7	18.7	75.4	41	58	33	0.0
November	3.41	2.70	6.11	30.0	11.5	20.8	18.5	85.4	53	69	32	0.0
December	3.34	1.71	5.05	23.7	7.5	15.6	16.2	93.6	59	76	34	0.9
January	2.68	0.72	3.40	20.7	5.3	13.0	15.4	90.0	56	73	33	14.3
Total	**20.90**	**13.36**	**34.25**									

Note: The data of June and July are of only one year (2008-09) therefore, these data are not being treated as mean of two years.

Table 2 : Correlation coefficients of some weather parameters with fruit dropping in kinnow (Citrus reticulata)

Fruit drooping	**Temperature (°C)**				**Relative humidity (%)**				**Total**
	Max	**Min**	**Avg.**	**Difference**	**Max**	**Min**	**Avg.**	**DifferEnce**	**rainfall (mm)**
Pathological (A)	-0.466	-0.608*	-0.551*	0.735*	0.574*	0.013	0.432	0.648*	-0.827*
Physiological (B)	0.118	-0.138	-0.026	0.700*	0.094	-0.450	-0.109	0.383	-0.443
Overall (A + B)	-0.270	-0.474	-0.388	0.795*	0.432	-0.179	0.250	0.603*	-0.751*

* Significant values of correlation coefficient.

parameter with the pathological fruit dropping led to conclusion that maximum and minimum temperature and average of them negatively correlated with fruit dropping, having 'r' values of -0.466, -0.608 and -0.551 respectively, however, relative humidity as maximum (0.574), minimum (0.013), average (0.432) and difference (0.648) of them exhibited a positive correlation. The difference between maximum and minimum temperature and total rainfall showed significant positive (r= 0.735) and negative (r= -0.827) correlation with fruit dropping accordingly (Table 2).

Pooled data of two years (2007-08 and 2008-09) also indicate that physiological fruit dropping increased from 1.38 to 2.70 per cent from during the month of June to November. From November onward physiological fruit dropping showed fast decreasing trend (2.70 to 0.72%).

The present studies (Table 2) indicated that physiological fruit dropping was negatively correlated with minimum (-0.138) and average (-0.026) of maximum and minimum temperature as well as minimum (-0.450) and average (-0.109) of maximum and minimum RH. Rainfall also showed negative correlation of -0.443 with fruit dropping. It was further observed that maximum and difference of maximum and minimum temperature as well as RH were positively correlated with fruit dropping having 'r' value of 0.118, 0.700, 0.094 and 0.383 respectively.

Premature fruit drop is caused as a rule by a complex of different factors including at a high probability adverse environmental conditions. Meteorological events before, during and following the development and vigour of flowers, bloom, fertilization and flower subsequently fruit drop are highly decisive. Similar to present findings, a negative correlation between temperature and fruit dropping in citrus have been reported earlier (Pozo *et al*., 2007). According to Peres *et al.* (2002) inoculum availability and relative humidity the main basic factors which influenced the post bloom fruit dropping in citrus. Prolonged damp weather has been proved favourable to pathological fruit dropping in citrus (Singh, 2000; Agrios, 2005). The results of present investigation are also in consonance with Farro *et al.* (2011) who established a negative correlation between pluvial precipitation and fruit dropping in camu-camu (*Myrciaria dubia* Mc Vaugh H.B.K.). It is hypothesized that the microclimatic factors might induce specific changes within the abscission zone (e.g. lack of carbohydrate supply, reduced export of indole"3-acetic acid [IAA] out of the fruit; increased fruit ethylene synthesis) which subsequently leads to fruit drop.

Conclusively, overall fruit dropping (pathological + physiological) in kinnow positively correlated with maximum relative humidity, average and difference of maximum and minimum relative humidity. Maximum and minimum temperature, their average as well as minimum relative humidity have negative correlation with fruit dropping. Furthermore, two weather factors viz., difference between maximum and minimum temperature and total rainfall exhibited significant positive and negative correlation with overall fruit dropping respectively.

ACKNOWLEDGEMENT

The authors are grateful to the Director, Department of Horticulture, Govt. of Rajasthan for providing financial support under the National Horticulture Mission on ad hoc Project "*Studies on physiological and pathological induced fruit dropping, post-harvest fruit decay and biochemical changes in kinnow fruits (Citrus reticulate Blanco) in relation to pre- harvest spray scheduling*" and to the Director Research, S.K. Rajasthan Agricultural University, Bikaner for providing facilities during the course of these investigations.

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Received : January 2012 ; Accepted : May 2012