Abscission of mango fruitlets
I. In relation to endogenous concentrations of indole-3-acetic acid, gibberellic acid and abscisic acid in pedicels and fruitlets

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Received 14 January 1997
Accepted 28 July 1997

Fruits, 1997, vol 52, p 159-165
® Elsevier, Paris

***Resumen Español**, p. 165*

Abscission of mango fruitlets. I. In relation to endogenous concentrations of IAA, GA_3 and abscisic acid in pedicels and fruitlets.

ABSTRACT

INTRODUCTION. The aim of this work was to determine the relationship between fruitlet abscission and endogenous concentrations of indole-3-acetic acid (IAA), gibberellic acid (GA_3) and abscisic acid (ABA) in the pedicels and the fruitlets of mango. **MATERIALS AND METHODS.** Intact fruitlets of Dusheri mango and their pedicels, as well as fruitlets about to abscise and their pedicels, were collected at three developmental stages of the fruit, eg, pin head, pea and marble stage, during 2 years. The three phytohormones were extracted, purified, derivatized and their concentrations were calculated. **RESULTS AND DISCUSSION.** The study revealed that fruitlets about to abscise exhibited a decrease of mean concentrations of IAA, GA_3 and an increase of mean concentrations of abscisic acid as compared to intact fruitlets at pin head, pea and marble stage of fruit development. Likewise, the pedicels of fruitlets about to abscise showed a decrease of mean concentrations of IAA, GA_3 and an increase of mean concentrations of abscisic acid in comparison with the pedicles of intact fruits at the three developmental stages. So, fruitlet abscission in mango would be associated with lower levels of IAA, GA_3 and higher levels of abscisic acid in pedicels and fruitlets.

KEYWORDS
India, *Mangifera indica*, fruit, plant developmental stages, plant growth substances.

Abscission des jeunes mangues. I. Lien avec les teneurs endogènes en AIA, gibbérelline et acide abscissique, dans les pédoncules et les fruits.

RÉSUMÉ

INTRODUCTION. Les relations existant entre l'abscission de jeunes fruits et les teneurs internes en acide indole acétique (AIA), gibbérelline (GA_3) et acide abscissique des tissus du pédoncule et de la pulpe de jeunes mangues ont été recherchées. **MATÉRIEL ET MÉTHODES.** De jeunes mangues de la variété Dusheri, soit intactes, soit proches de l'abscission, ont été échantillonnées avec leurs pédoncules, à trois stades différents de leur développement, pendant 2 années consécutives. Les trois phytohormones ont été extraites, purifiées et dérivées et leurs concentrations dans les tissus ont été mesurées. **RÉSULTATS ET DISCUSSION.** L'étude a révélé qu'aux trois stades de développement considérés – stades tête d'épingle, petit pois et marbré – les tissus des jeunes fruits proches de l'abscission présentaient une diminution de leur concentration moyenne en AIA et gibbérelline, et une augmentation de leur taux d'acide abscissique, par rapport aux tissus de jeunes fruits intacts. De la même façon, les pédoncules de ces fruits ont montré une diminution de leur concentration moyenne en AIA et en GA_3, et une augmentation de leur teneur en acide abscissique, comparés aux pédoncules de jeunes fruits intacts de chacun des trois stades étudiés. Ainsi l'abscission des jeunes fruits chez la mangue serait associée à de plus faibles teneurs en AIA et à des concentrations plus élevées en acide abscissique dans les pédoncules et les fruits.

MOTS CLÉS
Inde, *Mangifera indica*, fruit, stade de développement végétal, substance de croissance végétale.

introduction

Excessive fruitlet abscission occurs in the early stages of fruit development in many cultivars of mango (MUKHERJEE, 1952; SINGH 1960; YOUNG and SAULS, 1979; DESAI et al, 1985). Abscission occurs at all stages of fruit development, but is particularly high (> 90%) during the 2–4 weeks period following fertilization (SINGH, 1960; NUNEZ-ELISEA and DAVENPORT, 1986). Premature fruit abscission is thought to be due to failure of fertilization and/or embryo abortion, which hinder normal fruit development (SINGH, 1961, 1978). Anatomical investigations have shown that the abscission zone in mango fruit is formed in the pedicel at the flower initiation stage and it is composed of irregular rows of small meristematic cells (SINGH 1961, 1978). Using bioassays, RAM et al (1983), RAM (1983, 1992) and PRAKASH and RAM (1984) reported that lower concentrations of auxins, gibberellins and cytokinin-like substance(s) and higher concentration of inhibitor(s) in the developing fruits were associated with fruit drop in mango. The substantial reduction in fruitlet abscission with the exogenous application of naphthalene acetic acid or 2,4-D (JAGIRDAR and CHOUDHRY, 1967; SINGH, 1978; ARAVINDAKSHAN et al, 1979; DAHSHAN and HABIB, 1981; SINGH and RAM, 1983), gibberellic acid (RAM, 1992) and polyamines (SINGH and SINGH, 1995) has also provided strong circumstantial evidence of the involvement of plant growth substances in fruitlet abscission of mango. Enhanced ethylene biosynthesis has been involved in abscission of mango fruitlets (VAN LELYVELD, 1982; NUNEZ-ELISEA and DAVENPORT, 1986). In mango, the relationship between fruitlet abscission and endogenous concentration of indole-3-acetic acid, gibberellic acid and abscisic acid in the pedicles of the fruit is not yet known. Earlier study on the 'Comice' pear showed that fruitlet abscission appears to be due to loss of pedicel capacity to transport auxins, rather than a decline in fruit auxin production (ANONYMOUS, 1984). The aim of this work was, therefore, to determine the relationship between fruitlet abscission and endogenous concentrations of indole-3-acetic acid, gibberellic acid and abscisic acid in the pedicels and the fruitlets of mango.

materials and methods

plant material

Mango (*Mangifera indica* L) cv Dusheri trees grafted on mango seedlings were used for these studies in the college orchard of Punjab Agricultural University Ludhiana (30°50' N and 75°52' E) in North India. The trees were 16 years old. Uniform trees were selected for the experiment. All the experimental trees received similar cultural practices regarding fertilizers, irrigation and plant protection (ANONYMOUS, 1988) during the investigations.

collection of pedicels and fruitlets

The shoots bearing panicles of similar phenological development were chosen and tagged at full bloom stage of panicles on ten randomly selected trees. The panicles were tagged by wrapping adhesive tape around the shoots (50 shoots per tree). Fruitlets and their pedicels (two fruits per panicle) were collected at pin head stage (< 5 mm fruitlet diameter) on 18th April, pea stage (6–10 mm fruitlet diameter) on 25th April and marble stage (11–20 mm fruitlet diameter) on 7th May from the tagged panicles. At each of the above developmental stages, fruitlets and pedicels were collected from intact fruitlets and fruitlets about to abscise. Intact fruitlets were characterised by green colour and did not drop with the 3–4 repeated shakes to the panicles. Whilst, about to abscise fruitlets were intact with the panicles but showing yellowing of the sinus portion of the fruit and dropped with a single shake of the panicles. Mango fruitlets and pedicels collected from ten different trees were pooled in one sample. The pedicles and fruits were separated, weighed and stored in methanol (80%) at –20°C till extraction.

extraction, purification, derivatization and quantitation of indole-3-acetic acid, gibberellic acid and abscisic acid

Mango fruitlets or pedicels were extracted in methanol (80%) containing 20 mg/l butylated hydroxy toluene (BHT) at 4 ± 1°C for 24 h in the dark. The extraction was repeated three times before the combined extract was purified and derivatized according to the methods described in detail elsewhere (SINGH, 1986; SINGH and DHILLON, 1990). After derivatization, trimethylsilyl (TMS) derivatives were injected into a gas liquid chromatograph, PYE Unicam (UK), fitted with a glass column (1.5 m long × 0.5 cm internal diameter) and flame ionization detector. The temperature of the detector was 350°C, injector 290°C and column 140–270°C for indole-3-acetic acid, gibberellic acid and abscisic acid. The linear temperature was programmed at the rate of 6°C/ min when temperature rose to 270°C, isothermal condition were maintained for 20 min. Nitrogen was used as the carrier gas. The phytohormones in the plant extract were identified by comparing the retention time of TMS derivatives to those of authentic standards indole-3-acetic acid (Sigma, 11.2 min) and abscisic acid (Sigma, USA, 16.2 min), and gibberellic acid (BDH, UK, 23.5 min). The relative retention time and co-chromatography of plant extracts with authentic standards were also done to facilitate legitimate identification of phytohormones. The concentrations of phytohormones were expressed as 10^{-9} g/g fresh and dry weight of plant tissues during both the years.

results and discussion

indole-3-acetic acid

The mean concentrations of indole-3-acetic acid was lower in fruitlets about to abscise (29.5, 30.6, 26.7%) and their pedicels (7.3, 33.6, 33.6%) as compared to the intact fruitlets and their pedicels at pin head, pea and marble stage, respectively (table I). The decrease in the concentration of indole-3-acetic acid in the pedicels of fruit-

Table I
Mean concentrations of indole-3-acetic acid (10^{-9} g/g) on fresh and weight basis, in intact and about to abscise fruitlets and their pedicels in Dusheri mango at pin head, pea and marble developmental stages of the fruit.

Material collected		*Fruitlet*			*Pedicel*		
		Pin head	*Pea*	*Marble*	*Pin head*	*Pea*	*Marble*
First year	Intact fruitlet						
	Fresh weight basis	2360	2778	3098	880	1440	1590
	Dry weight basis	3630	3700	4020	1170	1800	1870
	About to abscise fruitlet						
	Fresh weight basis	1661	2070	2336	820	880	1050
	Dry weight basis	2550	2760	3025	1090	1100	1230
Second year	Intact fruitlet						
	Fresh weight basis	2370	3123	3123	880	1300	1620
	Dry weight basis	3645	3795	4055	1170	1620	1900
	About to abscise fruitlet						
	Fresh weight basis	1673	2024	2219	810	940	1080
	Dry weight basis	2574	2695	2885	1080	1170	1270
Mean decrease[1] (%)		29.5	30.6	26.7	7.3	33.6	33.6

[1] Mean decrease (%) exhibits a decrease of mean concentration of IAA in about to abscise fruitlets/pedicels as compared with intact fruitlets/pedicels.

lets about to abscise was less pronounced as compared to the pedicels of intact fruits at pin head stage as compared to pea and marble stage (table I). The concentrations of indole-3-acetic acid were lower in the pedicels and in fruitlets at pin head stage as compared to pea and marble stage. The results were similar during both years of study (table I). The lower concentrations of indole-3-acetic acid in the fruitlets about to abscise and their pedicels at all the stages of development may be attributed to lower production of indole-3-acetic acid in the fruitlets and its higher oxidation. Higher peroxidase activity in abscised fruit as compared to intact fruits of mango has been reported by VAN LELYVELD (1978), and the present studies also support the above hypothesis. In general, concentrations of indole-3-acetic acid were lower in the fruitlets and their pedicels at their early stages of development. It may be attributed to lower rate of biosynthesis of indole-3-acetic acid in the fruitlets. The zygote and endosperm nuclei of Dusheri mango are known to rest for about 2 weeks after fertilization (SINGH, 1961; SHARMA and SINGH, 1972). Using bioassay, CHACKO et al (1970) and PRAKASH and RAM (1984) also reported lower concentrations of auxin like substances in mango fruitlets 2 weeks after fertilization. The substantial reduction in the abscission of fruitlets of mango with exogenous application of auxins, eg, NAA (Planofix) or 2,4-D, at full bloom or fruit set (JAGIRDAR and CHOUDHRY, 1967; SINGH, 1978; ARAVINDAKSHAN et al, 1979; DAHSHAN and HABIB, 1981; SINGH and RAM, 1983, PRAKASH and RAM, 1987) support our experimental findings that indole-3-acetic acid deficiency in the fruitlets and their pedicels play an important role in abscission of mango fruitlets.

gibberellic acid

The mean concentration of gibberellic acid were lower in fruitlets about to abscise (42.3, 54.0, 42.8%) and their pedicles (50.3, 51.0 and 46.5%) as compared with the intact fruitlets and their pedicels at pin, pea and marble stage, respectively (table II). The concentrations of gibberellic acid showed a similar patterns in fruitlets and pedi-

Table II
Mean concentrations of gibberellic acid (10^{-9} g/g) on fresh and weight basis, in intact and about to abscise fruitlets and their pedicels in Dusheri mango at pin head, pea and marble developmental stages of the fruit.

Material collected		*Fruitlet*			*Pedicel*		
		Pin head	*Pea*	*Marble*	*Pin head*	*Pea*	*Marble*
First year	Intact fruitlet						
	Fresh weight basis	1130	1740	1890	900	1065	1226
	Dry weight basis	1740	2320	2450	1200	1325	1445
	About to abscise fruitlet						
	Fresh weight basis	626	840	1218	450	510	643
	Dry weight basis	960	1120	1580	600	635	755
Second year	Intact fruitlet						
	Fresh weight basis	1000	1890	2010	810	880	1060
	Dry weight basis	1540	2520	2610	1080	1100	1240
	About to abscise fruitlet						
	Fresh weight basis	604	830	1013	401	444	578
	Dry weight basis	930	1100	1309	530	554	680
Mean decrease(1) (%)		42.3	54.0	42.8	50.3	51.0	46.5

(1) Mean decrease (%) exhibits a decrease of mean concentration of GA_3 in about to abscise fruitlets/pedicels as compared with intact fruitlets/pedicels.

Table III
Mean concentrations of abscisic acid (10^{-9} g/g) on fresh and weight basis, in intact and about to abscise fruitlets and their pedicels in Dusheri mango at pin head, pea and marble developmental stages of the fruit.

Material collected		*Fruitlet*			*Pedicel*		
		Pin head	*Pea*	*Marble*	*Pin head*	*Pea*	*Marble*
First year	Intact fruitlet						
	Fresh weight basis	2140	1610	1300	1000	780	510
	Dry weight basis	3290	2140	1690	1330	970	600
	About to abscise fruitlet						
	Fresh weight basis	3270	1970	1490	1180	1030	660
	Dry weight basis	5030	2620	1930	1570	1280	770
Second year	Intact fruitlet						
	Fresh weight basis	2020	1510	1220	940	710	600
	Dry weight basis	3110	2020	1580	1250	880	700
	About to abscise fruitlet						
	Fresh weight basis	2710	1940	1680	1060	930	780
	Dry weight basis	4170	2580	2180	1410	1160	910
Mean increase(1) (%)		30.4	20.2	20.5	15.5	31.9	29.2

(1) Mean increase (%) exhibits an increase of mean concentration of ABA in about to abscise fruitlets/pedicels as compared with intact fruitlets/pedicels.

cels during both years (table II). The lower concentration of gibberellic acid in the fruitlets and their pedicels seem to play an important role in causation of fruitlet abscission of mango. The exogenous application of gibberellic acid (40 ppm) at prebloom stage has been reported to reduce fruitlet abscission of Dusheri mango (RAM, 1983) and also support our experimental results that lower concentrations of gibberellic acid in fruits and their pedicels have been associated with fruitlet abscission. Likewise, using bioassay, RAM (1992) has also reported that lower levels of gibberellin-like substances coupled with higher levels of inhibitors appeared to cause fruit drop in mango. Nevertheless, since 90 gibberellins have been characterised and identified (GASKIN and MACMILLAN, 1991), further work on the identification of different gibberellins from seed and pericarp mango fruit and pedicel as well as their role in fruitlet abscission needs to be done.

abscisic acid

The fruitlets about to abscise and their pedicels showed higher mean concentrations of abscisic acid (30.4, 20.2, 20.5% and 15.5, 31.9, 29.2%) compared with intact fruitlets and their pedicels at pin head, pea and marble stage, respectively (table III). The fruitlets and pedicels showed a similar trend during 2 consecutive years of study (table III). The higher concentrations of abscisic acid in fruitlets about to abscise and their pedicels seems to play a role in fruitlet abscission of mango. Abscisic acid and abscisic acid-like substances have also been ascribed to cause fruit drop in *Citrus unshiu* (TAKAHASHI et al, 1975), *Prunus persica* (MARTIN and NISHIJMA, 1972; YAMAGUCHI and TAKAHASHI, 1976), *Pyrus pyrifolia* (MARTIN et al, 1980) and also abscission of other plant organs (ADDICOTT, 1983). It may also be argued that higher levels of abscisic acid in fruitlets and pedicels stimulate ethylene production as a result of abscisic acid-induced ethylene production which may cause fruitlet abscission in mango. Likewise, it has been demonstrated that enhanced ethylene biosynthesis is involved in the abscission of young mango fruitlets (VAN LELYVELD, 1982; NUNEZ-ELISEA and DAVENPORT, 1986). Our experimental results also indicate that concentrations of

indole-3-acetic acid, gibberellic acid and abscisic acid in the pedicels were similar to those in the fruitlets tested at three developmental stages of the fruit. It may also be argued that, after the biosynthesis of these phytohormones in the fruitlets, presumably translocated into the pedicels and abscission zone to trigger the biosynthesis of hydrolytic enzymes which initiate formation of abscission layer (SEXTON and ROBERTS, 1982). The abscission layer in pedicels can be formed at any stage of mango fruit development because the pedicel possesses a predetermined abscission zone (SINGH, 1961). Thus the hormonal imbalance in the pedicel and/or fruit may cause fruitlet abscission in mango. Abscisic acid appeared to play a role in the fruitlet abscission directly or through abscisic acid induced ethylene production. However, the deficiency of indole-3-acetic acid and gibberellic acid in the pedicels and developing fruitlets may be another factor contributing in the process of fruitlet abscission of mango. Earlier reports of PRAKASH and RAM (1986) and BAINS (1992) also support this hypothesis that exogenous application of 2,4-D, IAA or GA_3 has substantially reduced fruit drop in mango. In conclusion, it appears that fruitlet abscission in mango is associated with lower levels of IAA, GA_3 and higher levels of abscisic acid in pedicels and fruitlets.

acknowledgments

We would like to thank Ms RK Jamwal, Regional Research Laboratory, CSIR, Jammu, India for her help in quantitation of indole-3-acetic acid, gibberellic acid and abscisic acid on Gas Liquid Chromatograph. We are also thankful to Dr V Kesavan, Western Australian Department of Agriculture, Kununurra and Dr D Turner, University of Western Australia, for critically reading this manuscript.

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Abscisión de los mangos jóvenes. I. Relación con los contenidos endógenos de AIA, giberelina y ácido absícico en los pedúnculos y los frutos.

RESUMEN

INTRODUCCIÓN. Se estudiaron las relaciones existentes entre la absición de frutos jóvenes y los contenidos internos de ácido indolacético (AIA), giberelina (GA_3 o ácido giberélico) y ácido abscísico de los tejidos del pedúnculo y la pulpa de mangos jóvenes. **MATERIAL Y MÉTODOS.** Se muestrearon mangos jóvenes de la variedad Dusheri y sus pedúnculos, ya sea intactos o próximos de la abscisión, en tres etapas diferentes de su desarrollo. **RESULTADOS Y DISCUSIÓN.** El estudio reveló que, en las tres etapas de desarrollo consideradas (cabeza de alfiler, guisante y manchón), los tejidos de los frutos jóvenes próximos de la abscisión presentaban una disminución de su concentración media de AIA y giberelina y un aumento de proporción de ácido abscísico respecto a los tejidos de los frutos jóvenes intactos. Del mismo modo, comparados con los de los frutos intactos de cada una de las etapas estudiadas, los pedúnculos de dichos frutos presentaron una disminución de su concentración media de AIA y AG_3, así como un aumento de su contenido de ácido abscísico. Por consiguiente, la abscisión de los frutos jóvenes del mango parece estar asociada con contenidos inferiores de AIA y concentraciones más elevadas de ácido abscísico en los pedúnculos y los frutos.

PALABRAS CLAVES

India, *Mangifera indica*, fruto, etapas de desarrollo de la planta, sustancias de crecimiento vegetal.