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Effect of time and width of girdling on flowering and yield of mango (*Mangifera indica* L.) cv. Alphonso

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Abstract
The experiment was laid out in Randomized block design with factorial concept comprising four treatments of girdling width viz., 0.75 cm (W_1), 1.00 cm (W_2), 1.25 cm (W_3) and 1.50 cm (W_4) and three treatments of girdling time i.e. 15th July (T_1), 15th August (T_2) and 15th September (T_3) of girdling time as along with control. The treatments were replicated thrice. Results of present investigation revealed the girdling treatment during 15th July with girdled width of 1.50 cm was significantly influenced maximum percentage of fruit set at harvest stage, fruit weight (g), volume of fruit pulp (ml), number of fruits per shoot and fruit yield (kg/plant) compared to other treatments.

Keywords: Width, girdling, flowering, yield mango (*Mangifera indica* L.) cv. Alphonso

Introduction
Orchardists have practiced the use of girdling and related techniques in horticulture since last few decades in order to increase the fruit production. The culture of fruit trees is geared toward production of a high-value crop, reduce fruit drop integrating quantity and quality. This is achieved by various techniques; including breeding, nutrition, pest control and bio-regulators as well as direct manipulations of the plant itself. Direct plant manipulations leading to the desired yield consist of two kinds of horticultural techniques. Removal of certain tree organs (e.g. training, pruning, fruit thinning) and interference with translocation between major tree organs (e.g. girdling, ringing, scoring, branch bending, which modifies auxin distribution, may be included in this second category). Fruit trees might be viewed as a system of sinks and sources (leaves, reproductive organs and roots) interconnected via vascular organs (trunk, branches and scaffold roots). Girdling is basically an intervention in the phloem transport between canopy and roots, in an attempt to manipulate the distribution of photosynthate, mineral nutrients and plant bio-regulators (Goren *et al*., 2004) [9].
Pattern of movement and distribution of 14 C - photosynthate in mango at various stages of flowering and fruit development, the immediate and most direct reason for the heavy drop of fruit lets is the competition between them for a limit supply of photo-assimilates, as well a competition from developing shoots for these substances. Girdling generally causes an accumulation of carbohydrate above the girdle and a diminution of carbohydrates in the root system (Noel, 1970; Wallerstein *et al.*, 1974 and Wallerstein *et al.*, 1978) [15, 24, 23]. It would be there for expected that the number of fruit retained by bearing mango trees would be increased by girdling before fruitlets begin to drop (Chacko, 1984) [3]. Wide varieties of fruit species are girdled to induce flowering, improving fruit set, enlarge fruit size, advance maturity and increase yields. Grape, mango, litchi, orange, peach, olive, avocado, apple *etc*. have responded in these areas. With this back ground, the present study on "Effect of time and width of girdling on flowering, yield of mango (*Mangifera indica* L.) cv. Alphonso".

Materials and methods
The experiment was conducted at Agriculture Experimental Station, Navsari Agricultural University, Paria, which is situated at Valsad district of Gujarat state at elevation of 10 meter above mean sea level latitude of 200.44' N and east 720.94' E longitude and Regional Horticultural Research Station, Navsari Agricultural University, Navsari. Geographically Navsari is situated at 200.92'N latitude and 720.89'E longitude and at an elevation of 13 meter above mean sea level.

The experiment was laid out in randomized block design with factorial concept comprising four treatments of girdling width viz., 0.75 cm (W_1), 1.00 cm (W_2), 1.25 cm (W_3) and 1.50 cm (W_4) and three treatments of girdling time i.e. 15th July (T_1), 15th August (T_2) and 15th September (T_3) of girdling time as along with control.

Girdling practiced mainly on secondary branches (50-60%) of the plants. Selected healthy plants having five or more than five secondary branches. Use of sharp pruning saw and small scale measurement tape for management of proper width of girdled portion. Girdling was done very carefully without damage of xylem tissue, only cut were made between peel and xylem. After girdling, applied the copper oxychloride 50% WP paste on girdled portion for protection of girdled portion.

Results

Percentage of fruit set at harvest stage: The data presented in Table 1. revealed that fruit percentage at harvest stage was significantly highest fruit percentage was found in 1.50 cm girdling width (W_4) treatment in pooled analysis (1.52%). While minimum percentage of fruit set was observed in 0.75 cm girdling width treatment (W_3) treatment (1.00%) which was at par with W_2. Also different girdling time was significantly influenced on fruit set percentage at harvest stage. Among the different girdling time, girdling during 15th July (T_1) treatment produced significantly highest percentage fruit set at harvest stage (1.40%). While, girdling during 15th September (T_3) treatment produced significantly lowest fruit set percentage at harvest (1.05%).

Fruit Weight: Significantly maximum fruit weight (g) was obtained with 1.50 cm of girdling width (W_4) treatment (301.66 g). While, minimum fruit weight was noted in 0.75 cm of girdling width (W_1) treatment (269.53 g) which was at par with W_2 treatment (Table 2). Girdling during 15th July (T_1) treatment produced significantly maximum fruit weight (293.49 g) which was statistically at par with T_2 treatment. While, the minimum fruit weight (g) was obtained in girdling during 15th September (T_3) treatment (268.84 g) which was statistically at par with T_2 treatment (Table 2).

Volume of Pulp: Significantly the maximum volume of pulp (ml) was obtained with 1.50 cm of girdling width (W_4) treatment (190.55 ml) which was statistically at par with W_3 treatment. While, minimum volume of pulp (ml) was noted with 0.75 cm of girdling width (W_1) treatment (165.02 ml) which was statistically at par with W_2 treatment (Table 2). Girdling during 15th July (T_1) produced significantly maximum pulp volume (184.73 ml) which was statistically at par with T_2 treatment. While, the minimum volume of pulp (ml) was obtained in T_3 treatment (Table 2).

Number of fruits per shoot: Significantly highest number of fruits per shoot was noted in 1.50 cm of girdling width (W_4) treatment (2.06), significantly the lowest number of fruits per shoot (Table 2) was observed in 0.75 cm of girdling width (W_1) treatment (1.59) which was at par with W_2 and W_3 treatment. Among the different girdling time, girdling during 15th July (T_1) produced significantly highest number of fruits per shoot (1.99). While, 15th September (T_3) produced significantly lowest number of fruits per shoot (1.62) which was at par with T_2 treatment.

Fruit Yield: Maximum yield (kg/plant) was recorded in 1.50 cm of girdling width (W_4) treatment (97.42 kg/plant). While, lowest yield was noted in 0.75 cm of girdling width (W_1) treatment (81.75 kg/plant) which was at par with W_2 and W_3 treatments (Table 2). Girdling in 15th July (T_1) treatment produced significantly maximum yield (94.20 kg/plant). While, the minimum yield (kg/plant) was obtained in T_3 treatment (81.57 kg/plant) which was statistically at par with T_2 treatment.

Control *vs* Rest

The control *vs* rest of the treatment (Table 2) on fruit weight, volume of pulp (ml), number of fruits per shoot, Fruit yield (kg/plant), were significantly affected with different treatments of girdling width and girdling time.

Table 1: Effect of time and width of girdling on flowering attributes of mango (*Mangifera indica* L.) cv. Alphonso.

Treatments	Days taken to flowering	Length of flowering shoots (cm)	Hermaphrodite to male flower ratio	Percentage of fruit at harvest stage
Width of Girdling (W)				
W_1	124.88	25.17	0.24	1.00
W_2	122.73	24.13	0.25	1.16
W_3	121.29	25.55	0.24	1.18
W_4	117.38	25.54	0.26	1.52
S.Em.±	4.20	0.86	0.01	0.05
C.D. at 5%	NS	NS	NS	0.13
Time of Girdling (T)				
T_1	116.37	25.03	0.26	1.40
T_2	122.60	25.17	0.24	1.19
T_3	125.74	24.84	0.24	1.05
S.Em.±	3.64	0.74	0.01	0.04
C.D. at 5%	NS	NS	NS	0.11
Interaction effect (W x T)				
S.Em.±	7.28	1.49	0.01	0.08
C.D. at 5%	NS	NS	NS	NS
CV%	14.72	14.42	14.64	15.81
Treated *vs* Control				
Treated Mean	121.57	25.35	0.25	1.21
Control	130.09	23.41	0.21	0.82
S.Em.±	7.57	1.55	0.02	0.08
C.D. at 5%	NS	NS	NS	0.17

Table 2: Effect of time and Width of girdling on yield of mango (*Mangifera indica* L.) cv. Alphonso.

Treatments	fruit weight (g)	Volume of pulp (ml)	Number of fruits per shoot	Fruit yield (kg/plant)
Width of Girdling (W)				
W_1	269.53	165.02	1.59	81.75
W_2	270.36	167.38	1.73	84.37
W_3	282.37	174.82	1.78	88.04
W_4	301.66	190.55	2.06	97.42
S.Em.±	4.21	2.75	0.07	2.25
C.D. at 5%	11.97	7.82	0.19	6.40
Time of Girdling (T)				
T_1	293.49	184.73	1.99	94.20
T_2	280.62	172.87	1.76	87.91
T_3	268.84	165.73	1.62	81.57
S.Em.±	3.65	2.38	0.06	1.95
C.D. at 5%	10.37	6.77	0.16	5.54
Interaction effect (W x T)				
S.Em.±	7.29	4.77	0.11	3.90
C.D. at 5%	NS	NS	NS	NS
CV%	6.40	6.70	15.12	10.70
Treated *vs* Control				
Treated Mean	280.98	174.44	1.79	87.89
Control	246.73	150.19	1.13	71.89
S. Em. ±	7.59	4.96	0.12	4.06
C.D. at 5%	15.26	9.97	0.24	8.16

Discussion

Different girdling widths were reacted in a different way to the flowering parameters. Among the different girdling widths, maximum percentage of fruit set at harvest stage was significantly influenced in 1.50 cm girdling width (W_4) treatment and minimum percentage of fruit set noticed in 0.75 cm girdling width (W_1) treatment. This might be due to the phloem stress by girdling on the branch. Actually girdling block the transport of sugars to the roots, large amount of carbohydrates produced by photosynthesis will accumulate in vegetative organs above the girdling, the enhancement of carbohydrate availability has been associated with an improvement fruit set percentage (Gaskins, 1963 and Oothuyse, 1990) [6, 16]. The similar confiding were found by Hossain and Boyce (2009) [11] in fig; Cotrut and Stanica (2015) [4] in ber; Khandekar *et al.* (2011) [13] in jamun. 15th July girdling time (T_1) gave significantly maximum fruit set (%) and minimum fruit set (%) observed in 15th September girdling time (T_3). This might be due to the environmental conditions and 15th July treatment is one and two month before than other treatments. Early girdling increased carbohydrates continuously as compare to later girdling. So this might be the main reason for accumulation of carbohydrate which was more in 15th July girdled than both times and after July treatment. This higher content of accumulated carbohydrate help to increased in fruit set percentage.

Maximum fruit weight (g) and volume of pulp (ml) were found in 1.50 cm girdling width (W_4) treatment and while, minimum fruit weight (g) and volume of pulp (ml) were recorded in 0.75 cm girdling width (W_1) treatment. This might be due to the girdling severes phloem vascular vessels thereby preventing translocation of photosynthates from the source to sinks located below the girdled until the wound heals. Thus, girdling has an indirect effect of reducing sink size and increasing the amount of photosynthates available to fruits and other active meristems above the girdled region and which lead in improvement of fruit weight and volume of pulp (Poll-van Der *et al,* 1991) [17]. The similar trends were found by Tuan *et al.* (2012) [22] in apple; Goldschmidt *et al,* (1999) [7] and Goren *et al*. (2003) [10] in citrus. Nearer to similar findings were also reported by Reddy and Prakash (1989) [20] and Desouza *et al.* (2010) [5] in grape; Rani and Brahmachari (2002) [19] in litchi.

Significantly highest number of fruits per shoot, yield kg per plant were significantly influenced in 1.50 cm girdling width (W_4) treatment and while, minimum conformed in 0.75 cm girdling width (W_1) treatment. It is might be due to girdling can improved carbohydrate availability to fruits and as a consequent lead to an increased fruit set percentage with decreased bud drop due to branch girdling and also which leads to increased maximum number of fruit per shoots and maximum fruit weight which help to increased fruit yield kg per plant in same treatment (Goren *et al.,* 2003) [10]. Thus, our results could be in agreement with the findings of Hossain and Boyce (2009) [11] in fig; Khandekar *et al*. (2012) [14] apple and Rakshe *et al.* (2013) [18] and Shinde *et al*. (2014) [21] in mango.

Fruit weight (g) and pulp volume (ml), showed significantly maximum in 15th July of girdling time (T_1) treatment as compare to 15th August (T_2) and 15th September (T_3) treatments. The increased in carbohydrate level in the leaves increased in fruit retention and girdling application ascribed to increased level of carbohydrates. Carbohydrate availability to fruits and as a consequent lead to an increased fruit set percentages with decreased bud drop due to branch girdling. Nearer to same finding also discovered by with Rakshe *et al*. (2013) [18] in mango, Tuan *et al.* (2012) [22] and Khandekar *et al.* (2012) [14] in apple and Hossain *et al*. (2006) [12] in peach.

Number of fruits per shoot and fruit yield kg per plant were significantly influenced by 15th July girdling time (T_1) treatment which was superior over other girdling time. This might be due to the 15th July girdling time (T_1) treatment in which accumulation of carbohydrate was higher than other treatments. The enhancement of carbohydrate availability has been associated with fruit set and number of fruits per shoots which leads to increased yield attributes *viz.,* yield kg per plant and yield tons per hectare. These finding are in agreement with Wright (2000) [25] and Shinde *et al.* (2014) [21] in mango; Ahmad and Zargar (2005) [2] and Abu-Zahra (2010) [1] in grape.

In case of control *vs* rest of the treatment maximum percentage of fruit set at harvest stage, fruit weight (g), volume of fruit pulp (ml), number of fruits per shoot and fruit yield (kg/plant) was significantly perform better in all girdled treatment than the control (un-girdled treatment). This is might be due to the phloem stress by girdling. Girdling blocked the transport of sugars to the roots, large amount of carbohydrates produced by photosynthesis will accumulate in vegetative organs above the girdling which leads to increased fruit set percentage. The similar confiding were found by Goren *et al.,* (2003) [10] in citrus and Gaskins (1963) [6] and Oothuyse (1990) [16] in mango. Girdled treatment gave maximum number of fruits per shoots and yield kg/plant over the control. This might be due to the girdling interruption of the phloem pathway and hence temporarily stop the downward flow of carbohydrates, has been utilized experimentally for increasing fruit weight as well as increased pulp volume (ml) and seems to be quantitatively correlated with carbohydrate availability (Goldschmidt *et al,* 1985) [8]. The enhancement of carbohydrate availability has been associated with an improvement fruit weight (g) as well as increased pulp volume (ml) by more carbohydrate accumulation in girdled branches which leads to increased fruit yield kg per plant. Similar findings were reported by Tuan *et al.* (2012) [22] in apple; Goldschmidt *et al.,* (1999) [7] and Goren *et al.,* (2003) [10] in citrus.

Summary and Conclusion

On the basis of results obtained in the experiment, it can be concluded that girdling during 15th July with 1.50 cm width gave maximum percentage of fruit set at harvest, fruit weight, pulp volume, number of fruits per shoots, yield kg per plant. From present study it can be inferred that the girdling during 15th July with 1.50 cm width were proved beneficial for improving flowering and fruiting parameters of fruit of mango cv. Alphonso.

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