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Enhancing Pawpaw Chip Budding Success

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Abstract

The pawpaw [*Asimina triloba* (L.) Dunal] is gaining popularity as a commercial tree fruit. Pawpaw cultivars are usually propagated by chip budding. The objectives of this study were to determine 1) if leaving 6 to 8 leaves on pawpaw rootstock upon chip budding improved budding success and scion growth in greenhouse-grown container production and 2) if genetic background of the seedling rootstock or scion affected chip budding success or scion growth. An experiment was conducted using a three-way factorial design with six replicate blocks, with treatments of two scions ('Sunflower' and 'Susquehanna'), two seedling rootstocks (Sunflower and K8-2), and two leaf treatments (removing leaves vs. leaving 6-8 leaves at budding). Trees were chip-budded in late June 2006. Retaining leaves on the rootstock seedling increased scion bud break (76%) on rootstocks compared to budding onto rootstocks with all leaves removed (54%). Removal of the remaining rootstock leaves after 6 weeks had an additional positive effect. After leaf removal at 6 weeks, an additional 11% of buds broke on rootstocks that had previously retained their leaves. Only 1% more buds broke after the 6 week point on rootstocks that had leaves removed from the beginning. The K8-2 seedling rootstock had a higher budding success (80%) than Sunflower seedling rootstock (62%). Although cutting back the rootstock and removing competing leaves at the time of chip budding would be more convenient and require less labor for nurseries, this practice cannot be recommended due to the reduced chip budding success (55% vs. 87%).

The North American pawpaw is a high-value tree fruit crop and edible landscape plant that is gaining popularity in the United States (6). Historically, pawpaw has been a challenging species to propagate (2). Pawpaw trees develop a strong taproot with a fragile root system, which can be easily damaged upon digging; therefore, many commercial nurseries in the United States propagate pawpaw trees in containers (5). Over 40 pawpaw cultivars are propagated clonally by grafting or budding with scionwood from superior trees onto common seedling rootstock of diverse genetic origin (3, 6).

Pawpaws can be propagated by several cloning methods, such as grafting and budding. These techniques include whip-and-tongue, cleft, bark inlay, and chip budding (1, 2, 3, 8). Chip budding is reportedly most successful when using winter-collected, dormant scion budwood, with its chilling requirement fulfilled, and seedling rootstock that is actively growing and is at least pencil thick (6 mm) in diameter (3). Although no data were presented, based on experience Layne (3) recommended chip budding onto actively growing rootstock, after which the top of the stock should be cut back to 30 to 60 cm in height, leaving six or more functional lower leaves to support the development of the scion bud. After scion growth commences, all competing buds are rubbed off the rootstock. Thus apical dominance is reduced, enabling the bud to grow actively while maintaining photosynthesis to supply carbohydrates and nutrients for the developing scion. Once the scion is at least 30 cm long, the lower leaves on the stock are removed and the stock is cut back to a height of 20 to 25 cm above the union. Cutting back the rootstock at the time of chip budding would be more convenient and require less labor for nurseries; however the chip budding success of such an approach has not been reported.

No clonal rootstocks are currently available for use with pawpaw cultivars. Variation in scion growth and suckering on rootstocks of diverse genetic origin has been observed in the pawpaw trial at Kentucky State University

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(KSU; unpublished data). Grafted pawpaw trees will begin flowering by two years after planting; however, most trees will not set fruit until four or five years after planting (4, 7). The ability of the grafted trees to set or retain fruit clusters appears to be dependent on tree size and vigor. Identification of vigorous seedling rootstocks that would result in greater tree uniformity and promote early bearing would be desirable to growers. The objectives of this study were to determine 1) if leaving 6 to 8 leaves on pawpaw rootstock upon chip budding promoted budding success and scion growth in greenhouse-grown container production and 2) if genetic background of the seedling rootstock or scion affected chip budding success or scion growth.

Materials and Methods

A three-way factorial randomized complete block design was conducted to determine best chip budding practices for pawpaw. The treatments consisted of 2 scions, 'Sunflower' and 'Susquehanna', 2 open-pollinated seedling rootstocks, Sunflower and K8-2, and 2 leaf treatments, removing all leaves at time of grafting or leaving 6-8 leaves on the rootstock; with 9 trees (subsamples) per rep, and 6 replicate blocks, blocked by grafting date (21, 22, 23, 26, 27, and 28 June, 2006) for a total of 216 trees. These seedling rootstocks were chosen because seedlings of the cultivar 'Sunflower' display high vigor and seedlings of K8-2 low vigor in greenhouse container experiments at KSU (data not shown).

One-year-old rootstock was used for the chip budding experiment. The rootstock trees were grown from seed which was extracted from fruit of the pawpaw cultivar 'Sunflower' and the KSU advanced selection K8-2 which are grown in orchards at the KSU Research and Demonstration Farm (Frankfort, Ky.). Seed was stratified at 5°C for at least 3 mo. in moist peat moss and sown to a depth of 3 cm in February 2005 into 4 L Treepots (Stuewe and Sons, Corvallis, Ore.) containing ProMix – BX (Premier Horticulture, Red Hill, Pa.) with Osmocote 14-14-14 (3 to 4 month release product; Scotts Co., Marysville, Ohio) at a rate of 2.22 $kg \cdot m^{-3}$, and placed in the greenhouse under supplemental lighting (5). Seedling germination rates were similar for both seedstocks (90%). The seedlings were allowed to grow for 8 mo., and then overwintered at 4°C. The seedlings were then brought back into the greenhouse to resume growth in April 2006.

Scionwood was collected in March 2006 from dormant 'Sunflower' and 'Susquehanna' grafted trees in the KSU research orchards. The scionwood was stored in resealable plastic storage bags at 4°C after the ends were dipped in paraffin to prevent desiccation. The trees were chip budded from June 21-28, 2006 as described by Layne (3). Large vegetative buds were used in chip budding and every attempt was made to match the diameter of the budwood with that of the rootstock plant. Vegetative buds occur oppositely and alternately on pawpaw trees, and branching usually occurs in one plane. Rootstock plants were chip budded on the side perpendicular to this plane to reduce confusion with rootstock shoots. Parafilm M Laboratory Film (Pechiney Plastic Packing, Menasha, Wis.) was used to wrap the bud to the rootstock plant. Expanding buds easily penetrated the Parafilm M and the film degenerated over time and was not actively removed. Immediately after chip budding, the following treatments were implemented: 1) removing all leaves at time of grafting, cutting back the rootstock to about 10 cm above the chip bud or 2) cutting back the stock to about 30 cm above the chip bud and leaving 6-8 leaves on the rootstock plant. Layne (3) recommended that once scion growth commences, the top of the rootstock should be cut back to 30 to 60 cm in height, leaving six or more functional lower leaves, and rubbing off the competing buds on the rootstock. Unlike the protocol of Layne (3), in this study the stock was cut back to about 30 cm after budding, the growing tips were removed at budding, and new shoot tips were pinched back weekly to reduce competition with the developing scion bud in treatment #2. Rootstock leaves were removed 6 wk after budding. Scion leaf number was counted weekly from July to October. Scion diameter was measured 22 wk after budding.

Treepots were watered at least weekly to runoff during germination. Additionally, seedlings were also fertilized with 250 mg•L^{-1} N using Peters (Scotts Co., Marysville, Ohio) 20N-8.6P-16.6K water-soluble fertilizer plus soluble trace elements each week after emergence. Seedlings were grown in a white-washed greenhouse under a 16-h photoperiod supplemented by high pressure sodium lights. Photosynthetic photon flux was measured at canopy level on a clear sunny representative day at 1200 h at 1200 µmol•m^{-2}•s^{-1} using a LiCor LI-185B photometer with a quantum sensor (LiCor, Lincoln, Nebr.). Mealybugs (*Planococcus citri* Risso) can move under chip buds and prevent the bud from forming a vascular connection with the rootstock plant. Mealybugs were controlled with two applications of imidacloprid (Marathon, Olympic Horticultural Products, Mainland, PA) during the summer of 2006.

Data on scion leaf number, bud take, and diameter were subjected to GLM analysis of variance and GLM regression analysis using the statistical program Costat (CoHort Software, Monterey, Calif.). Means were separated using a Student's t test (P≤ 0.05).

Results and Discussion

Six weeks after budding, chip budding success was the same regardless of scion or rootstock cultivar; however, retaining leaves at budding significantly improved bud take. No significant interactions occurred among the main effects (Table 1). There were trends for 'Susquehanna' buds to have a better success rate than 'Sunflower' buds, and for chip buds on K8-2 rootstock to have a higher success rate than those on Sunflower rootstock; however, these trends were not significant. Scion leaf number was unaffected by scion or rootstock (Table 1).

Retaining 6-8 leaves at budding resulted in a higher percentage of bud take than when all leaves were removed, this prior to leaf removal at 6 wk (Table 1). While rootstock leaf retention was beneficial for budding success, it subsequently reduced scion growth compared to the leaf removal treatment (Table 1). We attribute this to competition between the scion shoot and remaining rootstock leaves

Table 1. Chip budding success, expansion of the scion bud to at least one leaf, and scion growth of the pawpaw *(Asimina triloba)* cultivars 'Sunflower' and 'Susquehanna' on seedling rootstock from 'Sunflower' and K8-2, with and without supporting rootstock leaves, and before and after rootstock leaf removal.

	Chip bud success (%)		Scion growth (number of leaves)		Scion Diameter (mm)[x]
	before leaf removal[z]	after leaf removal[y]	before leaf removal	after leaf removal	
Scion					
Sunflower[w]	58[ns]	64[ns]	7.2[ns]	7.6[ns]	5.3[ns]
Susquehanna	71	78	6.3	7.6	4.7
Rootstock					
K8-2	72[ns]	80*	6.5[ns]	7.4[ns]	5.0[ns]
Sunflower	57	62	7.0	7.8	4.9
Leaf removal treatment					
Leaves remaining	76*	87*	5.5*	6.3*	4.5*
Leaves removed	54	55	8.0	8.9	5.5

[z] before being cut back - 8/25/06
[y] after being cut back - 9/22/06
[x] at 10 cm from the base of the bud 12/13/06 or 22 weeks after budding
[w] ns = means not significantly different. *means significantly different using a Student's t test (P≤0.05).

and shoots that develop at the axils of leaves.

Four weeks after removal of the 6-8 leaves that had been retained at budding, chip budding success was not significantly different between the two scion cultivars; however, rootstock significantly influenced chip budding success, with K8-2 having greater budding success than Sunflower (Table 1). No significant interactions occurred among the main effects. Neither scion nor rootstock affected scion leaf number 4 wk after leaf removal (Table 1).

When the 6-8 leaves retained at budding were removed, additional scion buds broke that had been dormant. After leaf removal, the percentage of buds that expanded increased from 76% to 87% for chip buds that had retained leaves at budding (Table 1). It is likely that competing shoots that would occasionally form at the leaf axils of the retained leaves had inhibited bud break in some trees. Scion leaf number remained lower for trees that had 6-8 leaves at budding at 4 wk after leaf removal (Table 1).

By 22 wk after chip budding, trees had set terminal buds. At this time, no significant differences were found in scion diameter for the scion cultivar or rootstock main effects; however, retaining leaves at budding significantly reduced scion diameter; there were no significant interactions (Table 1). The competition between the scion shoot and remaining rootstock shoots likely resulted in reduced growth of the scions.

When the individual scion/rootstock chip budding success is plotted over the course of the experiment, it is apparent that additional buds expanded, or broke, after the 6-8 retained leaves were removed (Fig. 1). One scion/rootstock combination ('Susquehanna'/K8-2) displayed a high chip budding success rate (85%) when cut back at budding so that no rootstock leaves were retained. We do not know why the 'Susquehanna'/K8-2 (scion/rootstock) combination was so successful in chip budding success, when the other combinations without 6-8 leaves retained at budding were so poor (<50%).

Leaf removal or retention had a significant impact on both chip budding success and scion leaf number, supporting the observations of Layne (3). Chip-budded pawpaws which had 6-8 leaves remaining for 6 wk on the rootstock seedling had a higher percentage bud take than chip-budded pawpaws on which the rootstock's leaves had been removed when budded. Additional chip buds expanded when the leaves were removed after 6 wk. The rootstocks in this study were chosen because seedlings of the cultivar 'Sunflower' display high vigor and seedling of K8-2 low vigor in previous greenhouse container experiments at KSU (data not shown). Chip budding onto the K8-2 rootstock was very successful when leaves were retained at budding but then removed at 6 wk. The reduced vigor of the K8-2 rootstock may have allowed more photosynthate to be allocated for graft union development.

Budded pawpaw trees which had the rootstock's leaves removed had a higher scion leaf number than grafted trees on which leaves were retained. While rootstock leaf retention was beneficial for graft union development, the resulting scions had fewer leaves. This is likely due to competition between the scion shoot (apical dominance) and remaining rootstock shoots. Pawpaw chip-bud emergence improved by retaining leaves on the rootstock to support the scion budbreak and growth. However, it is beneficial to remove these leaves after 6 wk to encourage scion growth.

In conclusion, retaining 6-8 leaves on pawpaw rootstock at chip budding can improve chip budding success. However, retained leaves should be removed by cutting back the rootstock to about 30 cm above the chip bud about 6 wk after budding to maximize bud break. The K8-2 seedling rootstock (80%) had a higher bud take than did the Sunflower seedling rootstock (62%). Although cutting back the rootstock and removing the competing leaves at the time of chip budding would be more convenient and require less labor for nurseries, this practice is not recommended due to the reduced budding success.

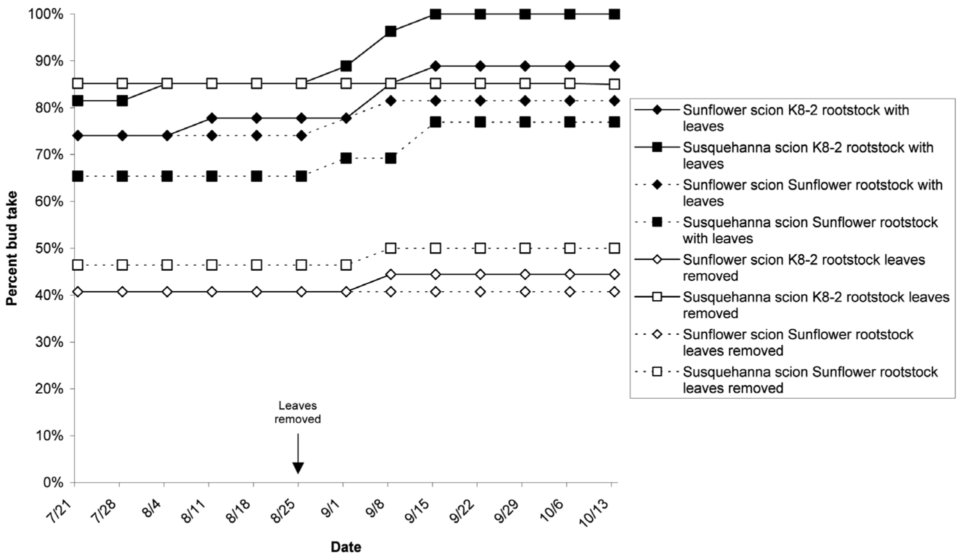

Fig. 1. Percentage bud take, defined as bud expansion to at least one leaf, of 'Sunflower' and 'Susquehanna' pawpaws on two seedling rootstocks in greenhouse-grown container production from late July until late October. Leaves that were retained at budding were removed from trees on 8/25/2006, as indicated by the arrow. Dates are shown as month/day.

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Literature Cited

1. Davis, C. 1974. The paw paw in Southern Michigan. Calif. Rare Fruit Growers Year-book 6:181-187.
2. Geneve, R., S. Kester, and K. Pomper. 2003. Autonomous shoot production in pawpaw (*Asimina triloba* (L.) Dunal). Propagation of Ornamental Plants 7:51-56.
3. Layne, D.R. 1996. The pawpaw [*Asimina triloba* (L.) Dunal]: a new fruit crop for Kentucky and the United States. HortScience 31:777-784.
4. Pomper, K. W., D. R. Layne, R. N. Peterson, and D. Wolfe. 2003. The pawpaw regional variety trial: background and early data. HortTechnology 13:412-417.
5. Pomper, K. W., D. R. Layne, and S. C. Jones. 2003. Container production of pawpaw seedlings. HortTechnology 13:434-438.
6. Pomper, K.W. And D.R. Layne. 2005. The North American pawpaw: botany and horticulture. Hort. Rev. 31:351-384.
7. Pomper, K. W., S.B. Crabtree, D. R. Layne, R. N. Peterson, J. Masabni, and D. Wolfe. 2008. The Kentucky pawpaw regional variety trial. J. Amer. Pomol. Soc. 62:58-69.
8. Thomson, P.H. 1974. The pawpaw-brought up to date. Calif. Rare Fruit Growers Year-book 6:138-180.