Development of Organic Production Practices for Pawpaw on Selected Rootstocks

Final Report for LS03-151

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Principal Investigator:

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Project Information

Abstract:

Pawpaw is a unique native tree fruit; however, there is little information concerning organic culture and methods to promote early fruit production available for this new crop. The objectives of this study were to determine: 1) the optimal orchard application rate of organically approved nitrogen to enhance pawpaw tree establishment and promote growth, 2) if flame cultivation can be used to control weeds/grass competition with trees compared to straw, woodchips or glyphosate application and the cost of each treatment, and 3) if seedling rootstocks derived from two cultivars ('PA-Golden' and 'Sunflower') would enhance tree survival, growth, and flowering of pawpaw cultivars. Organically approved (OMRI) nitrogen fertilizer was applied (0, 1, 2, 3, or 4 oz of N/tree) and growth and survival of seedlings examined. About 50% of trees in all treatments survived after one year, but by the fall of the second season only about 10% of the trees survived. This poor survival rate was likely due to the addition of N to plots promoting growth of grass and weeds in plots that also spread to control plots, high rainfall totals increasing weed competition, poor organic weed control (wood chip mulch), and a continuing problem of unknown causes for poor tree establishment rates in orchards. The rate of nitrogen required by pawpaw trees for optimum growth and survival was inconclusive; however, this experiment indicated the need for a holistic approach to tree establishment. Flame cultivation with a backpack flamer was effective in controlling grass/weed coverage around mature pawpaw trees without damage to trunk. Flame cultivation was found to be 2.5 times less expensive than straw mulch (organic) but 15 times more expensive than glyphosate (conventional) for grass/weed control. Several drawbacks of flame cultivation are that it uses fossil fuel for organic crop production and weed organic matter is lost for incorporation into the soil. Pawpaw chip-bud emergence was improved by leaving 6-8 leaves on the rootstock for 6 weeks after budding to support the scion budbreak and growth. None of the seedling rootstocks examined, 'Sunflower', 'PA-Golden', and 'K8-2', provided superior survival rates or earlier flowering of cultivars, and poor pawpaw tree establishment rates continue to be a challenge to growers. Over 20 grower

workshops and five hands-on grafting demonstrations were conducted during the granting period.

Project Objectives:

Objective 1. To determine the optimal application rate of organically approved nitrogen that enhances tree establishment, growth, early flowering, and fruit production in the orchard.

Objective 2. To determine if flame cultivation can be used effectively compared to glyphosate (RoundUp) application for weed control to promote pawpaw tree establishment and growth in orchards.

Objective 3. To determine if seedling rootstocks derived from two pawpaw cultivars ('PA-Golden' and 'Sunflower') will enhance tree survival, growth, flowering, fruit set, and fruit size of four pawpaw cultivars (PA-Golden, Sunflower, Shenandoah, and K8-2) compared to rootstock produced from commercially available mixed seed. Plantings for this objective will be established at six sites in three states (KY, VA and NC), including sites at KSU, UK, and four farms. All sites will serve as demonstration orchards in the future for pawpaw production for limited resource and organic farmers.

Introduction:

The North American pawpaw [Asimina triloba (L.) Dunal] is in the early stages of commercial production and has both fresh market and processing appeal, with an intense flavor that resembles a combination of banana, mango, and pineapple (Pomper and Layne, 2005). Pawpaw is resistant to many disease and insect pests (Layne 1996), making this crop attractive to organic farmers. However, little information concerning organic production of pawpaw is available. Development of organic production recommendations would allow growers to facilitate fruit production and assist in the development of pawpaw as a niche organic crop.

The 40 or so pawpaw cultivars with excellent fruit quality that are commercially available are propagated clonally by grafting buds selected from superior trees to seedling rootstock (Pomper and Layne, 2005). There are no clonal rootstocks currently available for pawpaw. Although pawpaw cultivars budded onto seedling rootstock of diverse origin will flower 2 to 3 years after planting, they will not produce harvestable crops for 4 to 5 years after planting (Pomper et al., 2003); this compared to apple where production can begin 3 years after planting. Rootstocks have been developed for many fruit tree species to allow tolerance of certain soil-related stresses, for dwarfing, to increase yield efficiency, and to improve fruit quality (Westwood 1993). Improvements in pecan production have come as a result of vegetative propagation of selected cultivars on specific seedling rootstocks (Grauke and Pratt, 1992). Seedling rootstocks for pecan are grown from open-pollinated seed of selected cultivars, with particular seedstocks being preferred for different growing regions (Gast and Overcash, 1980, Grauke, 1991; Thompson, 1990). Differences in the percentage of nuts germinating, the earliness of germination, and the size of resulting seedlings have been reported between open-pollinated seed nuts from various cultivars (Grauke and Pratt, 1985). For production of pecan seedling rootstocks, nurseries choose seed stocks that have high levels of germinability, uniformity, and vigor (Grauke, 1991; Madden, 1978). Leaving six to eight leaves on the rootstock seedling when chip-budding pawpaw may support the scion bud and enhance bud take and scion growth. Thus, the photosynthetic activity of the remaining rootstock leaves will provide energy for the developing scion bud, until the bud has broken and initiated leaves, and is able to photosynthesize at a

level to support its own growth, when the rootstock's leaves would be pruned away. This method has not been tested to determine effectiveness and if seedstock affects chipbud take.

In pawpaw, great variation in scion growth and suckering, by rootstock of diverse genetic origin, has been observed in the pawpaw trial at KSU (unpublished data). The ability of trees to set or retain fruit clusters appears to be dependent on tree size and vigor, with 90% of trees greater than 40 mm in diameter in the KSU regional variety trial able to produce fruit. Selected seedling rootstocks for pawpaw cultivars could result in greater tree uniformity, increased orchard establishment rates, and promote early fruit production of grafted trees, thus greatly assisting limited resource farmers interested in this low input crop. Rootstock produced from seed from the same grafted cultivar may be more compatible and promote long-term survival of grafted trees; this will also lengthen the income generated from trees. Pawpaw seedling rootstocks that positively influence tree growth, flowering, fruit set, and fruit size could be selected that would greatly benefit growers.

Orchard fertilization and weed control techniques are extremely important to promote fruit tree establishment, tree growth, and fruit production (Westwood 1993). For the first two years, pawpaw growth is slow as the root system establishes itself, but thereafter it accelerates (Jones et al. 1998). Some grafted trees, such as 'PA-Golden', will begin to bear some fruit at 2 or 3 years after field planting; however, fruit production on grafted trees is best on trees 4 years old and older, and about 6 feet in height (unpublished data). Other pawpaw cultivars take longer to come into production. Fertilization of young pawpaw trees is necessary for tree growth and early fruit production. It is not known if high rates of application of nitrogen (N) would promote early bearing, or induce vegetative vigor and delay bearing in pawpaw. Development of organically approved fertilizer recommendations that maximize tree growth, but promote early fruit production need to be developed. Without some form of weed control in fruit plantings, crop yields and plant vigor will be greatly reduced (Skroch and Shribbs 1986; Brown and Glenn 1999). Mulching with wood chips or landscape fabric around pawpaw trees at the KSU farm has only been effective in controlling weeds for two years, and then replacement is needed (unpublished data).

Flame cultivation uses a torch-directed flame to kill weeds, and the flame sears the weeds causing the plant cells to rupture. Flame cultivation or weeding offers an organic alternative to herbicide use for control of grass and perennial weeds (Seifert and Snipes 1998; Parish et al. 1997; Seifert and Snipes 1996). Seifert and Snipes (1998) found that in the first year of a three year study that young cotton was more susceptible to flame cultivation than older cotton, and flaming at an LP-gas pressure of 175 kPa without watershield protection increased plant injury regardless of growth stage; however injury was not evident in following two years. Injury caused to the cotton by flame cultivation was a transient browning of lower leaf margins and the use of a watershield sprayed above the burner reduced injury. Although flame cultivation caused some injury in the first year of the study, total seed cotton and cotton lint yields were not reduced. Little information concerning the effectiveness of flame cultivation and the potential for trunk injury is available for tree fruit crops.

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Research

Materials and methods:

Objective 1.

Experiment 1. A planting was established on April 18-19, 2005 at the Kentucky State University Research Farm with pawpaw seedlings from the cultivar PA-Golden. The trees were dormant and about 18 inches in height at planting. The field was cultivated the previous year in an effort to reduce weed growth. The planting was cared for following National Organic Program Standards. On June 19, 2005, organically approved (OMRI) nitrogen was applied (0, 1, 2, 3, or 4 oz of N/tree) to determine the optimal application rate for maximum growth and survival. The OMRI approved nitrogen source applied was in the form of NatureSafe All Season Fertilizer (10−2−8; Nature Safe, Cold Spring, KY); it was decided to use this form of nitrogen instead of fish emulsion, as was initially intended, since this was an organic fertilizer that was easily available to local organic farmers. This fertilizer contained hydrolyzed feather meal, meat meal, bone meal, blood meal and sulfate of potash and contained 9.0% slow release nitrogen from hydrolyzed feather meal and meat meal. Nitrogen was reapplied in June 2006. The trees were planted in a randomized complete block design with three blocks and four replicate trees per treatment per block. Weed control was maintained by mulching with wood chips (about 10 inches in depth and two feet around each tree) applied in the spring of 2005 and 2006. The trees were irrigated as needed by trickle irrigation. Statistical analysis of data (analysis of variance and LSD means separation) was performed using CoStat statistical software.

Objective 2.

Experiment 1. A planting was established on April 18-19, 2005 at the Kentucky State University Research Farm to determine if flame cultivation could be used effectively for weed control to promote pawpaw tree establishment and growth in orchards, compared to glyphosate (RoundUp) application or wood chip mulch. Thirty-six grafted pawpaw trees of PA-Golden scions on PA-Golden rootstock and Susquehanna scions on Sunflower rootstocks that were propagated in 2004, see Objective 3, were planted in a randomized complete block design with three blocks and two replicate trees per treatment per block, and assigned weed control treatments of flame cultivation, wood chip mulching (local hardwood), or control. Trees were dormant and about 18 inches in height at planting. On June 19, 2005, 1 oz of organically approved (OMRI) nitrogen (NatureSafe All Season Fertilizer; 10−2−8; Nature Safe, Cold Spring, KY) was applied per tree. Irrigation was as needed by trickle irrigation. Wood chip mulch was applied in early June and trees were flame cultivated in mid-June 2005. Flaming was accomplished using a Red Dragon BackPack Flamer with a 400,000 BTU torch and 3 gallon fuel cylinder (Peaceful Valley Farm Supply, Inc, Grass Valley CA). Grass and weeds in control plots were removed by a weed eater

as needed.

Experiment 2. The objectives of this experiment were to determine if: 1) flame cultivation with a backpack flamer would control grass/weed coverage around mature pawpaw trees without damage to trunks, and 2) flame cultivation is economically viable. A completely randomized experimental design was implemented using 12 five-year-old seedling trees. These trees were treated with either: control (weed eating), flaming with avoidance of the trunk (normal flaming), and flaming without avoiding flame contact with the trunk (heavy flaming). Flaming was accomplished using a Red Dragon BackPack Flamer. There were four replicate trees in each treatment. Trees were mature and averaged 7.0 cm in diameter. On July 24 and August 2 and 18, 2006, a three foot area around treatment trees was either subjected to the flaming treatments or weed eating (to a height of 2 inches). On August 25, and September 7 and 15, 2006, re-growth in plots was rated from 1 to 10 with 1 having no grass/weed coverage and 10 having total grass/weed coverage. Weed species encountered in flaming plots prior to flaming were: Dandelion, Crabgrass, Fescue, Plantain, Johnson grass, Pigweed, and Clover. Adjacent pawpaw plots were treated with straw (laid to 10 to 12 inches in thickness in March) or treated with glyphosate (four applications in May, June, and July) to control grass/weeds and provide data for cost comparisons of the different grass/weed control techniques. Statistical analysis of data (analysis of variance and LSD means separation) was performed using CoStat statistical software.

Objective 3.

Experiment 1.

In September 2003, 2004, and 2005, seed was collected from ripe fruit of the pawpaw cultivars ‘Sunflower’, ‘PA-Golden’, and ‘K8-2’ and used in the propagation of rootstock for grafting the following year. In all greenhouse production and experiments, stratified seed was sown in February the following year into Pro-Mix BX potting medium (Premier, Red Hill, Pa.) containing Osmocote 14-14-14 (Scotts Co., Marysville, Ohio) at 3.70 kg•m-3 in 3.8-L Tall One Gallon Tree Pots as described by Pomper et al. (2003). Scionwood was collected from Sunflower, PA-Golden, and Shenandoah trees in February in 2003, 2004, 2005, and 2006 for use in chip budding. In June and July each year, the rootstock that had been started in February was chip budded (when at the diameter of a pencil or greater) with the scionwood collected earlier that year and grown in the greenhouse for the rest of the year. In December the rootstock was placed in a walk in cooler at 4 C and removed from the cooler for field planting.

Kentucky State University Rootstock Trial. Grafted trees produced in 2004 were overwintered in a walk-in cooler and removed for field planting in early April, 2005. The rootstock trial was established on April 18-19, 2005 at the Kentucky State University Research Farm with the following pawpaw cultivar scion/rootstock combinations: Sunflower/Sunflower, Sunflower/PA-Golden, PA-Golden/Sunflower. The trees were dormant and about 18 inches in height at planting. The trees were planted in a randomized complete block design with three blocks and eight replicate trees per treatment per block. Irrigation was as needed by trickle irrigation. Wood chip mulch was applied in April to control weeds.

University of Kentucky-Organic Area Rootstock Trial. Grafted trees produced in 2004 were overwintered at KSU in a walk-in cooler and removed for field planting in early April, 2005. The rootstock trial was established on April 18-19, 2005 at the University of Kentucky, Lexington, South Farm in the Organic Area with the following pawpaw cultivar scion/rootstock combinations: Sunflower/Sunflower, Shenandoah/Sunflower, Sunflower/PA-Golden, Shenandoah/PA-Golden, Sunflower/K8-2 and Shenandoah/K8-2. The trees were planted in a randomized

complete block design with three blocks and eight replicate trees per treatment per block. Irrigation was as needed by trickle irrigation. Woodchip mulch was applied during the growing season to control weeds.

Grower Site Rootstock Trials. Due to culture problems in the greenhouse in 2004 and 2005 (see results section), there were fewer grafted trees available for planting at growers sites; however, three cooperator growers planted grafted trees and dozens of additional farmers planted rootstock trees. Some trees were also propagated for growers in Experiment 2 below.

Experiment 2. In the process of producing trees for rootstock trials at various sites, a pawpaw chip budding experiment was implemented in the KSU greenhouses to determine if it is more beneficial for grafting success and bud break to remove leaves from rootstock trees or maintain the leaves on the tree for 6 weeks. The experiment was a three-way randomized complete block design, consisting of 2 scions (Sunflower and Susquehanna), 2 seedling rootstocks (Sunflower and K8-2), and 2 leaf treatments (removing all leaves at time of grafting vs. leaving 6-8 leaves on the grafted tree), with 9 trees (subsamples) per rep, and 3 replicate blocks, blocked by grafting date, for a total of 216 trees. Pawpaw seeds were extracted from fruit collected from either K8-2 or Sunflower grafted trees, all grown in orchards at the KSU research farm, were sown in one-gallon TreePots in February 2005 and placed in a greenhouse under supplemental light and heat. Seedling germination rates were similar for both seedstocks (90%). The seedlings were allowed to grow for 8 months, and then overwintered at 4C. The seedlings were then brought back into the greenhouses 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 Ziploc bags at 4C after the ends were dipped in paraffin to prevent desiccation. The trees were chip budded from June 21-July 3, 2006. Scion leaf number was counted weekly from July - October. Rootstock leaves were removed six weeks after grafting. Mealy bugs were controlled with two applications of Marathon during the summer of 2006. Statistical analysis of data (analysis of variance and LSD means separation) was performed using CoStat statistical software.

Research results and discussion:

Objective 1.

A planting was established at KSU on April 18, 2005 to determine the optimal application rate of an organically approved nitrogen source that would enhance tree establishment, growth, early flowering, and fruit production in the orchard. Pawpaw seedlings were planted and 5 levels of N were applied to determine the optimal application rate. Survival of this planting was evaluated in late September, 2005. Tree survival was 58%, 50%, 33%, 50%, and 58% for 0, 1, 2, 3, and 4 oz N treatments, respectively. In the spring of 2006, the tree survival was 50%, 50%, 33%, 50%, and 33% for 0, 1, 2, 3, and 4 oz N treatments, respectively. By September 2006, less than 10% of the trees survived and the experiment was terminated. This poor survival rate in 2006 was likely due to a combination of factors that included the fairly small size of the trees (about 18 inches in height) at planting, the addition of N to plots promoting growth of grass and weeds in plots that also spread to control plots, high rainfall totals increasing weed competition, poor organic weed control (wood chip mulch), and a continuing problem of unknown causes for poor tree establishment rates in orchards. A preexisting Johnson grass infestation in the field prior to planting in 2005 resulted in significant competition by this weed on tree growth. Pawpaw trees do not compete well with grass and weeds and will die when challenged by these plants. Weeds and grasses can be difficult to

control with organic weed control measures where large seed banks are present in fields. The rate of organic nitrogen required by pawpaw trees for optimum growth and survival was inconclusive; however, this experiment indicates the need for a holistic approach to pawpaw tree establishment under organic culture where weed control measures, nitrogen level, irrigation/rainfall, and condition of plant material are intertwined and increasing one variable, such as increasing nitrogen, may require adjustments in other aspects of the organic culture system to achieve the desired results.

Objective 2.

Experiment 1. A planting was established on April 18-19, 2005 to determine if flame cultivation could be used effectively for weed control to promote pawpaw tree establishment and growth in orchards, compared to glyphosate (RoundUp) application or wood chip mulch. The flame cultivation treatment was applied in mid-June and fatally damaged all the trees subjected to this treatment. We did not wish to use PVC pipe guards or tree shelters around trees in the experiments due to previous experience with excessive weed growth often occurring around the stem within the pipe or tree shelter. The torch of the backpack flamer was difficult to control and could not be used near small plants without damage. Straw (about 10-12 inches in depth around young trees) is a better organic weed control measure than wood chip mulch and flaming.

Experiment 2. This experiment was conducted to determine if flame cultivation with a backpack flamer would control grass/weed coverage around mature/larger pawpaw trees without damage to trunks, and if flame cultivation is economically viable. By August 25, 2006 all flame plots had significantly less grass/weed coverage (about 2.25 rating) than control plots (7.75). On September 15, flame treatment plots had increased grass/weed coverage (about 4.75), but less coverage than control plots (9.5). Additionally, trees in either flaming treatment in 2006 did not display noticeable trunk damage or wilting. Trunk damage was evaluated again in 2007 and one heavy flamed tree died and did not leaf out by June 1, 2007. As for regrowth of broadleaf weed species, dandelions were the predominant weed species to grow back and on August 25, 2006 control plots had an average of 31 plants where normal and heavy flaming plots had an average of 10 plants. Regrowth of grass and weeds was evaluated on June 19, 2007, or about one year after the last flame treatments, and grass and weed growth was still greatly reduced in flamed plots compared to control plots. The grass and weed control cost per 100 trees/year was calculated to be: 1) $158 for flame cultivation (assuming 6 applications each year), 2) $400 for straw mulch (applied once each year), and 3) $9.97 for glyphosate (applied 4 times each year). Therefore, flame cultivation was found to be 2.5 times less expensive than straw mulch (organic) but 15 times more expensive than glyphosate (conventional) for grass/weed control. The flame cultivation cost included fuel; however, a backpack flamer must also be purchased for about $230 as a one time investment for a small farmer. A one time purchase of a backpack sprayer for glyphosate application is about $25 to $150 for a small farmer.

Flame cultivation can be used to control grass/weed coverage around large pawpaw trees. During this growing season, it did not appear that trunks were damaged by either flaming treatment, nor in the next growing season. Flame cultivation can control grass and weeds without herbicide use and deplete weed root reserves preventing regrowth of weeds. Several drawbacks of flame cultivation are that it uses fossil fuel for organic crop production and weed organic matter is lost for incorporation into the soil. Flame cultivation (normal flaming) with a backpack flamer can be used to control grass/weed coverage around mature (at least 7 cm or greater in trunk diameter) pawpaw trees without damage to trunks; however care

must be practiced in controlling the flame and fire dangers. A yearly application of straw (about 10-12 inches in depth) was found to be effective for organic weed control around small trees (< 7.0 cm in diameter). Voles living under straw can damage fruit trees; however, vole damage has not been observed in pawpaw, possibly due to acetogenin compounds in the plant tissues that apparently repel vole feeding on tree trunks and roots.

Objective 3.

Experiment 1.

Propagation of Rootstock. During the first year of the grant, unforeseen difficulties were encountered in propagating grafted trees for the pawpaw rootstock trials due to mealy bug infestations in the KSU greenhouses. In February 2004, seed from the pawpaw cultivars Sunflower, PA-Golden, and K8-2 were sown into 2500 one gallon containers in the greenhouse. About 1800 trees were chip budded in July 2004. Upon evaluation of the trees in September 2004 , only about 250 of the buds had successfully taken. In 2005, about 1500 seedlings were overwintered outside until April, 2005 and were then brought back into the greenhouses and budded again in June 2005. Only about 5% of these chip buds took. Mealy bugs were discovered under the dead chip buds and these insects were apparently the cause of the poor bud takes of grafted trees. Additional seedling rootstocks, 750 trees each year, were produced in 2005 and 2006. Chemical measures (Marathon) were used to control mealy bugs in pawpaw seedlings in 2006 and 2007 and budding success rates were much higher. Although pawpaw has been reported to contain acetogenin compounds in twig tissues that have pesticidal properties, mealy bugs are apparently not killed or deterred from feeding on pawpaw plants by these compounds. Grafted trees that were successfully propagated were used in the trials described below.

Kentucky State University Rootstock Trial. The influence of two scions budded on to two seedling rootstocks on tree survival, growth, and flowering, was evaluated in a planting established in April, 2005. Survival of trees in this planting was evaluated in late September, 2005 and only 35% of these trees survived. The combination with the highest survival rate was Sunflower grafted onto Sunflower seedlings, with a survival rate of 38%, while the lowest survival rate was with PA Golden grafted onto Sunflower rootstock, with a survival of 32%. By 2006, 90% of the plants died and the experiment was terminated at KSU. Pawpaw has a continuing problem with high mortality rates in conventional and organic plantings. This poor survival rate in 2006 was likely due to a combination of factors that included the fairly small size of the trees (about 18 inches in height), high rainfall totals increasing weed competition, poor organic weed control (wood chip mulch), and a continuing problem of unknown causes for poor tree establishment rates in orchards.

University of Kentucky-Organic Area Rootstock Trial. Seventy two trees were planted at the University of Kentucky research farm in April 2005. In fall of 2005, survival rate was 51%. In 2006, replacement trees were planted for those that were lost. By the end of 2006, the best survival (original and replacement trees) was with the scion Sunflower on PA-Golden rootstock (88%) and poorest survival with the scion Shenandoah on K8-2 rootstock (56%). In March 2008, the scion Sunflower had a 50% survival rate, average 27 mm in diameter, 140 cm in height, and had an average 12 flower buds per tree, while the scion Shenandoah had a 64% survival rate, average 28 mm in diameter, 142 cm in height, and had an average 7 flower buds per tree (an average of 12 for Sunflower and 7 for Shenandoah). However, there was not a significant difference between the two cultivars for these characteristics. There was also not a significant difference in rootstock effect on the growth of the scions. The average survival was 57%, average diameter was 27 mm,

and average height tree was 142 cm for the three rootstocks. However, there was a trend for trees with the rootstock PA-Golden (4) to have fewer flower buds per tree than Sunflower (13) and K8-2 (12). Based on this data, all the rootstocks yielded similar survival and flowering results with the two cultivars examined. None of the rootstocks examined provided superior survival rates and poor pawpaw tree establishment rates continue to be a challenge to growers.

Grower Site Rootstock Trials. Due to culture problems in the greenhouse in 2004 and 2005 (see results section), there were few grafted trees available for planting at grower sites. About 50 grafted trees were available to grower cooperators Ron Powell, Roland McIntosh, and Ilza Sillers. Cooperator Leslie Sanderson decided to not participate in the trial. In 2007, 100 grafted trees of the cultivars Sunflower and Susquehanna, budded onto the seedling rootstocks Sunflower and K8-2 (see experiment 2) were given to Ron Powell to plant in a replicated trial to examine survival, growth, and flowering characteristics of these cultivars on these rootstocks. About 2000 extra rootstock trees were distributed to over 50 small farmers during fall workshops and five grafting demonstration workshops, where growers learned how to graft trees. Trees that were planted at the grower sites as well as the KSU and UK sites will serve as demonstration orchards in the future for pawpaw production for limited resource and organic farmers. Over 20 grower workshops and hands on grafting demonstrations, where growers took grafted trees home, were conducted at KSU during the granting period.

Experiment 2. Few differences were noted between scion cultivars on chip bud take percentage and scion leaf number. There was a trend for chip budding performed with Susquehanna buds (70%) to have a better success rate than Sunflower buds (59%), but the two scion buds' take rates were not significantly different. There were no significant differences in scion leaf number between scion cultivars (about 7). Rootstock seed source did have an effect on chip budding success. Chip buds performed on K8-2 rootstock (73%) had a higher percentage take than those budded onto Sunflower rootstock (56%). There were no significant differences in scion leaf number between rootstocks. It is possible that the reduced vigor of the K8-2 rootstock, as noted in unpublished experiments, itself allowed more photosynthate to be allocated for graft union development. Leaf removal or retention had a significant impact on both bud take and scion leaf number. Chip-budded pawpaws which had 6-8 leaves remaining for 6 weeks 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. Even more chip buds took when the leaves were removed after 6 weeks (an increase of 13% vs 2%). Budded pawpaw trees which had the rootstock’s leaves removed from the beginning, when grafted, had higher scion leaf number than grafted trees on which 6-8 leaves were retained for 6 weeks after grafting. While rootstock leaf retention was beneficial for graft union development, the resulting scions actually had fewer leaves. This is likely due to competition between the scion shoot and remaining rootstock shoots. There was a blocking effect seen by the end of the study, with those budded on July 2 having the best take rate and those budded on June 27 the worst. Budding date also had an effect on leaf number, with trees budded on June 23 having the most leaves and trees grafted on July 2 having the fewest leaves. This could simply be due to scions having more time for growth. Pawpaw chip-bud emergence improved by leaving 6-8 leaves on the rootstock to support the scion budbreak and growth. However, it is also beneficial to remove these leaves after 6 weeks to encourage scion growth.

Participation Summary

Educational & Outreach Activities

PARTICIPATION SUMMARY:

Education/outreach description:

Publications:

Pomper, K.W. 2007. Can Pawpaws Be Grown Organically? Pomona 40:40-49.

Pomper, Kirk W. and Sheri B. Crabtree. 2007. Weed Control and Economic Considerations of Flame Cultivation in Pawpaw Orchards. HortScience 42:457-458.

Pomper, Kirk W. and Sheri B. Crabtree. 2007. Is Flame Cultivation a Viable Method for Organic Weed Control in Pawpaw Orchards? Journal of the Kentucky Academy of Science 68:103.

Crabtree, Sheri B. and Kirk W. Pomper. 2007. Rootstock Leaf Retention Aids Bud Break in Chip-Budded Pawpaw (Asimina triloba). Journal of the Kentucky Academy of Science 68:103.

Pomper, K.W. 2006. Growing Pawpaw Organically in Kentucky. University of Kentucky-Cooperative Extension Service. FruitFacts (October issue) 10:3-6.

Pomper, Kirk W., 2005. Pawpaw: A New Potential Fruit Crop. HortScience (40:947).

Pomper, K.W. And D.R. Layne. 2005. The North American Pawpaw: Botany and Horticulture. Horticultural Reviews. Vol. 31:351-384.

Outreach:

A web site describing the project can be found at: http://www.pawpaw.kysu.edu/sare.htm

Pomper*, Kirk W., and Sheri Crabtree. Pawpaws. Presented at 2007 Small Farm Field Day, September 20, 2007. (approximately 600 people attended the field day).

Pomper*, Kirk W. Presentation entitled “Pawpaw 101” at the Ninth Annual Ohio Pawpaw Festival on September 15- 16, 2007, at Albany, Ohio. (approximately 4000 people attended the festival).

Pomper*, Kirk W. and Sheri Crabtree. Growing Gooseberries and Currants in Kentucky.and SARE hands on pawpaw grafting workshop. Third Thursday Workshop. June 21st, 2007. (approximately 75 people attended)

Crabtree*, Sheri B. Hands-on SARE grafting workshop. April 19, 2007 Third Thursday field day at KSU’s research farm

Pomper*, K.W. Gave a presentation entitled “Pawpaw 101” at Gardening Study School sponsored by The Garden Club of Kentucky, Inc. on March 22, 2007. (About 50 people attended the garden school that was held at Franklin Co. Extension Office.)

Pomper*, K.W. Organic weed control in Pawpaw. Third Thursday held on February 15, 2007 at the KSU research farm (approximately 75 people attended).

Pomper*, Kirk W. and Sheri B. Crabtree. 2007. Weed Control and Economic Considerations of Flame Cultivation in Pawpaw Orchards. Presented at the American Society for Horticultural Science-Southern Region Annual Meeting in Mobile, AL, February 3-5 2007.

Pomper*, K.W. Growing Pawpaw. SAWG meeting on January 26, 2007 at KSU’s research farm. (approximately 200 participants)

Pomper*, Kirk W. and Sheri B. Crabtree. Is Flame Cultivation a Viable Method for Organic Weed Control in Pawpaw Orchards? Oral presentation at the Kentucky Academy of Science annual meeting held at Morehead State University, Morehead, KY, on November 10, 2006.

Crabtree*, Sheri B. and Kirk W. Pomper.Rootstock Leaf Retention Aids Bud Break in Chip-Budded Pawpaw (Asimina triloba). Poster presentation at the Kentucky Academy of Science annual meeting held at Morehead State University, Morehead, KY, on November 10, 2006.

Pomper*, Kirk W. 2006. Pawpaw Production in Kentucky. Pawpaw Field Day at the Kentucky State University Research Farm on September 21, 2006. (approximately 75 attended)

Pomper*, Kirk W. 2006. Pawpaw 101. Ohio Annual Pawpaw Festival in Albany, OH, 16-17 September. (approximately 2000 people attended)

Pomper*, Kirk W. 2006. Pawpaw, Currant and Gooseberry Varieties for Kentucky and the Southeastern United States. The North American Fruit Explorers Annual Meeting in Lexington, Kentucky, August 31, 2006. (approximately 125 people attended)

Crabtree*, Sheri B. Hands-on grafting workshop. July 20, 2006 Third Thursday field day at KSU's research farm.

Pomper*, Kirk W. and Sheri Crabtree. 2006. Gooseberry, Pawpaw, and Blackberries Trials at the KSU farm. and Hands On Pawpaw SARE Grafting Workshop (where growers learned to graft pawpaw trees and take home trees). Third Thursday Workshop, June 15, 2006. (approximately 75 people attended)

Pomper*, Kirk W. 2006. Pawpaw Growing in Kentucky. Spring meeting of the Kentucky Nut Growers Association on April 22, 2006 in Elizabethtown, KY. (approximately 125 people attended)

Pomper*, K.W., and Sheri B. Crabtree. Budding Success and Field Establishment of Two Pawpaw Cultivars on Five Seedling Rootstocks. Association of Research Directors, Inc. 14th Biennial Research Symposium. April 1-4, 2006, Atlanta GA.

Pomper*, K.W. 2006. Growing Pawpaw in Kentucky and the Southeastern United States. Southern Sustainable Agriculture Working Group (SAWG) meeting held at the KSU farm on January 20, 2006. (approximately 75 people attended)

Crabtree*, Sheri B. Hands-on SARE grafting workshop. Southern Sustainable Agriculture Working Group (SAWG) meeting held at the KSU farm on January 20, 2006. (approximately 75 people attended).

Pomper*, K.W. 2005. "The Pawpaw Story: Cooperative Research and Extension Efforts Between Kentucky State University and SARE in Developing a New Fruit Crop" Presented at the AEA/ARD Joint Conference in New Orleans, Louisiana, June 19-22, 2005. Received second-place honors in the Community and Economic Development category.

Pomper*, K.W. 2005. "Pawpaw and the SARE Project" Presented on Jan. 3, 2005 at the Kentucky Annual Fruit and Vegetable Grower Conference and Trade Show, Lexington, KY.

Pomper*, K.W. 2004. Pawpaw 101, KSU Pawpaw Research Update, and Pawpaw fruit tasting demo for approximately 800 people September 18-19, 2004 at the 6th Annual Pawpaw Festival in Albany, Ohio.

Pomper*, K.W. 2004. presentations "Pawpaw 101" and "An Update on the Kentucky Pawpaw Regional Variety Trial." At the KSU/PPF Pawpaw Workshop on September 11, 2004 at the KSU Research and Demonstration Farm.

Approximately 100 people attended.

Pomper*, K.W. 2003. Growing Pawpaws in Kentucky Biennial Small Farm Festival on Thursday, September 18, 2003 at the KSU Research and Demonstration Farm. Approximately 275 people attended.

Project Outcomes

Project outcomes:

Small farmers in the southeastern U.S. are interested in pawpaw as a new crop. However, there is little information concerning organic culture and methods to promote early fruit production available for pawpaw. A number of important recommendations were developed by conducting this study. Under high rainfall amounts, wood chips were ineffective in controlling grass and weed growth that compete with pawpaw tree establishment. We found that a holistic approach to pawpaw tree establishment under organic culture will be required where weed control measures, nitrogen level, irrigation/rainfall, and condition of plant material are intertwined and increasing one variable, such as increasing nitrogen, may require adjustments in other aspects of the organic culture system to achieve the desired results. Removal of perennial weeds prior to planting pawpaw trees is imperative because this species does not compete well with grass and weeds. Flame cultivation with a backpack flamer is an economical method for organic farmers to control grass/weed coverage around mature pawpaw trees without damage to trunks; however, yearly straw application can be used for organic weed control for small trees during establishment. Nurseries and farmers should propagate pawpaws by chip-budding and leave 6-8 leaves on the rootstock for 6 weeks to improve bud take. None of the seedling rootstocks examined can be recommended over another to increase survival rates and promote earlier flowering of cultivars. Poor tree establishment rates continue to be a challenge to pawpaw growers. Three farm cooperators participated in rootstock studies and dozens of others planted rootstock for later grafting. Over 20 grower workshops and five hands on grafting demonstrations were conducted. A web site describing the project has been constructed and can be found at: http://www.pawpaw.kysu.edu/sare.htm

Economic Analysis

Flame cultivation was found to be 2.5 times less expensive than straw mulch (organic) but 15 times more expensive than glyphosate (conventional) for grass/weed control. For flame cultivation, a backpack flamer must also be purchased for about $230 as a one time investment for a small farmer. A one time purchase of a backpack sprayer for glyphosate application is about $25 to $150 for a small farmer.

Farmer Adoption

Several farmers are using straw to control grass and weeds around young pawpaw trees during tree establishment. A number of small farmers have stated an interest in using flame cultivation in orchards and vineyards. Nurseries were interested in whether specific seedling rootstocks could be recommended for production, but unfortunately, all are similar in performance. Over a dozen farmers planted pawpaw trees produced in these studies that will bear fruit in the coming years.

Recommendations:

Areas needing additional study

Additional studies examining the nitrogen requirement of pawpaw in relation to a holistic approach to tree establishment under organic culture will be required where weed control measures, nitrogen level, irrigation/rainfall, and condition of plant material are examined. Additional pawpaw seedling rootstocks should be examined for the potential to increase tree survival rates and promote earlier flowering of cultivars. Poor tree establishment rates continue to be a challenge to pawpaw growers. Enhancement of nursery production techniques to promote more fibrous root systems in nursery stock could improve establishment rates and growth of trees and should be investigated.

US Department of Agriculture

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