

A review of pruning fruit trees

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Abstracts. The focus of this review is to present the results of studies and articles about ways to prune fruit trees. Pruning should be done in late winter or early spring so that the infection risk can be significantly decreased. This review will also offer an overview of methods to prevent infections and speed up recovery on the trees. The following is an interpretation of why high-power ultrasonic assisted pruning in the fruits trees is needed and will elaborate on the efficiency, labor costs, and safety, as well as space, location, and some environmental issues.

1. Introduction

1.1. Importance of pruning

Pruning refers to the process of cutting the branches that are not wanted from the fruit trees; it is done to strike a balance between vegetative and reproductive growth. Making them safe, healthy, and aesthetic is the most concerned reason to prune trees ^[1]. As for those branches that are crisscrossed, diseased and dried are ought to be pruned, we should make sure that there is enough light penetration in the tree canopy, and there is regular fruit bearing. Pruning increases the yield of quality fruit and so on ^[2]. Proper pruning techniques and wound treatment should be required and used to minimize the hazard of wood decay, fungi, and other pathogens ^[3].

1.2. Pruning method

The time and scope of pruning depend on the age, type, habits, and purpose of the tree. In determining the nature and extent of trimming, the patterns of growth and flowering must be taken into account - for example, the fruit bud position, the length of the inter-nodes, the flowering time of a particular



variety and grower ^[2]. Pruning branches during the end of winter or early spring allows trees to compartmentalize their "wounds" during the current season. Hence, as for the trees or shrubs that bloom in early spring should be pruned as soon as possible after their flowering ^[1]. During this time, trees are at their most stressed and worst condition with diseased branches, broken branches, etc. Meanwhile, young trees and newly planted trees are pruned especially during drought seasons while dead branches should be removed at any time ^[3]. Peach trees, nectarine trees, and other such fruit trees grow faster and much vigorously to acquire solid, stocky limbs and enhance light and airflow issues ^[4]. The main purpose of summer trimming is to increase the penetration of light and increase the growth of the fruit in order to remove the longest water buds in the overcrowded crown. Besides, as for the trees or shrubs that bloom in the summer or autumn, they can be pruned during the dormant season. This is done to prevent the buds from forming new shoots during the next season of growing ^[1]. Prune or cut trees only during dry weather, and do not prune trees in high humidity ^[5]. Pruning must be done during favorable weather conditions and avoided on rainy days or days with an immediate forecast of rain. Drizzle can stir up disease-causing growths like fungal spores.

Pruning treatments like light, medium, and heavy or severe use among different trees. Heavy pruning should be conducted when fruit trees are in a dormant and less stressed state, and late pruning could risk winter injuries ^[4]. As for the light pruning, it refers to removing 25% of the fruits; as for the medium pruning, it refers to cutting 30% of the shoot from the upper end, and as for the heavy pruning, it refers to removing 50% of the shoot from the growing point. The last type of pruning is necessary on old, winter-injured trees to save them ^[6]. When pruning the branches, the first cut should be one foot away from the intersection and the underside of the lime, and the final cut should go from the top to the bottom to let the branch fall freely ^[7]. Some important hints for pruning fruit trees: 1) Cutting edges should be kept very sharp. 2) Prune a tree as soon as it grows. 3) Never leave stubs on the trees. 4) Undercut all big branches before pruning. 5) Branches should always be less than the trunks. 6) The lowest branch should be 2 or 3 feet from the ground ^[8]. When planting well-grown nursery trees, the height and diameter should be taken into consideration. The peach tree is pruned at planting time by cutting back the leader to a height of 36 to 40 inches. First, large branches are removed, and then, the weak, slender, and poorly attached branches are cut out ^[6].

1.3. Pruning tools

Pruning equipment must be sharp, sterilized before and after use, and suitable for the branches' length and blunt. Secateurs or hand pruners can be used to prune small branches (diameter of 3 cm) and extensive (width of more than 3 cm) ones. Handsaws can be used to cut large branches (diameter more than 3 cm). Pole pruners can be used to prune the branches of tall trees. Chainsaws are used to prune large branches with a width of more than 3 cm ^[3].

1.4. Tree response to pruning

By firstly changing the balance of C: N (carbohydrate: nitrogen), pruning can realize the effect of improving the quality of the fruits ^[2]. Too much crown raising will reduce the photosynthesis process in trees ^[3]. Girdling and summer pruning on apple trees can help increase soil respiration, which is due to significant rainfall event, but it was very short-lived, so it did not have long-term damaging effects on the roots ^[9].

After pruning wound and cut conditions may occur, including sprout growth, proper wound closure, and tearing-bark wound closure ^[3]. A flush cut removes the branch collar, which includes the protection zone, and a significant wound is caused that will result in the wounds' healing slowly. From outside to inside of the tree layer, the layers are bark, cambium (a cell factory), sapwood, heartwood, and pith (at the very center of a tree) ^[10]. The cambium is the only area of the trunk that generates new cells. Cells formed outward from the cambium develop into the phloem, and those formed inward extend into xylem (water-conducting tissue). Here, living cells (called parenchyma cells) grow into various tissues to isolate infections ^[11]. Trees respond to wounding in two

ways: healing and the growth of barrier zones ^[11]. Trees can close wounds in nature from callus formation and oxygen, and soil effects can enhance the callus formation rate ^[7]. Calluses are formed in the surrounding area of the wound. Decay-spreading mechanisms are successful in most vigorous or actively growing trees in barrier zones ^[9]. Branch wounds that result from hand pruning might become potential infection courts leading to the decay and fungi of woods, which will increase the risk of infection ^[12]. ER (electrical resistance) exists in the cambium zone of trees and is inversely proportional to the rate of growth and also has the same relationship with the wound closure; however, it has different relations with the amount of wood discoloration. Trees with lower ER grew faster, and their wound healing was more rapid than the higher ones ^[13]. Wound closure has a positive relationship with the width of the wound. What's more, more massive wounds contained more calluses than smaller injuries did ^[14-15]. However, changes in the wound shape, the direction it faced, its height, and its dressing type affected the healing rate less ^[15]. Most round wounds closed because of the identical season that they were made while 25-mm-wide elliptical wounds closed entirely, which required 2 or more growing seasons ^[16]. In addition, the tree species affected the healing rate and size of the injury. Soft maple and American elm have a more significant rate of healing than the white ash, pin oak, tulip tree, and honey locust ^[17]. Wound closure per unit of radial growth differed by annual growth. The speed for wounds of large size to heal is faster than that for the wounds of medium-size to heal. In addition, the speed for the large and medium-sized wounds to heal is even faster than that for wounds of small size. What's more, the speed of wounds to heal in the first quarter is faster than that of wounds to heal in the second year, which in turn improved more quickly than in the 3rd year ^[17]. Various researchers have reported the inconsistent effects of pruning on the quality of fruit, or the size of the fruit as well as the fruit's yield. Strict trimming can help increase the diameter of the fruit. However, sever trimming has nothing to do with the soluble solids content. RP (reduced number of pruning cuts) and IP (intensive number of pruning cuts) were done on two of the peach cultivars--JD (Jersey Dawn) and RS (Redskin). As such, by adopting RP ways, peaches of large size and increased crop load were realized in trees and RP helps to maintain marketable yield. With a more massive crop load, the average fruit weight was less. Pruning treatment size affected number and weight of fruit growing in every tree, however, at the same time, the distribution of fruit among different size classes had little effect.

Regarding impacting yield, variety and pruning interact with the yield of fruit with more market value, especially in the RS tree^[18]. Strict pruning increases fruit diameter but does not affect total soluble solids content ^[19].

1.5. Methods to prevent or reduce infections and speed up recovery

Several proper care methods can be taken to avoid diseases or speed up recovery.

(1) Physical Repair. The dead bark contains many tiny air pockets that insulate trees from robust and rapid temperature changes. Bark also provides physical protection from minor abrasions, and certain insects and chemical constituents of dead bark--such as suberin, lignin, and tannins--may be toxic to some microorganisms ^[20]. Any ragged bark edges should be cleared with a sharp tool. However, be sure to leave the excellent bark. Also, remember that no more live tissue should be exposed than necessary. An elongated oval is always the best wound shape. As such, let the long axis face vertically along the trunk. Besides, all bark around the wound should not be too loose.

(2) Wood dressings. Wood dressings do not decrease decay or accelerate wound healing rate and rarely prevent insect or disease infestations. Wood dressings like tar or paint do not stop decay and may affect wound closure. Wood dressings are not suggested for several reasons: prevent drying and cause fungal growth; impede the formation of wound wood or callus tissue; curb healing; supply a portion of food for pathogens. The best way to prevent infection or decay is to let the cleaned tissue to dry out ^[5].

(3) Cavity Filling. It is not recommended to fill the cavity because it precludes the sound wood or the callus growth from the decayed wood.

(4) Pruning wounds. Dead, dying and damaged branches and trunks should be removed as soon as possible.

Tree response after wounding is related to disease resistance, environment, and host genetics. Poor irrigation, low temperature, and levels of water stress can result in delayed wound healing^[21]. Die-back is one major complicating factor that determines the extent of seasonal closure (more extensive in low tree vigor), the season of wounding (more significant in fall), wound location (more on the stubs), and position on the wound margin^[22]. If there was early pathogen growth in a peach stem, it showed that suberization of rapid bark exhibited a relatively weak form of xylem obstacles. The weaker bark response cultivar had inversely stronger xylem responses^[21]. Frost affected and was responsible for the continuation of the crack. When temperatures fall below the freezing point of water, the migration of water out of moist cell walls to ice in the cell lumens is the chief cause of frost crack formation^[23]. Pruning should be done in late winter or early spring so that the infection risk can be significantly decreased^[24]. The closure rate was much more related to the species than the vigor and growth of the tree^[25]. Closure times and callus production were altered with wound size, the species of the tree, and the tree's vigor and limited by light sap and reduced vascular cell division^[22]. "Caliper increase" and "twig extension" was used to measure the growth rate. Immediately before/after pruning, the various measurements will be taken, and subsequent readings will be taken at the end of the controlled growing months^[25].

The frequency and degree of colonization of peach bark wounds inoculated with mycelial cell spor e mycelia Fr can form lignified and lignoimine tissues, reducing the colonization rate of fungi, and make at least 3 cells in new cork cells which are sufficiently inhibited by fungal colonization^[26]. Suberin in wounds can have some active effects in resistance to the disease, especially in the production of peach. On condition that the disease can be controlled^[27], the production of peach can be increased by at least 50 percent. It is impossible for wound injection or implantation to slow the growth of a tree^[22]. As for the wounds which are inoculated with faster suberin accumulation, they also became resistant to the fungus at an earlier time^[27]. The best healing was with root injection of small trees, and the worst healing was with stem injection of large trees^[28]. Watering them during droughts and providing proper fertilization can increase the closure rate and callus growth. Cultural practices, the deprivation of water, and pruning by labor force jointly reduced brown rot incidence, sensitivity towards diseases, as well as the adoption of pesticide sprays in peaches. The practices mentioned above also enhanced taste by increasing total soluble solids, improved the quality of the peach, and at the same time, the yield of peach will not be reduced, the fruit's market value will also be increased^[29].

1.6. Justification

There are many advantages to hand pruning. It can shorten branch occlusion time. Besides, hand pruning can decrease the size of the knot, as well as reduce the risk of decay or discoloration in the stem of *Betula Alnoides* with different pruning treatments^[11]. Trees must be appropriately pruned; even some highly knowledgeable workers with over five years of pruning experience sometimes still have less or weak awareness of the importance of appropriate pruning^[3]. Incorrect pruning can damage the structure of a tree. It is dangerous to prune large trees by using a chainsaw^[30]. Mechanical devices may be of great help in preventing splitting of the main branches^[6]. The life of a tree may be shortened because of the heavy pruning. The growth of microorganisms, mushrooms, fungi, and bacteria may be caused because they have been pruned in a lousy way, and this kind of pruning can even result in decay and rotting limbs. Pruning at the wrong time can damage a tree to a great extent and reduce the growth of trees. Some harmful pruning practices can destroy trees; for example, unsmooth cuts will promote infection^[5]. The disease may kill the whole tree, limb, or shoots, resulting in later blooming, delayed fruit maturity, and small fruits, which will increase picking percentages^[24].

Second, the efficiency of hand pruning is low, and labor costs are high. It is challenging work, especially for severe pruning. Research shows that by using HT (hand thinning), the operating time was decreased to 291 h ha⁻¹, more than ten times of that with MT (mechanical thinning) (27 h ha⁻¹). There is an even a more expensive system is HT 2442€ha⁻¹, more than eight times of systems with MT

296€ha⁻¹^[31]. Because of machine pruning, the cost of grapevine pruning decreased from as much as \$180 per acre to \$35 per acre^[32]. MT refers to a kind of promising technique which is used to thin the peach trees. It works because of its effect on accelerating the speed of working^[31]. The mechanical pruning helps in controlling canopy size for some vigor cultivars which are of medium height (traditional and new Italian) and makes mechanical harvesting possible^[33].

Third, hand pruning limits on safety, space, and location. We need to climb up and down to prune. Even sometimes you may suffer from the being stung by wasps and hornets. The working height is often inappropriate, working on a ladder is unstable, and people often have aches in one's hand and arms after pruning^[34]. Besides, those tools which are not ergonomically designed may lead to the aggravation of the strain on the joints. What's more, a pressure will be induced on the side, which directly harms to the pruner's health. Moreover, hand pruning limits by the space and location. Long-handled pruning tools work well to prune evergreen shrubs and hedges. But when coming into awkward areas and pruning thick stems, it will be the extra cutting leverage and strength needed in the long-handled pruners^[35]. From an ergonomics point of view, this kind of devices which have more extended handles will be installed to increasing the reach of the workers^[36], the problem will be gone if the pruning work done by mechanical pruning.

2. Discussion

The current methods may cause some environmental issues, like fruits and branches wastage after pruning. Some of the residues are used as mulch to protect the plants while some of them are burned or mostly disposed of in landfills^[37]. To decrease the above problems and to get smooth and even cuts, a new method for pruning is needed. The ultrasonically assisted pruning (UAP) can meet these requirements. The objective of this article is to put forward the effects of ultrasonic-assisted pruning (UAP) on tree health and wound closure by using the ultrasonic pruning. The parameters for the future research analysis can use the pruning time, cutting force, crop load, and labor cost to testify the benefits of the UAP methods. UAP as a new way to prune trees has many excellent benefits, and it will be a useful, promising method in the future.

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