UTILIZATION OF COTTON GIN WASTE

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Waste management is a nuisance and an added business cost for many cotton ginners. However, innovative gin owners and others have found value using gin waste as a potting soil ingredient, landscape material, livestock feed, livestock bedding, fuel for heat or power generation, raw mix for building material, etc. Others have shown gin customers the value of gin waste as a soil amendment or have developed other local markets. Waste utilization depends on your gin location, yard space, labor, management interest and complementary local industry. There is no single approach; innovative waste utilization is often the result of finding local partners or markets.

Plan Waste Handling

If yard space allows, storing waste near the gin until the season is nearly over avoids stretching gin management, especially during multi-shift ginning. Locate the waste pad to ease gin traffic flow and minimize ruts, allowing adequate space for loading. A good pad for a waste stack is free-draining sand (ASTM Std D2487). Consult environmental regulations, pink bollworm and other insect regulations, fire insurance policy clauses and fire protection laws to meet waste handling requirements and avoid penalties.

The amount of gin waste depends primarily on whether cotton is harvested with pickers or strippers (Table 1). Picked cotton contains from 75 to 150 pounds of waste per bale of ginned lint (Anthony and Mayfield). Stripped cotton may have from 250 to 1600 pounds of waste per bale, with 700 to 900 pounds of waste per bale typical enough to suffice for planning where strippers don't use bur extractors. Strippers using bur extractors to remove sticks and burs commonly reduce the gin waste per bale down to 350 to 500 pounds.

Take precautions to avoid a gin waste fire. A fire may ignite in the harvester, gin or in other ways. Smoke may affect nearby workers, highway traffic or residential neighbors. The fire may smolder, producing disagreeable odors and smoke that may prompt environmental regulatory action. Smoldering waste may break into a hazardous open fire without warning. Whether fires and smoke are caused by spontaneous combustion or an outside ignition source doesn't matter, it diverts gin staff from gin tasks. Gin waste fires may threaten equipment and gin buildings.

It is better not to have green bolls concentrated under a deep stack of waste from stripped cotton. Respiration of green plants generates heat and moisture, and given a choice, bolls are best placed near the outside of a stack where heat dissipates. Interior heat drives temperatures very high because gin waste is an outstanding heat insulator.

Initially, biological activity may raise the interior temperature of a waste stack to 140^0F to 165^0F (Mote and Griffis, Reddell et al.). Chemical oxidation may raise temperatures well above 200^0F if any oxygen (air) is available to the heated zone. Interior temperatures may "char" or "caramelize" (Cotton plant sugars are the first compounds to convert.) waste in deep stacks. Rarely does adequate oxygen for ignition reach the hot area but when it does, a fire may break out.

Adding Moisture to Gin Waste

Apply approximately 10 gallons of water per bale of picked cotton initially if waste adsorbs the water without runoff. For waste from stripped cotton, add more water in proportion to the amount of waste that accumulates. Wetting the waste slowly allows greater adsorption. Select a nozzle with medium to fine atomization and position it to cover the waste uniformly. Periodically re-wet the waste (either a rain or surface spray) to rid the stack of dry areas where a fire may start. Avoid anaerobic decay by not applying too much water. Too much water may cause offensive odors and form puddles that attract insects. It is helpful to open and turn enough of the stack after a rain to assess whether some sections are too soggy. If possible, mix the waste in wetter zones with dry zones to gain moisture uniformity and simultaneously provide air to speed composting. Mixing is also very helpful in reducing viable weed seed and certain disease organisms.

Spraying water when you're not ginning as well as rain may cause puddles. If air doesn't reach wetted zones, anaerobic decomposition may produce hydrogen sulfide, methane, fatty acids, complex gases and/or metabolites with undesirable odors (Reddell et al.). Puddles may attract mosquitoes or flies. Certain states have an insecticide registered to control insects. An injector can be installed in the water supply line to provide .1% to .25 % in the spray (Thomasson and Willcutt).

Natural Deterioration

Stacked or windrowed waste eventually decays in the rainbelt. Rainfall runs into the crevices and aids decay. If left unturned, the surface 6 inches of the cotton gin waste may remain loose and somewhat unaltered for months. Decay takes much longer in very dry climates. The outer 6-inch surface decomposes slowly because heat readily leaves the surface (Mote and Griffis). Weed seeds, insects and disease (verticillium wilt, etc.) pathogens typically remain viable in this cooler zone. Mixing the stack after a rain restores temperature uniformity (113°F to 140°F preferred), distributes moisture and supplies additional oxygen, thereby aiding compost microbes (Reddell et al., Rynk et al.).

A deep brown layer below the outer shell is often well composted, but this second zone doesn't attain temperatures as high as the interior. Deep stacks often reach very high temperatures (gray-white zones), sometimes with lint unaffected. Microbes become dormant or are destroyed if temperatures rise above 150°F to 165°F (Reddell et al., Rynk et al.). In the hotter regions energy is utilized, leaving waste with high ash content and low energy content for cattle feed or low fertility and water storage capacity for soil. Regular mixing to maintain temperatures between 113°F and 150°F prevents rotting or smoldering.

Some ginners stack waste from the full ginning season. A number of gins have an auger conveyor (up to 120 ft long) supported on posts for stacking waste under the length of the conveyor. Gin waste density varies from 8 to 12 lb/ft^3 depending on stack height. Another commercial system distributes waste around 280 to 320 degrees of a circle to form a stack up to 30 feet high. As waste accumulates to the bottom of the auger, a gin worker pivots the auger system, forming a pie-shaped stack. Waste "cones" with natural crevices where rainfall enters the stack. Anaerobic deterioration begins if excess water collects in portions of the waste. Typical stack heights restrict air penetration into the interior; thus, chemical oxidation is limited to zones somewhat nearer the surface or where conditions in crevices foster high temperatures and, possibly, begin smoldering long before a flame appears.

Handling/Sorting Gin Waste

Profitable uses may be developed from a portion or segment of your gin waste. Table 2 summarizes the waste components that made up samples of both picked and stripped cotton. Sticks and burs compose a high proportion of stripped cotton. Typically, picked cotton has a larger percentage of immature seed, leaf portions and lint. Maintaining grid bars well and using only one stage of lint cleaning both reduce fiber content in the waste (Anthony and Mayfield). Waste is reduced if motes are reclaimed; motes averaged 16.5 pounds per bale in one national survey (Thomasson).

A market may be developed that justifies separating waste as it is discharged from the gin. Separation and use of portions of gin waste such as the discharge from overhead cleaners or the plant portions left after removing soil, has been profitable. For example, collecting waste other than that from the unloading system or the lint cleaners, etc. may be beneficial. The ash content in the waste from the unloading fan (Table 3) is significantly higher. Extractor, lint cleaner, feeder and gin stand wastes have less ash; therefore, are better fuel or feed roughage. Furthermore, pesticide residues in selected waste components are lower; i. e. certain residues may not exist in lint, seed, plant fragments or soil, etc. after harvest (Holt et al., Winterlin et al.). Simple screens under an auger conveyor readily sift out dense soil. Removing soil from the plant material improves its quality for burning, feeding livestock and paper or wood product ingredients (Holt et al., Thomasson). Soil contamination increases wear on dies or saw blades and other equipment if waste is pelleted or used as an ingredient in a wood product (Thomasson). Well-designed separation processes attain a more uniform, salable product. When some portion of your gin waste is sold profitably, unsold portions may be spread on local cropland. If only soil screenings are spread on the fields the volume is reduced greatly and there is more flexibility to haul when fields are suitable for a truck.

Waste with a high bulk density is easier and may be less costly to move (Table 4). Gin waste may be pretreated and extruded, pelleted, ground, moduled and baled in rectangular hay balers, mote presses and cotton presses. A few gins have arranged seasonal use of stationary cubers. If soil isn't removed, it is abrasive to equipment components.

Soil Application

Many plants/crops grow better and produce higher yields with gin waste added to the soil. Under a wide range of conditions, cotton yield has been maintained or has increased (doubled in one field test) or cotton has produced lint on "sand blows" where previously cotton died (Fryrear, Thomasson). Gin waste increases the water-holding capacity of the soil, reduces soil-surface crusting, improves soil tilth, provides organic matter and retards soil erosion. Fryrear's measurements indicated soil water storage increased 31 % to 50 % from the application of 4.1 tons/A of gin waste. Supplemental gin waste reduced soil bulk density and increased hydraulic conductivity, air porosity, total porosity and organic matter content. All of these factors contribute to better soil tilth.

The nutrients in gin waste vary but if you haven't obtained a lab analysis, 25 pounds of nitrogen (N), 12 pounds of phosphorous (P) and 25 pounds of potassium (K) per ton of dry weight are suggested as a "rule of thumb" (Anthony et al.). Nitrogen content ranges from 15 to 80 pounds per ton and K content up to 100 pounds per ton in gin waste. Five tons or less per acre of gin waste has provided excellent yields (Keisling, Thomasson). Non-irrigated cotton plots where waste had been applied produced greater yields in the 3rd, 4th and 5th years after application (Fryrear). The soil pH, crop needs and the potassium content and pH of your gin waste should all be evaluated before applying rates above 5 tons per acre.

Soil Remediation/Erosion Control

One major contribution of gin waste is to enhance yield by improving the water-holding capacity of the soil. If waste is applied annually on certain soils, increased soil organic matter is another factor. Dramatic agronomic improvement has been evident with soils lacking humus, organic matter, water storage and/or water infiltration qualities (Table 5). Improved water infiltration and water retention in the soil have benefited crops, eroded areas, surface excavation sites and construction sites. Cotton has wilted and died on "sand blows" prior to repeated applications of 4-8 tons/A of gin waste. High rates of gin waste on a sodic soil restored production for several seasons (Thomasson). Table 5 lists two measures of the effect of gin waste and chicken litter in restoring productivity to areas where topsoil was graded to improve surface drainage. One year's data is preliminary, but roughly 3 tons of gin waste per acre provided the same rice yield increase as 1 ton of chicken litter pellets per acre (Keisling).

Spreading gin waste is an effective erosion-control measure for erosion-prone slopes on hills, river levees, pond spillways, construction sites or sandy fields and areas like sand blows (Table 6). Damaging winds in areas with sandy soils can destroy cotton seedlings, often causing growers to replant. Spreading several tons per acre of gin waste helps to prevent this seedling damage. The USDA Natural Resources Conservation Service has specifications that allow gin waste to be used for at least two standard conservation practices, #484-Mulching and #342-Critical area planting (NRCS). Gin waste helps retain moisture in the soil, reduces surface soil temperature, retards soil erosion, restores turf and decomposes readily.

Ginners are providing waste for local remediation or selling to contractors managing construction sites, roadways, commercial and residential developments, etc. to control sediment and prevent stream pollution as mandated by the EPA. Ginners have been able to contract with local farmers or landscapers or others to provide a specific waste quantity at times specified by the user. Other ginners have been careful to specify their requirements for hauling the waste away and then advertised for sealed bids in a local newspaper. Ginners using this approach typically retain their right to accept or reject any bids. Bidders specify tonnage with their price offer, allowing the ginner to sell to one or more buyers. The ginner isn't compelled to sell to the highest bidder if the ginner is concerned about the buyer's compliance with his needs.

Pesticide Residue

In Raw Waste

Pesticide residues in soil or plant fragments that enter a gin tend to exit unchanged (Table 7). Arsenic, Cotoran, sodium chlorate, Karate, methyl parathion, DEF, Dropp and Gramoxone are examples of cotton pesticides that may persist in gin waste at low residue levels (Buser, Holt et al., Mayfield, Thomasson, Winterlin et al.). Many herbicides and insecticides metabolize and disappear prior to harvest as a result of ambient heat, light, microbial activity, etc. Certain pesticides don't persist in any of the waste components, i.e., soil particles, immature seed, cotton seed or lint, leaf, bract, boll, bur or stem fragments (Holt et al., Thomasson, Winterlin et al.). However, other residues concentrate in one or more of the waste components. Arsenic residues have been sampled extensively. Residues from many pesticides have been published---too many to summarize. Residues of certain pesticides tend to remain in the food chain. Tolerance levels are set to avoid harm from residues. Tolerance levels are given on material safety data sheets or can be requested from the pesticide manufacturer.

Hopefully, more label tolerances for residues will be added as pesticides are registered or reregistered. Revised tolerance levels for feeding gin waste to finishing beef and lactating dairy are anticipated. Practical tolerances are an important factor whether gin waste will become more desirable for rations and whether treatments that enhance waste digestibility become widely used. Label guidelines on feeding gin waste are the law and should be followed.

In Processed Waste

Processing may metabolize, detoxify or destroy pesticide residues in gin waste components and broaden the use of gin waste (Buser, Thomasson, Winterlin et al.). Waste mixed with cottonseed and extruded for livestock rations has almost eliminated certain residues and reduced others (Buser). Methyl parathion and Dropp residue levels were lowered significantly with one pass through a screw extruder (Table 8). Evaluating more pesticides may add feeding options, once regulatory approval is granted.

Composting is one of the most effective processes for lowering a number of pesticide residues. Pesticide properties primarily determine the degree of decay during composting (Table 9). Raw gin waste residues of both sodium chlorate and Supracide were dissipated by aerobic and anaerobic compost (Winterlin et al.). Aerobic composting nearly dissipated Omite and anaerobic composting reduced raw waste residues 70 % (Table 9). A residue of 45 ppm DEF in raw waste was lowered somewhat by aerobic composting but remained virtually unchanged by anaerobic composting. The processing characteristics of extruding or composting that reduce certain pesticides to acceptable levels may enhance gin waste utilization opportunities.

Compost

Composted gin waste, mixed into potting mixtures or spread on fields, enhances plant growth and yield. Compost has furnished superior growth for beans, beets, bell peppers, cotton, spinach, tomatoes, garlic and other crops, especially vegetables and fruits (Thomasson). Successful potting mixtures for a variety of plants, including tomatoes, poinsettias, chrysanthemums, marigolds, salvia and vinca and rooted cuttings of forsythia, are documented in several technical references (Thomasson). Gin waste, either alone or mixed with wet materials such as manure from swine, dairy and poultry or municipal sludge, is excellent for compost (Thomasson). Broiler litter and gin waste mixes produced high yields and excellent grazing. High rates of compost application may raise the soil pH too high; at high rates gin waste compost has been unsatisfactory on saline soil (Thomasson). Various combinations are helpful for land reclamation, soil conditioning, landscaping, turf management (parks, athletic fields, golf courses, cemeteries, etc.) and potting soil mixes for vegetables, ornamental plants, etc.

Well-managed compost reduces total waste volume by approximately half and may double the content of primary nutrients (Anthony et al.). Compost stabilizes nutrients in an organic form. The amount of primary fertilizer nutrients in compost varies widely; laboratory analyses are recommended for gins that develop a consistent process. One suggestion for well managed compost, if better data aren't available, is to use 50 pounds N, 25 pounds P and 50 pounds K per ton of dry weight (Anthony et al.). However, the residual effect of compost application lasts several years. One suggestion was to plan for 15 % of the nitrogen from the compost to be available for the first crop (Rynk et al.). Compost from gin waste provides plant nutrition not available from commercial fertilizer, as well as an unusual capability to increase soil water holding capacity. In addition, waste adds structure, organic matter and humic acid to the soil and several minor elements essential for plant growth (Rynk et al., Thomasson). Completed, cured or quality compost is in an organic form that doesn't compete for nitrogen like raw gin waste may immediately after incorporation.

Composting is simply providing a favorable environment for microorganisms, including bacteria and fungi, to convert gin waste into a friable, soil-like material. Lint and large sticks are more resistant to microbial activity; turning the stack or windrow is necessary to get uniform, humus-like compost. Lint, sticks and large bur portions have a fairly high carbon content. Their C:N ratio is somewhat higher than the 25 - 30 C:N ratio recommended for compost (Mote and Griffis, Rynk et al.). Bulk gin waste has a composite C:N ratio between 25 - 40 (Parnell 1981).

Composting is either aerobic, in which the microbes use oxygen to digest the waste, or anaerobic if there is a lack of oxygen. Stable organic matter, carbon dioxide and water vapor are the products of aerobic composting. The aerobic process is favored partially because the carbon dioxide and water vapor products are harmless and odorless. Stabilized aerobic compost has a sweet odor as opposed to a gin waste, manure or rotten egg odor. A uniform product with consistent properties has potential to get a better price. Anaerobic compost may produce methane, hydrogen sulfide, aldehydes, alcohols and other organic gases (Reddell et al., Rynk et al., Thomasson). Also, ammonia volatilizes from poorly managed waste (Mote and Griffis, Reddell et al.). Unstable waste compounds may continue to use oxygen from the soil, and waste with a low nitrogen content may "starve" plants. This is a practical concern for seed germination and for potted plants.

Composting Guidelines

Moisture needs to be added after waste leaves the gin. Forty to 65 % m.c., wet basis, is the best range for composting (Mote and Griffis, Parnell 1977, Reddell et al., Rynk et al.). Add and maintain enough water to raise waste to at least 40 % m.c., wet basis, to help speed composting. A surfactant (.5 %) in the spray may help water adsorb on the waste more readily and help to "jump-start" microbial processes that convert waste (Thomasson and Willcutt). Nitrogen can be sprinkled on compost to "fortify" it as a fertilizer but neither nitrogen or various inoculates, such as biological microorganisms, are needed for compost (Mote and Griffis, Rynk et al.).

Monitoring when the temperature reaches 150^{o}F is a good method to determine when to mix and turn compost. As waste dries, both adding water and mixing the waste cool the compost. Initially, the compost temperature may rise back to 150^{o}F in 4 – 7 days after mixing (Thomasson and Willcutt). As compost cures, mixing intervals are extended into 1 to 2 weeks. By adding water to keep waste above 40 % m.c. and maintaining temperatures from 120^{o}F to 150^{o}F, you'll get sweet-smelling, uniform soil-like compost in 4 to 10 weeks (Mote and Griffis, Winterlin et al.). Composting is rapid when temperatures are maintained within the range favorable for aerobic microorganisms. Temperatures above 150^0F to 165^0F may destroy thermophilic (heat-loving) microbes; they later "restart" from cooler, exterior portions. Once the temperature peaks above 150^0F, reestablishing microbial activity delays the completion of high quality composting.

Proper temperature, proper moisture content and adequate oxygen are the keys to making a musky, sweetish, almost odorless final product. Raw gin waste can be trucked from the gin to the compost site and unloaded in windrows. A compost area with 1½ % to 2 % slope aligned with the windrows is recommended for wet climates. For reloading and selling into quality compost markets, pavement is preferable unless weed seed and other soil contaminants pose no problem in the mixture. Compost is denser than gin waste; thus, it may be loaded, hauled and handled more economically (Table 4).

Effect of Compost on Disease and Weed Seed

Compost processes killed all the seeds of weeds and certain common fungal disease organisms sampled by Griffis and Mote and Sterne et al. Aerobic composting destroyed verticillium wilt and *verticillium alboatrum* organisms during composting. *Verticillium dahliae*, a vascular wilt fungus, was destroyed, except in surface zones of the compost that didn't reach the sustained interior temperature (Sterne et al.). *Alternaria*, related to fungal leaf blight was also destroyed, again with the exception of the cooler surface zone. However, cotton bacterial blight, *xanthomonas malvacearum*, survived in all zones.

Bermudagrass, Johnsongrass, pitted morningglory, purple moonflower, redroot pigweed, sesbania and watergrass seeds were killed (Griffis and Mote). The heat not only sterilized seeds, but moisture initiated germination and then heat destroyed the plumule or cotyledon. Weed seeds, insects, disease organisms or biological compost microorganisms cannot survive 180°F temperatures (Rynk et al.).

Livestock Feed

Livestock rations may be an excellent market for gins near feeding operations. A 1997 Texas High Plains survey disclosed that 48 % of the waste was fed to livestock, 33 % applied to fields and 16 % composted (Castleberry and Elam). A similar survey of Mississippi that year concluded that 95 % was applied to fields or composted and 2.3 % was fed. However, several years ago a Texas ginner delivered waste for $1.75 / ton three miles from his gin. He found the cost to load and haul exceeded this (Castleberry and Elam).

Feedlot rations for growing and fattening cattle throughout the United States require a minimum level of crude fiber or "effective" fiber to help reduce or eliminate digestive disturbances such as bloat and founder in feedlot cattle. Typical feedlot rations used in the final 3 to 5 months before animal slaughter typically contain 7 to 8 % crude fiber. Feed grains (corn, grain sorghum, etc.) and protein sources (soybean meal, cottonseed meal, etc.) are generally low in crude fiber content but they usually makeup 85 % or more of the ration. Therefore, there is a need for some effective fiber in finishing rations. To be justified economically, gin waste must compete with other fiber sources such as cottonseed hulls, wheat straw, sorghum stover, etc. In areas where alfalfa hay or other hay or silage is available, gin waste provides fiber, but hay and silage also provide protein and / or energy. The value of gin waste hinges on the cost and availability of fiber. During times when cottonseed hulls or other low quality roughages or crop residues are costly, gin waste may command a higher price. An analysis of average ration ingredient costs between 1991-1997 from a Texas feedlot, projected that 9.3 % gin waste was economical in a ration up to a feedlot cost of $87 per ton (Castleberry and Elam). Very few ginners receive $80 per ton for gin waste but this suggests there are times when or locations where gin waste has substantial value as a small portion of a ruminant ration.

Digestibility of gin waste for ruminants is typically low, even compared to most roughages (Thomasson). The nutritive value of waste is fairly similar to fescue for roughage and somewhat better than prairie hay (Table 10) (Buchanan). The crude protein content of raw gin waste varies from 6 % - 14 %. Waste from picked cotton usually has higher crude protein content than waste from stripped cotton (Holt et al., Lalor et al.). Adding cornstarch raised the protein, energy and fat content. Various treatments have been evaluated for their ability to improve intake, digestibility and increase the protein or energy of feed rations containing gin waste. Anhydrous ammonia, ammonium hydroxide, urea, hydrogen peroxide, molasses, sodium peroxide and other treatments have increased gin waste digestibility or palatability. Ensiling with moist forage improved the palatability of gin waste. In another trial, mixing waste and fluid cottage cheese whey improved digestibility and palatability (Thomasson).

The waste content of ruminant rations is limited by relatively low protein, low digestible energy for maintainence and growth and, at times, cotton pesticide residue. Rations with grain and other feedstuffs increase protein, improve palatability and dilute any pesticide residue in the gin waste. Moreover, by passing a mixture of 75 % gin waste and 25 % cottonseed through a screw extractor Buser lowered methyl parathion and Dropp residues (Table 8). As pesticides with less persistence are labeled, more gin waste may be fed in areas other than Texas. Common defoliants weren't even detected in one third of the waste samples gathered from the Midsouth and Southeast in 1991 and 1992 (Mayfield). However, other samples ranged as high as 40 ppm; well above feed tolerances.

Gin waste can be left out of livestock rations months prior to scheduled animal slaughter. This allows time for residues to decline or leave the animal. If a cotton pesticide label has no reference to feeding gin waste, the manufacturer can be contacted whether the pesticide or its metabolites are persistent and are likely to accumulate in livestock fat, liver, etc. Residues in beef tissue have been sampled and generally were below tolerances, yet high enough to warrant close attention (Thomasson). Feeding non-lactating beef cows or dairy herd replacements is a practical approach. Pesticide labels from certain persistent compounds prohibit feeding waste (Table 11). Lactating dairy cows should not be fed gin waste unless none of the products applied to the cotton have dairy feeding restrictions on the pesticide label. Before using gin waste in a livestock ration, it's always important to consult and follow current labels of pesticides that have been applied to the cotton.

Incineration

The Clean Air Act of 1970 and subsequent EPA regulations have virtually eliminated gin waste incineration. Fluidized bed combustion met federal incinerator standards when temperatures were maintained between 1,400^{0}F to 1,500^{0}F (Parnell 1981, Thomasson). Incinerator technologies with pre-combustion chambers and heat sensors that meet EPA air quality codes are costly. High cost hinders incinerator installation, especially, since gins typically operate only 2 to 4 months a year. Gin waste is rarely burned in the United States today, but increasing costs of most fuels have renewed incinerator development.

Gin waste contains from 6,000 to 7,500 Btus per pound, very comparable to wood (Griffin, Holt et al., Parnell 1981). Cotton bolls, alone, may have up to 8,000 Btus per pound (Griffin). European incinerators are in use in Greek cotton gins and in other locations. Soil is screened prior to incineration and ash is automatically removed from the burner. Gin wastes fire a steam boiler supplying low-pressure steam for seed cotton dryers, replacing LPG burners. Any surplus energy provides heat for work areas. Waste is not used for drying cotton in US gins because incinerators failed EPA requirements for air stack discharges. Years ago several gins burned waste and supplied 30 % to 100 % of the heat to dry lint. The high ash content of gin waste accumulated as slag or "glass" on the burners (Parnell 1981, Thomasson). Selecting the desirable plant components from bulk gin waste and incinerating it may lower the typical 10 % - 20 % ash content range down into the range of 5 % - 8 % (Holt et al.). Eliminating ash reduces furnace corrosion, burner crusting (clinkers, slag, or sand) and stack emissions. Waste hauling may be curtailed enough to allow a gin employee to haul soil screenings between other assignments.

Creative Solutions/Other Uses

Gin waste may be an excellent fuel. Applications for heat and electric power may become profitable for strategically located gins, as the cost of fuel and electrical power continue to rise. Current utility deregulation may offer greater opportunity for ginners to supply energy to power grids. One ginner provided waste to a power supplier using a fluidized-bed gasification process. The power supplier burned by-products to generate boiler heat. Incinerator innovations that reduce their cost and meet EPA's air emission limits may make incinerators feasible for the larger gins.

Gins may have opportunities to sell gin waste byproducts, possibly by partnering in charcoal briquette or activated charcoal production (Parnell 1981, Thomasson). White et al. recently investigated liquefaction using an extruder to convert gin waste to fuel. Converting waste into fire logs, ethanol, methanol and pyrolytic oil are technically feasible (Thomasson).

Recent efforts to develop pellets or extruded products mixed with starch show promise (Holt, Buser). This process prepares waste for use in cattle rations, as a pelleted fuel or as a soil amendment, depending on the best market. Gin wastes may become profitable where competitive raw materials are too costly. One product, burned in pellet stoves, generated 6500 to 7500 Btus per pound of pellets, matching or exceeding the heat provided by wood. This process can also be used to "fortify" or "spike" waste with nitrogen or other additives to meet fertilizer or feed ration needs. Identifying local opportunities for livestock rations, soil amendments or a convenient solid fuel may become profitable. A ginner may need to be ready to develop his own production, packaging and marketing.

Gin waste has the capability to absorb water and petroleum products. Dairies use gin waste for bedding. Local efforts may identify bedding mixes or define advantages of gin waste as a preferred source of livestock bedding.

Reports from 1972 – 1998 agree that gin waste is a desirable mushroom growth substrate. Edible mushrooms grown on a mixed substrate of gin waste and wheat straw have produced the greatest yields (Thomasson). A few mushroom growers have utilized gin waste to obtain quicker mushroom emergence and superior yields.

Gin waste has been evaluated as a partial substitute for wood construction materials. Wall board, insulation board, roofing felt paper, shingles and cinder blocks were made partially from gin waste (Thomasson). Gin waste or gin waste blends were stronger than typical construction for particle board, insulation board and millwork shapes. Saw blades and other tools wore rapidly if the waste was contaminated with sand. Good sand/soil separation equipment solves this. Partnering with a wood products industry may be an opportunity for several gins near a manufacturer.

Summary

Review your management time, management skills, gin yard space, labor and potential for building another enterprise or partnering with a complementary local industry. Insight, planning and management are vital to produce a product and develop reliable markets for your gin waste. Getting higher prices for gin waste, either in bulk or bagged, by merchandising it for specific markets requires creative and consistent effort.

Changing prices for fuel, fertilizer, feed and other potential markets shift the attractiveness for investment. Technology for processing raw biomass is expanding; the cost of collecting raw material for production is the most common constraint. The low bulk density of gin waste suggests that the more profitable markets for ginners are those that can be developed near the gin. Startup expenditures for converting gin waste may be justified more readily in west Texas where large amounts of waste gather from stripped cotton. The large gins may be able to develop and supply a larger gin waste market.

Currently, the two most popular options are compost production and gin waste as a small portion of livestock rations. Compost has more potential in populated areas. Many turf managers (community parks, cemeteries, athletic fields, golf courses, etc.) and vegetable growers are beginning to understand the "long-term" benefits of compost. Favorable pesticide residue tolerances may attract gin waste consumers for both livestock feed and bedding. Stewardship of gin waste, including pesticide residue potential, must be given high priority in choosing an option.

Currently, many growers, landscapers, etc. undervalue gin waste for agronomic or horticultural productivity. Soil amendment and remediation markets can be exploited more. Often soil application is a gin's least cost option. Offering gin waste on a bid basis may encourage competition and eventually get a better price. Make sure your solicitation for bidders outlines your needs for waste removal, timeliness, property cleanup, etc. See suggestions under "Soil remediation / erosion control". "Pick-up" customers have historically been one way many small gins moved one load of gin waste at a time. Specifying minimum bid values may be a less troublesome approach for larger gins.

Ultimately, supplying your customers a uniform product may be less complex than choosing a price that allocates your waste supply. Providing the quantity needed, whether it is for livestock feed, livestock bedding, landscaping, potting soil mix, land remediation or retarding soil erosion may become a challenge. Customers who rely on your supply develop a base price. Product consistency may translate into receiving a higher price.

Waste alternatives should be investigated, especially, before new gin construction is initiated. A creative evaluation of potential waste markets may uncover an opportunity. Exploiting gin waste properties and local markets may secure a dividend for your management time.

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Table 1. Estimated amount of waste from cotton harvested with pickers and strippers.

	Annual Gin Waste Production, est. tons	
Total Annual Gin Volume, bales/yr	**Picked cotton @ 100 lbs/bale**	**Stripped cotton @ 700 lbs/bale**
10,000	500	3,500
15,000	750	5,250
25,000	1,250	8,750
35,000	1,550	12,250
50,000	2,500	17,500

Table 2. Components of gin waste composition from picked cotton and stripped cotton.

Picked cotton, % (Griffin)		Stripped cotton, % (Parnell 1981)	
Leaf	21	Fines	24.9
Lint	42	Lint	7.7
Sticks, stems and hulls	35	Sticks	10.7
		Burs	56.6

Table 3. Average waste content sampled from chosen equipment outlets when ginning two stripped-cotton varieties. (Holt et al.)

Parameter	Unloading System	Feeder and Gin Stand	Lint Cleaners
Bulk Density, lb/ft^3	13.3	7.7	5.1
Net Heating Value, Btu/lb*	5620	6850	6930
Ash Content, %*	36.0	8.7	6.2
Available Protein, % **	5.3	9.8	5.1
Total Digestible Nutrients, %**	32.5	48.3	46.5

*Fuel analytical methods ASTM D 2015 for heating values and ASTM D 5142 for ash contents.

**Forage analytical methods for available protein and total digestible nutrients.

Table 4. Estimates of gin waste density from selected processes. (Anthony et al., Thomasson)

Gin waste form	Estimated bulk density, lbs/ft^3
Extruded (Buser, Holt et al.)	7 - 11
Stacks of gin run waste	7 - 12*
Chopped gin run	8 - 13*
Ground	10 - 15
Compacted modules	20 - 23
Dry compost (Parnell 1977, 1981)	18 - 28**
Compost (Parnell 1977, 1981)	22 - 35***
Pelleted(Lalor et al.)	35 - 40

*Higher densities are possible with deep stacking or additional moisture.

**Compost may range from 10 to 20 % m.c., wet basis, in equilibrium with ambient air.

***At 40% m.c., wet basis.

Table 5. Soil remediation for rice production after grading, comparing one application each of gin waste and chicken litter. (Keisling)

Soil amendment	Rate, tons/A	Rice yield, lbs/A	Soil test N, average %
None	-	3851	2.96
Gin waste	½	4902	-
Gin waste	1	4899	2.79
Gin waste	2	4729	-
Gin waste	5	5533	3.11
Chicken litter pellets	1	5340	3.23
Chicken litter pellets	5	4539	3.80

Table 6. Effect of gin waste on controlling soil erosion caused by wind. (Thomasson)

Waste application rate, tons/A	Wind erosion reduction, %
1	43
3	69
5	87

Table 7. Concerns about raw gin waste. (Parnell 1981, Thomasson)

(1) Live weed seed in cotton waste.
(2) Insect winter habitat in cotton waste.
(3) Disease organisms in cotton waste.
(4) Residue of a cotton pesticide in cotton waste hinders use in some markets.
(5) Cost, inconvenience and management necessary to transport low-density waste (and spread low-N, P and K product).

Table 8. Average pesticide residues in mixtures of 75 % gin waste (picked cotton) and 25 % cottonseed samples from both unprocessed and screw-extruded mixes. (Buser)

Pesticide	Residues in mix not extruded, ppm	Residues in mix after extrusion, ppm
DEF	46.4	66.4
Dropp	8.3	0.4
Methyl parathion	12.8	6.2
Karate	3.9	2.8

Table 9. Effect of aerobic composting on selected pesticide residues. (Winterlin et al.)

	Residue of pesticide in waste sample, ppm			
Sampling time	Omite	DEF	Gramoxone	Sodium Chloride
Prior to composting	3.2	1.3	15.7	437
26 days after composting	3.2	1.5	23.2	91
57 days after composting	0.7	1.4	19.4	< 20

Table 10. Nutritional characteristics of selected feeds developed by the National Research Council.(Buchanan)

Feedstuff	Dry Matter, %	NDF, %	NEm Mcal/lb	NEg Mcal/lb	CP, %	Ca, %	P, %	K, %
Flaked corn	86	9.0	1.06	.74	9.8	0.03	.31	.33
Cottonseed hulls	91	90.0	.36	.11	4.1	0.15	.09	.87
Cotton gin waste	90	59.9	.35	.11	9.3	1.19	.15	2.35
Fescue hay	88	65.0	.54	.28	9.1	0.37	.29	1.84
Prairie hay	91	72.7	.41	.16	5.3	0.35	.14	1.00
Alfalfa	91	39.3	.59	.34	25.0	1.41	.22	2.51
Cottonseed meal	92	28.9	.81	.53	24.4	.20	1.16	1.65
Soybean meal	90	7.8	.98	.67	54.0	.29	.71	2.36

NDF = neutral detergent fiber, NEm = net energy required for maintenance adjusted for acclimatization, NEg = Net energy required for gain, CP = crude protein, Ca = calcium, P = phosphorus and K = potassium

Table 11. Current sample label restrictions related to cotton foliage and gin waste.

Ammo 2.5 EC Bladex 4L (directed/layby) Karate Pix	Do not graze or feed cotton forage to livestock.
Asana XL Monitor 4 Quick Pick	Do not graze livestock on treated fields or feed treated trash.
Cotoran 4L Dropp Ultra Ginstar Supracide 2-E or 25-W	Do not feed foliage from treated cotton plants or gin trash to livestock.
Poast Gramoxone Sodium chlorate	Do not graze or feed gin waste to livestock.
Roundup (for regrowth suppression)	Do not harvest or feed treated vegetation for 8 weeks following application