PRODUCTION AND DISPOSAL/UTILIZATION OF COTTON GINWASTE FROM THE TEXAS HIGH AND LOW PLAINS

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Abstract

The 1996-97 Texas High and Low Plains Cotton Gin Waste (CGW) Utilization Survey was developed to provide a current assessment of the disposal methods used by gin operators. Results indicate that from a ginner's perspective costs associated with CGW disposal have increased since 1977. Results further suggest that even though basic disposal methods have remained constant, use of these methods has changed with compost and livestock feed increasing relative to soil amendment.

Introduction

The process of ginning cotton separates seed cotton into three commodities—lint, seed, and trash. The lint and seed are the most valuable and marketable of the three commodities and thus receive the majority of attention with respect to research and market tracking. By contrast, gin trash—or cotton gin waste (CGW)—is viewed as a low-value by-product of cotton production. From a ginner's perspective, CGW occupies space at the gin yard, is a potential fire hazard, and is costly to dispose of (Mayfield, 1991).

CGW from machine stripped cotton is composed of burs, sticks, leaves, fine trash, immature seed, sand, and rocks. When stripper harvested cotton is ginned, about 700 lbs. of CGW is produced per bale ginned (compared to 100-150 lbs. for picker harvested cotton) (Thomasson, 1990). On the Texas High and Low Plains—where stripper harvested cotton dominates production—an average of 1.17 million tons of CGW was produced for the cotton marketing years 1993-95 (based on 700 lbs. of CGW per bale ginned) (Texas Agricultural Statistics Service, 1996).

Given the problem of CGW disposal, research has been conducted on alternative uses and potential disposal practices. Various utilization/disposal methods have been studied: using CGW as an energy source, open air incineration, adding CGW to fields as soil amendment, and using CGW as a low quality roughage source for ruminants (Mayfield, 1991). A comprehensive review of CGW disposal and utilization is provided by Thomasson (1990).

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As early as 1979, attempts were made to discover an efficient process to gasify CGW and utilize the resulting fuel to power internal combustion engines (reported by Gembler and Misra, 1996). Srikanth (1985) researched gasification processes and reported that by using a downdraft gasifier CGW could be economically transformed into gaseous fuel for gins operating at or above 21 bales per hour ginning rate.

Prior to the Clean Air Act of 1970, incineration of CGW as a disposal method was commonplace. In 1965, 37 % of the CGW produced across the U.S. Cotton Belt was disposed of by incineration (Reeves, 1976). By 1977, only 1 % of CGW produced on the Texas South Plains was incinerated (Kolarik et al., 1978). Research in this area has resulted in systems that meet the strict emission standards of the Clean Air Act, however, implementation of these systems is not economically feasible for gin operators (Thomasson, 1990).

A disposal method that has wide acceptance is the utilization of CGW as soil amendment. In 1965, 58 % of CGW produced in the U.S. Cotton Belt was returned to the soil (Reeves, 1976). In this process, CGW is either applied to the field as raw gin waste or as composted gin waste. Raw gin waste is untreated waste that is applied directly to the soil. Composted gin waste is allowed to partially decompose over time before it is applied as soil amendment.

Past research on the effect of CGW on cotton production (from soil amendment) shows mixed results. Thomasson (1990) summarizes several studies that provide evidence that application of three to five tons of CGW to dryland cotton improves seed cotton production by 20 % and lint production by 16-36 %. The increase results from improved water holding capacity and physical structure of the soil and the fact that CGW fertilizes the soil and helps it retain nutrients. One study noted that the greatest yield increase from application of CGW on dryland cotton (sandy soils) occurred during drier years (Fryrear and Koshi, 1974). In contrast to the above studies, Gembler and Misra (1996) report on a study by Millhollon et al. (1984) that revealed no increase in lint or seed yield seven years after application of CGW. Moreover, raw CGW has been shown to increase weed and disease incidence (Thomasson, 1990; Mayfield, 1991). Thus, it is not surprising that there are varying opinions among practicing agronomists, agricultural consultants, and producers on the benefits of raw CGW as a soil amendment for cotton production.

Composted CGW has the same fertilizing effect as raw CGW. Several studies report increased plant growth for a wide range of vegetable, grain, and horticultural plants raised in soil containing composted CGW (Thomasson, 1990). By contrast, researchers in California report that cotton yields were not affected by application of 2 to 10 tons per acre of composted CGW (Pettygrove et al., 1996). An added benefit of composting CGW is that the temperature attained in the composting process destroys foreign seed content and decreases incidence of disease (Thomasson, 1990). Moreover, composted CGW weighs less once dried and has less volume than raw waste, thus reducing transportation and handling costs.

A third solution to the CGW disposal problem is utilization of CGW as a feed supplement for ruminant animals. According to Mayfield (1991), the highest value usage of CGW is for cattle feed. In 1977, 37 % of CGW produced on the Texas South Plains was fed to feedlot and range cattle (Kolarik et al., 1978). Laylor et al. (1975) provide one of the earliest nutritional analysis of CGW from various areas of the U.S. Cotton Belt, and state that CGW could be utilized as a ruminant roughage of moderate protein and energy value, similar to bermuda and prairie hay. Additional studies show that CGW is comparable to alfalfa hay in energy content but rates lower in total digestible nutrients (Thomasson, 1990).

In 1975, cattle feedlot managers in the Texas Panhandle were aware of the potential of CGW as a roughage ingredient in starter and finishing rations and paid up to $35 per ton delivered to the feedlot (Laylor et al., 1975). Subsequent research revealed that in 1982 CGW sold for about $20 per ton (delivered the feedlot) on the Texas High Plains (Williams et al., 1982).

Although feedlot managers utilize CGW as a roughage source, there are problems associated with feeding CGW. One problem is reduced palatability of the ration. Addition of molasses to CGW at the rate 0.4 lbs of molasses per 1.0 lb. of CGW can enhance palatability (Young and Griffith, 1976). However, due to the cost of molasses and the cost of additional processing, cattle feeders do not generally mix molasses with CGW.

Another problem associated with feeding CGW is that transportation is costly due to the bulky structure of CGW. CGW has been ground, cubed, and pelletized, not only to reduce transportation cost, but also to make the nutritive components of CGW more readily available to ruminant animals. Past research and information from area feeders and ginners lead to the following conclusions: (1) feeders produce higher gains from ground CGW than from pelletized CGW; (2) it is not economically feasible to use pelletizing equipment to pelletize CGW for livestock feed compared to the low cost of grinding (Laylor et al., 1975; Young and Griffith, 1976).

The overall objective of this research is to provide a current assessment of ginning industry practices with regard to CGW disposal/utilization for the Texas Panhandle. Studies by Reeves (1976) and Kolarik et al. (1978) provide the most recent information; however, these studies were done more than 20 years ago. The relationship among uses of CGW may have changed over the last 20 years, and thus a survey of area ginners is needed to document current practices of CGW disposal/utilization.

Data Collection

The Ginners' Red Book (Texas Cotton Ginners' Association) was used to determine the location of the operating gins in the Texas High and Low Plains. This region includes 49 counties and accounted for 80 % of Texas cotton production in 1996 (Texas Agr. Statistics Service, 1996). In 1996, there were 230 gins in the study area.

Because of production diversity across the counties, the study area was divided into four regions (defined by the Texas Agr. Statistics Service) shown in Figure 1. The Northern High Plains (Region 1) includes large commercial cattle feedlots and cotton farming operations. The Southern High Plains (Region 2) is where the majority of cotton is produced (64 % of the 1996 production in the study area). The Northern Low Plains (Region 3) and the Southern Low Plains (Region 4) consist of a mixture of both cotton farming and ranching operations.

The 1996-97 Texas High and Low Plains Cotton Gin Waste Disposal and Utilization Survey (available from the authors) included nine questions and was designed to accomplish three objectives: (1) to identify current disposal practices used by ginners; (2) to determine the aggregate production of CGW for the 1996-97 cotton crop; and (3) to evaluate the costs/returns associated with CGW disposal/utilization. The survey instrument was constructed using the advice of a local ginner. Originally, the survey was intended to collect data over a three-year period; however, the gin operator suggested that the survey should be limited to the latest production year to achieve a higher response rate. Furthermore, the gin consultant advised that the best means to obtain additional data would be to conduct the survey on an annual basis.

The survey form was mailed to 230 gins during the second week of August 1997. A reminder letter was sent two weeks later. A total of 87 surveys were returned. Five surveys could not be used due to lack of information. A total of 82 surveys was determined to be usable, which indicates a response rate of 36 % (82/230). The number of responses by region were 12 for Region 1, 38 for Region 2, 12 for Region 3, and 20 for Region 4. Additionally, the cost/return data collected from one large, markedly different gin (in Region 2) was omitted from the cost/return analysis to avoid disclosing information on a particular operation. The gins responding to the survey (ginning an average of 14,200 bales in 1996) were similar in size to the average of all gins in the study area (15,100 bales; Texas Agricultural Statistics Service, 1996).

The results presented in the remainder of this paper are compilations of the survey data. The authors feel that the sample represents a random sampling of area gins and along with the high response rate is sufficient to justify using the data to draw inferences about CGW disposal/utilization practices of the population of all gins in the study area.

Disposal/Utilization

Table 1 summarizes the primary uses of CGW over all regions of the study area for the 1996 crop year, and provides a comparison with the Kolarik et al. (1978) study for the 1977 crop year. Livestock feeding accounted for 47.9 % of CGW usage, which is up from 36.7 % for 1977. Soil amendment accounted for 33.2 % in 1996, and is down from 61.7 % in 1977. Compost as a disposal method increased from 0.2 % in 1977 to 15.9 % in 1996. It should be noted that the 1977 study included 15 counties that were not included in the 1996 survey.

Table 2 identifies the CGW disposal methods practiced in each region of the study area for the 1996 crop year. Livestock feeding accounted for 72.5 % of CGW produced in Region 1. The fact that cattle feeding operations are heavily concentrated in this region helps explain the high percentage of livestock usage.

Region 2 is unique compared to the other regions in that there is a more even distribution across disposal methods. CGW used as livestock feed is highest (42.8 %), followed by soil amendment (35.9 %) and compost (19.8 %). Gins reporting compost as their primary disposal method were highly concentrated within a 50-mile radius of southeastern Lubbock County (where a composting operation is located). The 50-mile radius includes portions of regions 2, 3, and 4. When this was discovered, the authors considered redefining the boundaries of Regions 2, 3, and 4 to account for the concentration of compost CGW disposal. However, to avoid disclosing information on specific operations, the regions were not redefined.

The leading disposal methods in Region 3 for 1996 were soil amendment (47.8 %) and livestock feed (35.4 %). Region 4 is similar to Region 3 in that 53.1 % and 41.0 % of CGW were used for soil amendment and livestock feed, respectively. The approximately equal division between soil amendment and livestock feed disposal methods in these regions may be explained by the geography. Portions of Region 3 and all of Region 4 are located below the Caprock Canyon, which acts as a natural geographical boundary between the Texas High Plains and Low Plains. Agricultural practices in both of these regions consist of a mixture of both farming and ranching.

CGW Production: Procedures and Estimates

A two-step process was used to estimate CGW production in the study area. The first step involved estimating the pounds of CGW produced per bale of cotton ginned. Each responding gin provided data on CGW produced per bale ginned. A weighted average was taken of the observations for each region (with CGW production used as weights). CGW per bale varied across regions (p=.053). Gins in Region 1 produced the lowest average of 583 lbs. per bale, and Region 3 produced the highest average of 931 lbs. per bale. The overall weighted average CGW per bale across all regions was 741 lbs. This compares to an estimated 900 lbs. per bale for the 1977 crop (Kolarik et al., 1978). Direct comparison of the 1996 estimate to the 1977 estimate is misleading due to the recent adoption of the field cleaner (which reduces CGW production).

The second step in calculating total production of CGW in the study area was to obtain the total number of bales ginned in each region, and to multiply this number by the pounds of CGW per bale in each region. Cotton Ginnings data (USDA, NASS) provide information on a county by county basis and are best suited for this process; however, the ginnings data are not reported for all counties. The next best source of bales ginned in each region is the Texas Agricultural Statistics Service (1996), which provides data on the total number of bales produced in each county. Recognizing that cotton can be produced in one county and ginned in a neighboring county, and vice versa, utilization of these data are justified because the slippage will occur in both directions. CGW production estimates are provided in Table 3. Region 2 leads the study area with 838,000 tons of CGW produced in 1996. Across all regions, approximately 1.25 million tons of CGW was produced in 1996.

Effect of Field Cleaner Use on CGW Production

Field cleaners or bur extractors (first researched in 1927) are becoming more popular among cotton producers (Kirk et al., 1970). The idea behind the field cleaner is to reduce the amount of waste that would otherwise be transported to the gin and thereby reduce ginning charges (Bennett et al., 1997). Gin operators were asked on the Texas High and Low Plains Cotton Gin Waste Disposal and Utilization Survey the percentage of the cotton ginned that was field cleaned cotton. A weighted average of the responses was calculated by region and for all regions combined (Table 4). Field cleaner use was highest in Region 1 (58 %) and lowest in Region 3 (18 %). Across all regions, field cleaners were used to harvest 40 % of the 1996 cotton crop. Interestingly, if the regions are ranked from highest percentage of field cleaned cotton to lowest, an inverse relationship with the pounds of CGW per bale is revealed. That is, Region 1 shows the highest percentage of field cleaned cotton ginned (58 %) and the lowest pounds of CGW per bale (583.0), compared to Region 3 with the lowest percentage of field cleaned cotton (18 %) and the highest CGW per bale (931 lbs.). The simple correlation using regional averages (n=4) between CGW per bale and percentage of field cleaned cotton is r=-0.92 (p=.04 for a one-tailed test).

The relationship between pounds of CGW per bale and percentage of field cleaned cotton was estimated and used to determine the impact of the field cleaner on total CGW production:

$$\text{CGW per bale} = \underset{(16.2)}{853} - \underset{(2.28)}{2.54} * (\text{\% bur extracted cotton}) \quad (1)$$

The number of observations used to estimate this equation was n=81, and the coefficient of determination was R^2=0.10. Statistical t-values are shown in parentheses below the estimated coefficients. Interpretation of this relationship indicates that 0 % adoption of the field cleaner should result in CGW of 853 lbs. per bale. Kolarik et al. (1978) estimated CGW per bale at 900 lbs. for the 1977 crop when bur extractors were not used. Furthermore, 100 % field cleaner adoption results in 599 lbs. of CGW per bale produced. The estimated reduction of CGW per bale is about 30 %. In contrast, John Deere claims that field cleaners should reduce the waste content per bale by 45-50 % (Cole). USDA claims the reduction is 60-70 % (Anthony and Mayfield, 1994). In their estimates, both John Deere and USDA assume that the field cleaner is properly maintained and correctly adjusted to harvest conditions. The estimate given in this study is based on real-world experiences and may be lower than those of John Deere and USDA because proper maintenance and adjustment of field cleaners are not achieved at all times. Moreover, the difference in the reduction estimates could be due to the econometric problem of "errors in variables." When the independent variable in a regression model is measured with error, the estimated slope coefficient is biased toward zero (Neter et al., 1996, pp. 164-66). Because of the difficulty on the part of the ginner to correctly assess field cleaner usage, the regression estimate of a 30 % reduction in CGW per bale with a field cleaner may be low.

The impact of the field cleaner is determined by comparing the tons of CGW produced without the implementation of the field cleaner to the tons of CGW produced with full implementation of the field cleaner. This comparison reveals that total CGW production in the study area would be reduced by 442,000 tons with 100 % adoption (Table 5).

Economics of CGW Disposal/Utilization

Disposal/utilization of a by-product is accomplished in two ways. First, the by-product is channeled to the market that offers the highest return. Second, if a positive return cannot be realized, the by-product is then disposed of at the lowest cost to the firm. Economic theory indicates that the cost/return associated with CGW disposal/utilization is related to spatial (geographical) location. Gins located in different areas use CGW for different purposes, and this is due to the proximity of the gin with respect to the end-use market. For example, in Region 1 of the Texas Plains study area there are a large number of cattle on feed, and thus a high percentage of CGW produced in this region is utilized as livestock feed. In Regions 3 and 4, which consist of a mixture of farming and ranching, a majority of the CGW is used as soil amendment followed by livestock feed. Thus, it is reasonable to assume that the cost/return of CGW disposal/utilization is related to the location of the gin and the type of end-use market. In the remainder of this section, information is provided on the cost/return of CGW disposal/utilization by region and by disposal method.

Production diversity across the study area is responsible for division of the study area into four regions. Using cost/return data generated from the Texas High and Low Plains Cotton Gin Waste Disposal and Utilization Survey, a weighted average of the disposal costs by region was calculated (with CGW production used as weights)—Table 6. Positive numbers represent a disposal cost to the gin, and negative numbers represent a positive return (income) to the gin. Due to insurance liability, most ginners are obliged to transport their CGW to a location that is a safe distance from their gin and in the process incur a yard-removal cost. The transportation cost incurred by the gin is included in the cost/return calculation; i.e., the cost/return is net of transportation cost.

Region 1 incurred the lowest average disposal cost of $0.80 per ton of CGW while Region 4 incurred the highest average disposal cost of $4.13 per ton. Across all regions, the weighted average disposal cost was $1.44 per ton. For individual gins, disposal cost ranged from -$8.00 per ton (net return) to $10.00 per ton (cost). The percentages of gins that reported a net return (including $0.00 per ton) versus a loss are given in Table 6. Overall, 29 % of the responding gins reported a net return from CGW disposal in 1996. The remaining 71 % reported a loss. Kolarik et al. (1978) indicate that 37 % of gins in their 1977 survey reported a net return and 63 % reported a loss. These data indicate that disposal of CGW was more costly in 1996 than 1977.

Although a number of gins incurred no cost from disposing of their CGW, the majority of gins had a cost. The tons of CGW produced in each region coupled with the average net disposal cost per ton in each region yields an account of total dollars spent for disposal by each region (Table 7). In 1996, the ginning industry on the Texas High and Low Plains spent an estimated $1.8 million on CGW disposal.

Table 8 segregates the disposal costs of each region into four categories. Each gin that responded to the Texas High and Low Plains Cotton Gin Waste Disposal and Utilization Survey provided an average disposal cost or return for the gin and the percentage of CGW that went to each disposal/utilization category. In making the calculations for Table 8, it was assumed that CGW was disposed of (or sold) to each end-use category at the average cost/return reported by the gin. As explained above, returns were included as negative values in combining results from gins (where some gins reported costs of disposal and others reported positive income). Using weighted averages (with CGW production as weights), the least expensive disposal method was compost at $0.43 per ton. However, as stated above, composting CGW is a highly concentrated activity. Most gins are not located within a reasonable distance of a composting facility to utilize this disposal method. Livestock follows composting at an average disposal cost of $0.81 per ton across all regions for 1996. Kolarik et al. (1978) report for 1977 that CGW was sold to feedlots and for range feed at an average price (at the gin) of $2.03 per ton. Average disposal cost for soil amendment was $2.33 per ton in 1996. By comparison, Kolarik et al. report a 1977 disposal cost for soil amendment of $0.95 per ton.

Summary and Conclusions

The 1996 Texas High and Low Plains Cotton Gin Waste Disposal and Utilization Survey showed that 47.9 % of CGW produced in the study region was used as livestock feed, 33.2 % as soil amendment, and 15.9 % as compost. Kolarik et al. (1978) reported for the 1977 crop that 36.7 % was used as livestock feed, 61.7 % as soil amendment, and 0.2 % as compost. The increase in CGW used for livestock feed may be explained by the expansion of the cattle industry in the Texas Panhandle, while the increase in composting is due to the location of a composting operation in southeastern Lubbock County and the expansion of the compost market.

The data reveal that the market for CGW as livestock feed dominates Region 1. Regions 3 and 4 utilize CGW primarily as soil amendment and livestock feed. Region 2 displays a more equal dispersion of CGW across usage categories, but all of the gins that rely on compost as a disposal method are concentrated within approximately 50 miles of southeastern Lubbock County.

The Texas High and Low Plains generated 1.25 million tons of CGW, with a majority coming from Region 2. Field cleaning technology is being adopted with the highest rate (over 50 %) in Regions 1 and 4. When used in actual farming situations, field cleaners reduce the amount of CGW transported to the gin by more than 250 lbs. per bale.

Across all regions, ginners spent an estimated $1.8 million on CGW disposal in 1996. Responding gins experienced a broad range of costs associated with CGW disposal ranging from $8.00 per ton net return to $10.00 per-ton cost. Region 1 reported the lowest average per-ton disposal cost of $0.80 and Region 4 reported the highest average per-ton cost of $4.13. In Region 2, where a majority of the cotton in the study area is produced, disposal cost averaged $1.27 per ton.

Overall, 29 % of the participating gins indicated a net return (including zero return) from CGW disposal. The remaining 71 % reported a loss. In 1977, the return/loss numbers were 37 % and 63 %. This indicates that from the ginners' perspective, CGW is a more costly problem today than it was in 1977.

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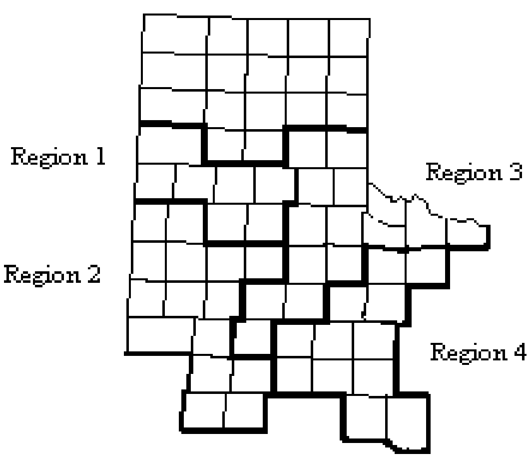

Figure 1. Texas High and Low Plains.

Table 1. CGW utilization in 1996 and 1977.

	% Used As			
	Livestock	Compost	Soil Amendment	Other
1996	47.9	15.9	33.2	3.0
1977*	36.7	0.2	61.7	1.4

* Kolarik et al. 1978

Table 2. CGW utilization by regions, 1996.

	% Used As			
Region	Livestock	Compost	Soil Amendment	Other
1	72.5	5.3	11.9	10.3
2	42.8	19.8	35.9	1.5
3	35.4	16.8	47.8	0.0
4	41.0	5.3	53.1	0.6

Table 3. Estimated CGW production, 1996.

Region	CGW / Bale (lbs.)	Cotton Prod.* (Bales)	CGW Prod. (Tons)
1	583.0	818,000	238,447
2	750.3	2,235,000	838,460
3	931.3	233,000	108,496
4	717.8	193,000	69,268
Overall	741.0	3,479,000	1,254,671

* Texas Agricultural Statistics, 1996.

Table 4. Field cleaner use and CGW per bale by region 1996.

Region	% Field Cleaned Cotton	CGW / Bale (lbs.)
1	58.0	583.0
2	35.0	750.3
3	18.0	931.3
4	55.3	717.8
Overall	40.1	741.0

Table 5. Impact of field cleaners on CGW production, 1996.

	CGW / Bale (lbs.)	Cotton Prod. (Bales)	CGW Prod.(tons)
Non-Field Cleaned	853	3,479,000	1,483,794
Field Cleaned	599	3,479,000	1,041,960
Impact	254	----	441,834

Table 6. CGW disposal costs by regions, 1996 and 1977.

Region	Average $ / ton	Range[a] $ / ton	% Positive / Zero Return 1996	1977*	% Loss 1996	1977*
1	0.80	-2.00 – 6.50	73	--	27	--
2	1.27	-5.00 – 6.66	31	--	69	--
3	2.05	-8.00 – 5.89	33	--	67	--
4	4.13	-2.50 – 10.00	20	--	80	--
Overall	1.44	-8.00 – 10.00	29	37	71	63

a/ Average net disposal cost for individual gins. A negative value indicates positive (average) income for a gin.
* Kolarik et al. 1978

Table 7. Total disposal costs by regions and all regions combined, 1996.

Region	CGW (tons)	Average Net Disposal Cost ($ / ton)	Total Cost (dollars)
1	238,447	0.80	190,758
2	838,460	1.27	1,064,844
3	108,496	2.05	222,417
4	69,268	4.13	286,077
Overall		1.44	1,764,096

Table 8. CGW disposal cost by disposal method, by region, and by all regions combined, 1996.

	Disposal Method			
Region	Livestock	Compost ($ / ton)	SAM	Other
1	0.13	0.00	0.37	6.47
2	0.82	0.36	2.09	1.72
3	1.60	-0.22[a]	3.19	n.d.
4	3.42	5.95	4.54	0.53
Overall	0.81	0.43	2.33	4.76

SAM = Soil Amendment
a/ Negative value represents positive income.
n.d. = No costs reported for other uses.