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THE COBY PROCESS: EROSION CONTROL STUDY RESULTS

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Abstract

Soil erosion from steep slopes, bare soil, or construction sites is a problem that can create gully formations that adversely effect various bodies of water (lakes and streams), fish and wildlife in those bodies of water, and/or grass seed establishment. Mulches have been one means of mitigating the effects of erosion. One of the most common mulches for controlling erosion from steep slopes are those that are applied with a hydro-mulcher, hydro-mulches. Some of the most commonly used hydro-mulches are made of wood and paper. In this study, conventional wood and paper hydro-mulches were compared to cottonseed hulls and three types of processed cotton gin byproducts. The mulches were applied at two rates, 1000 and 2000 lb/acre. Results indicate both the cottonseed hull and cotton gin byproduct mulches to perform equal to or better than the conventional wood and paper mulches. However, the coverage factor associated with most of the wood and paper mulches was higher than cottonseed hulls and all but one cotton gin byproduct mulch. Overall, the cottonseed hulls and cotton gin byproduct mulches showed great promise in erosion control applications.

Introduction

Excessive soil erosion from sites with steep slopes, bare soil, or construction activity creates on-site problems such as gully formation and off-site problems such as non-point source pollution (Flanagan et al. 2002a, b). Mulches are often applied to construction sites to minimize soil erosion until vegetative or permanent cover is established (Buchanan et al. 2002). On sites where vegetative cover is desired, a combination of grass seed and mulch is often applied to provide temporary cover until the grass reestablishes. Although mulches such as straw, paper, or wood chips are typically used, other organic material could perform as well as these typical mulches. In this study, mulches produced from by-products of the cotton gin industry were evaluated. Mulches were formed with cottonseed hulls and cotton gin byproducts processed using the COBY Process (Holt and Laird, 2002). It was predicted that the COBY mulches would provide adequate soil cover and because of their fibrous nature would perform well in erosion reduction. Therefore, the objective of this study was to perform an initial evaluation of the performance of cottonseed hulls and COBY as mulches for use in erosion control and vegetation reestablishment.

Materials and Methods

Setup and Treatment Application

An erosion study was performed at the USDA-ARS, Cotton Production and Processing Research Unit in Lubbock, TX. The soil used for this study was a sandy clay loam consisting of 20% clay, 17% silt and 63% sand. Prior to testing, the soil needed for each run was sieved and loaded into nylon tote bags and stored in a dry location for later use. The day before conducting the runs, nine to twelve trays, were each loaded with approximately 430 lbs of soil. The soil volume for each tray was 2 ft wide by 10 ft long and 3 in. deep (5 ft^3). The soil was packed and leveled to obtain a soil density of 87.4-lbs/ ft^3, which is similar to natural soil bulk density. After packing and leveling the soil, Rye grass seed was hand applied to the soil at a rate of 10-lb/1000ft^2 (435.6 lb/acre). Once the grass seed was applied, mulch was hand applied to the soil at either a rate of 1000 or 2000 lb/acre. The seven mulches evaluated in this study were: 1) wood hydro-mulch, 2) paper hydro-mulch, 3) cottonseed hulls, 4) COBY produced from stripper waste (COBY Red), 5) COBY produced from picker waste (COBY Yellow), 6) COBY produced from ground stripper waste (COBY Green), and 7) wheat straw hay. None of the mulches used in this study had any surfactants or polyacrylamides added to them prior to or during application. The rationale for applying the mulches by hand was primarily the result of there not being a consistent means of precisely measuring the amount of product applied to a given area when using a hydro-mulcher; consistent application is more art than science. Therefore, for the initial evaluation it was deemed best to apply the product by hand to ensure the specified mulch rates were obtained.

Once the mulches were evenly distributed across the surface of the soil area, water was sprayed onto the mulch at an equivalent rate as would have been used if the mulch had been applied with a hydro-mulcher/seeder. The water added to each tray was 1 gallon for the 1000 lb/acre treatments and 2 gallons for the 2000 lb/acre treatments. After the water was applied, the trays were stored in a covered area for a minimum of 16 hr before subjecting them to rain. The day of testing, digital pictures were taken of all the trays to be tested that day at two predetermined areas in each tray (i.e. a 4 ft^2 section at the front and back of each tray). The pictures were taken to determine the amount of coverage obtained by the mulch. After taking the digital pictures, three trays where loaded onto a cart that was wheeled into the rain simulator. Figure 1 shows a drawing of the trays on the tray cart, as they would be during a rain event. Once the tray cart was in position under the spray nozzle, each tray was elevated to the height necessary to produce a 9% slope. The slope of each tray was verified using an Empire Magnetic Protractor. After adjusting the slope on each tray, barrels were placed on a scale under the flume of each tray to catch the soil and water runoff. Once all equipment was setup and ready, the rain simulation began. The water supply to the nozzle was connected to the main water supply and passed through a flow meter and pressure gauge to assist in maintaining constant pressure and flow rate to the nozzle. The rain event simulated a rain of 2.5-inch/hr.

Once the rain started, the following data collection procedure was used: 1) record time rain started, 2) activate scale data loggers to record (every 5 seconds) the amount of runoff collected in the barrels under each tray's flume, 3) record the amount of time until runoff occurred for each tray, 4) once runoff occurred, grab samples, in pre-weighed glass jars, were collected every 5 minutes for 25 minutes, 5) after 30-minutes of runoff time had elapsed for a given tray, scale data logging was ceased and the collection barrel removed, 6) the rain continued until all three trays had experienced 30-minutes of runoff. Upon completing the rain event, the trays were lowered and digital pictures were taken of the same areas photographed prior to the rain simulation. The digital pictures were used as a check in determining the amount of mulch that was eroded due to the rain event. After the pictures, a 12-inch diameter metal ring was inserted into the center of the 4ft^2 area where the pictures were taken and two core samples per tray (i.e. one in the front and one in the back) were extracted. This procedure was repeated for each series of three trays until all 42 runs had been completed.

The grab samples collected for each tray were oven dried at a temperature of 180 deg. F for 48 hrs. After 48 hrs had elapsed, the grab sample jars were then reweighed with the dry soil and the weight recorded. The soil in each jar was then removed and stored in plastic bags for analytical analysis of the amount of organic matter collected (i.e. mulch and/or grass seed).

The core samples extracted from each tray were watered daily for two-weeks. At the end of two-weeks, the number of grass seedlings was counted to determine grass seed establishment of the mulches. The number of grass seedlings for each tray was broken down into the number of plants for both the front and back core samples.

The Mulch Products

The raw material used for the COBY Yellow and COBY Green product was acquired from two commercial gins whereas the COBY Red, which included motes, was obtained from the Lubbock Ginning Laboratory. The picker waste (COBY Yellow) was obtained from a gin in Arizona. The stripper waste (COBY Green) that had been ground through a tub grinder was obtained from a gin located within three miles of the Ginning Laboratory. All the gin byproducts were processed, using the COBY Process, at the USDA-ARS, Cotton Production and Processing Research Unit in Lubbock, TX. Table 1 shows the averaged results from three repeated measures of a sieve analysis for the mulches used in this study.

Figure 2 shows a schematic of the process used to produce the COBY material. The raw material was loaded using a pneumatic conveyer into a live-bottom bulk feed bin with five 9-inch augers. Upon exiting the feed bin, the gin byproducts were sprayed with either a gelatinized starch solution containing a red, green, or a yellow dye for coloring depending on the raw material being processed. The sprayed material was conveyed, in twin 12-inch cut-and-fold mixing augers, to a side-feeder that force-fed the byproduct slurry mix into an Insta-Pro model 2000 extruder (Insta-Pro International, Des Moines, IA). The product exiting the extruder was conveyed to a belt dryer where the product was exposed to 275 deg. F air. Upon exiting the dryer, the material was conveyed to nylon tote bags for storage.

The gelatinized starch slurry consisted of 1 lb of starch to every gallon of water in the cook tank. The starch slurry was applied at a consistent rate via a piston pump driven by a 0.75 Hp DC motor regulated by a closed-loop control system. The control system was comprised of flow meter with a 0-10 VDC output signal to the DC drive regulating the speed of the motor driving the starch pump. The amount of starch added to the byproducts was 5% by weight of the products (i.e. 15 lbs/min of byproducts had 0.75 lbs/min of starch added).

Feed rate from the bulk feed bin was determined from a mathematical relationship established prior to producing the mulch. A DC drive connected to a 1 Hp DC motor regulated the output from the bulk feed bin. The DC motor powered the feed bin augers through a 64 to 1 gear and sprocket reducer. Prior to processing the mulch, the raw material was loaded into the bulk feed bin and emptied, at four different drive settings, into a collection bin placed on a scale. The amount of material emptied during 15 minutes of operation was recorded for each of the four settings. This procedure was repeated three times for each setting in order to develop the mathematical formula necessary to determine the raw material output of the bulk feed bin at various intermediate settings on the DC drive. Temperatures of the extruder were recorded from two type-K thermocouples placed within the thermocouple wells located on the extruder barrel.

Experimental Design and Data Collection

There were seven mulches evaluated in this study. These are COBY Red, COBY Green, COBY Yellow, paper, wood, straw hay, and cottonseed hulls. Each of the seven mulches was applied at two application rates (1000 and 2000 lb/acre). Each treatment (mulch plus application rate) was replicated three times. The experiment was arranged as a complete randomized block design with treatments being blocked by tray position (South, Center, and North) on the cart (i.e. each treatment had one run in all three of the tray positions).

Standard analysis of variance techniques were used to analyze the various data associated with the mulches to determine statistically significant differences among the fourteen treatments by the Student-Newman-Keuls multiple range test at the 95% confidence interval (SAS Help, 2003). The response variables evaluated from the data included: 1) Mulch Coverage Factor (C-Factor), 2) Time to runoff, 3) Sediment loading of runoff (for 30-minutes of runoff), 4) Sediment loading 30-minutes after starting rain event, 5) Percent of mulch washed off, and 6) Grass count for front and back of erosion tray.

Results and Discussion

Several factors are important in determining the perceived and actual benefits of erosion control mulches. Table 2 shows the results for three of the six response variables measured. The coverage factor (C-Factor) is important in the perception of erosion control, i.e. if it looks like the soil is covered, it is assumed that it is protected from erosion. Table 2 illustrates that the mulches had significantly different C-factors. The highest C-Factor was for wood at 2000 lb/acre (81.2%) followed by wood at 1000 lb/acre (64.2%) and paper at 2000 lb/acre (68.1%). The COBY product with the highest C-Factor was COBY Green at 2000 lb/acre, 33.6%. COBY Green 2000 was not significantly different from paper 1000 or either of the straw treatments. However, all other COBY treatments and cottonseed hulls had significantly lower C-Factors than did the wood, paper, or straw treatments. The reason for the lower C-Factors for all but one of the COBY products was due in large part to the difficulty of uniformly applying the mulch. The COBY material had a greater tendency than all the other treatments to cling to itself thus causing clumps of the material to be distributed over the soil area. Even though effort was made to distribute the product as evenly as possible, the COBY material had to be pulled apart in an effort to obtain uniform hand application. Likewise, the straw hay tended to cling to itself but since it had longer strands, it was easier to pull apart and apply. Conversely, the wood, paper, and hulls were easy to distribute uniformly by hand. Table 1 illustrates why some of the mulches were easier to hand apply uniformly. The COBY and straw mulches had much larger particles than the other mulches. Specifically, between 47% and 69% of the COBY and straw mulches was larger than 5/16 inch, whereas the other mulches had between 0.0% (hulls) to 21.4% (wood) of their mass in the same sieves.

Another important factor in erosion control is the ability of mulches to absorb rainfall. Figure 3 shows the average time to runoff for each treatment. The differences in time to runoff were not significant at the 95% confidence limit. The numeric values in table 3 show the paper treatments took longer to runoff (approximately 20 min.) followed by the wood treatments at 17 min. The treatments with the shortest time interval before runoff occurred were the hull treatments and the 1000 lb/acre treatments of the COBY products (9 to 10 min.).

While other factors influence the perception and performance of mulches, measured soil loss is the most important indicator. Sediment losses for 30-minute runoff durations are presented in units of lb/acre in Table 2. The sediment loss values may appear extreme, but these plots were on a steep slope (9%) with unconsolidated soil and were subjected to intense rainfall (2.5 in/hr). Also, erosion rates can be very high for bare soils with steep slopes. Table 2 shows that the wood and paper treatments had the highest numerical soil loss with Paper 1000 having the greatest loss at 16.11 ton/acre. The lowest sediment loss occurred in the Hulls 2000 treatment (1.96 ton/acre). The COBY treatments performing significantly better than Paper 1000 were COBY Red 2000 (6.94 ton/acre) and COBY Yellow 2000 (6.69 ton/acre). The other COBY treatments, with the exception of COBY Yellow 1000, were not significantly different from either Paper 1000 or the hull treatments. The COBY Yellow 1000 treatment exhibited significantly more soil loss than did Hulls 2000. When comparing the sediment loss 30-minutes after starting the rain event, there were no significant differences between any of the treatments. The average amount of soil eroded after 30-minutes of starting the rain ranged from 3.34 ton/acre (Wood 2000) to 0.61 ton/acre (Hulls 1000). These results show that COBYmulches can provide reduced soil erosion compared to two typically used mulches (wood and paper) and that the rate of mulch application is important in erosion control.

The percent of mulch lost (Table 2) was greatest for the wood and paper at 1000 lb/acre, 54.7% and 47.8%, respectively. The treatments with the lowest numeric loss were Straw 2000 and Hulls 2000, 3.5% and 3.3%, respectively. The only COBY treatments having significantly more mulch washed off than either Straw 2000 or Hulls 2000 was COBY Green 1000 (21.9%) and COBY Yellow 1000 (23.8%). All the wood and paper treatments had significantly more mulch loss than Straw 2000 or Hulls 2000.

The ability to reduce erosion until vegetation is reestablished is another important consideration. The grass count for both the front and back core samples produced one treatment, in each location, that had significantly more grass than the other treatments. For the front core samples, the Straw 2000 treatment produced an average of 467 seedlings. The back core sample with significantly more grass than the others was the Wood 2000 treatment with an average count of 475 seedlings. The grass count ranges for the other mulches were 167 (Wood 2000) to 41 (Hulls 1000) for the front core sample and 285 (Straw 2000) to 73 (COBY Red 1000) for the back core samples. The rationale for counting grass from both the front and back was to see if the mulches held the grass seed as well as the soil.

Conclusions

Overall, the COBY mulches performed well in reducing soil runoff compared to conventional wood and paper hydro-mulches. Even though the straw mulch performed well, it is the only mulch evaluated in this study that could not have been applied using a hydro-mulcher, in the form evaluated in this study, due to the length of the material. The inclusion of the straw in this study was to obtain a reference for hand-applied ground cover versus a commercial or proposed hydro-mulch. Even though the mulches evaluated in this study were hand applied, they were manufactured for applications using a hydro-mulcher, except for the wheat straw hay. The rationale for not using a hydro-mulcher in this initial study was to be able to precisely regulate the amount of product distributed over the soil area. One area associated with the COBY product that is in need of refinement is the C-Factor. The C-Factor could be improved by reducing the size of the material further but it is uncertain at this time whether or not that would be necessary since material applied with a hydro-mulcher may distribute the product more uniformly than hand application. In spite of the low coverage, the COBY material showed promise as a mulch for use in erosion control applications. In addition to the COBY product, the hulls performed well in reducing soil loss due to rain and demonstrated a strong potential for use as a hydro-mulch. However, cottonseed hulls currently have a market and could become cost prohibitive compared to processed gin byproducts depending on their market value. Based on the results of this study, additional erosion studies are planned to evaluate the same mulches, with the exception of the straw, using a hydro-mulcher. It is anticipated that when the product is applied using a hydro-mulcher, the mulches will yield results different from those obtained in this study.

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Disclaimer

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References

Buchanan, J. R., D. C. Yoder, H. P. Denton, and J. L. Smoot. 2002. Wood chips as a soil cover for construction sites with steep slopes. *Trans. ASAE* 18(6):679-683.

Flanagan, D.C., K. Chaudhari, and L. D. Norton. 2002a. Polyacrylamide soil amendment effects on runoff and sediment yield on steep slopes: Part I. Simulated rainfall conditions. *Trans. ASAE* 45(5):1327-1337.

Flanagan, D.C., K. Chaudhari, and L. D. Norton. 2002b. Polyacrylamide soil amendment effects on runoff and sediment yield on steep slopes: Part II. Natural rainfall conditions. *Trans. ASAE* 45(5):1339-1351.

Holt, G.A. and J.W. Laird. 2002. COBY products and a process for their manufacture. U.S. Patent No. 6,383,548.

SAS Help. 2003. PROC GLM means statement. SAS Software: SAS Information, Release 8.02. SAS Institute, Cary, NC.

Table 1. Sieve analysis of the seven mulches showing the average percent of mulch remaining on each sieve from three replicated analyses.

Sieve Size (Inches)	Percent of Mulch Remaining on Sieve						
	COBY Green	COBY Red	COBY Yellow	Hulls	Paper	Straw	Wood
7/8	0.0	8.6	2.6	0.0	0.0	65.0	2.2
3/4	0.1	2.9	7.4	0.0	0.8	0.3	0.7
5/8	1.4	8.6	6.8	0.0	0.0	0.1	0.9
3/8	41.9	34.0	44.5	0.0	0.5	1.5	16.2
5/16	3.4	2.7	5.1	0.0	0.4	1.9	1.5
1/18	45.4	37.4	29.4	90.3	15.7	21.4	35.7
1/32	3.7	2.6	2.0	4.6	23.0	6.7	10.5
1/140	3.0	2.3	1.5	2.8	41.6	2.7	21.3
1/318	0.9	0.7	0.4	1.7	13.2	0.1	7.9
0	0.3	0.3	0.3	0.6	4.8	0.3	3.2

Table 2. Response variables of coverage factor, mulch loss, and sediment loss for each of the fourteen mulch treatments evaluated.

Treatments[(a)]	Coverage Factor (%)[(b)]	Mulch Loss (%)[(c)]	Sediment Loss (ton/acre)[(d)]
COBY Green 1000	20.1d[(e)]	21.9b	8.63abcd
COBY Green 2000	33.6c	9.7bc	7.49abcd
COBY Red 1000	9.30d	17.5bc	7.31abcd
COBY Red 2000	22.0d	8.9bc	6.94bcd
COBY Yellow 1000	18.9d	23.8b	12.19abc
COBY Yellow 2000	21.8d	7.8bc	6.69bcd
Hulls 1000	14.9d	10.7bc	3.71cd
Hulls 2000	20.3d	3.3c	1.96d
Paper 1000	41.9c	47.9a	16.11a
Paper 2000	68.1b	23.5b	15.45ab
Straw 1000	34.9c	10.7bc	7.64abcd
Straw 2000	45.4c	3.5c	3.50cd
Wood 1000	64.2b	54.7a	13.13ab
Wood 2000	81.2a	20.1b	12.65ab

(a) The numbers following the treatment names indicate the amount of product (lbs) applied per acre (i.e. COBY Green 1000 was 1000 lbs per acre).
(b) The average percent of soil covered by the mulch prior to the rain event.
(c) The average percent of mulch washed off the erosion tray after the rain event.
(d) The calculated amount of sediment loss occurring in the erosion tray after experiencing 30 minutes of runoff from a 2.5-inch/hr rain event.
(e) Means within the same column followed by different letters are significant at the 95% confidence limit.

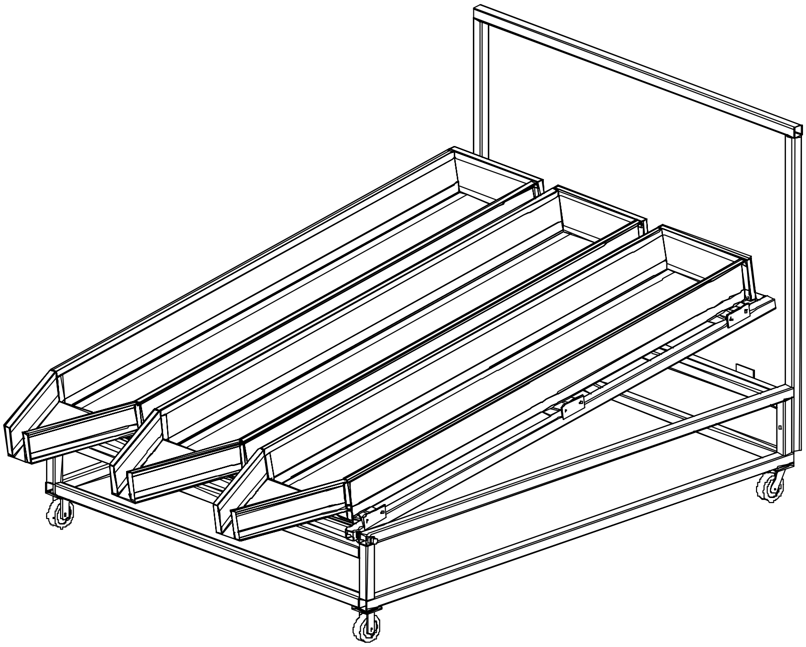

Figure 1. Drawing of soil erosion trays on the tray cart.

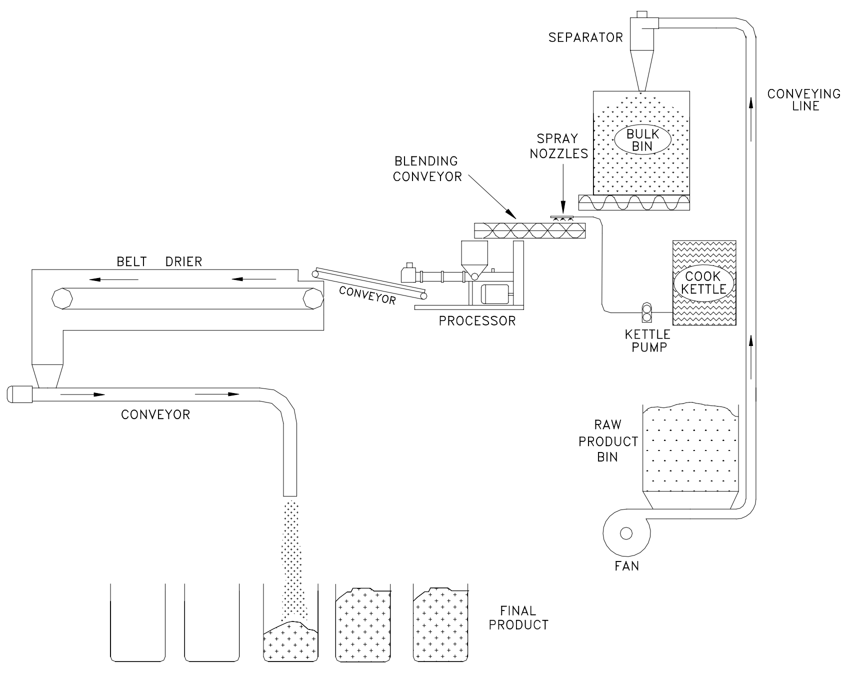

Figure 2. Schematic of the process used to produce the COBY mulch.

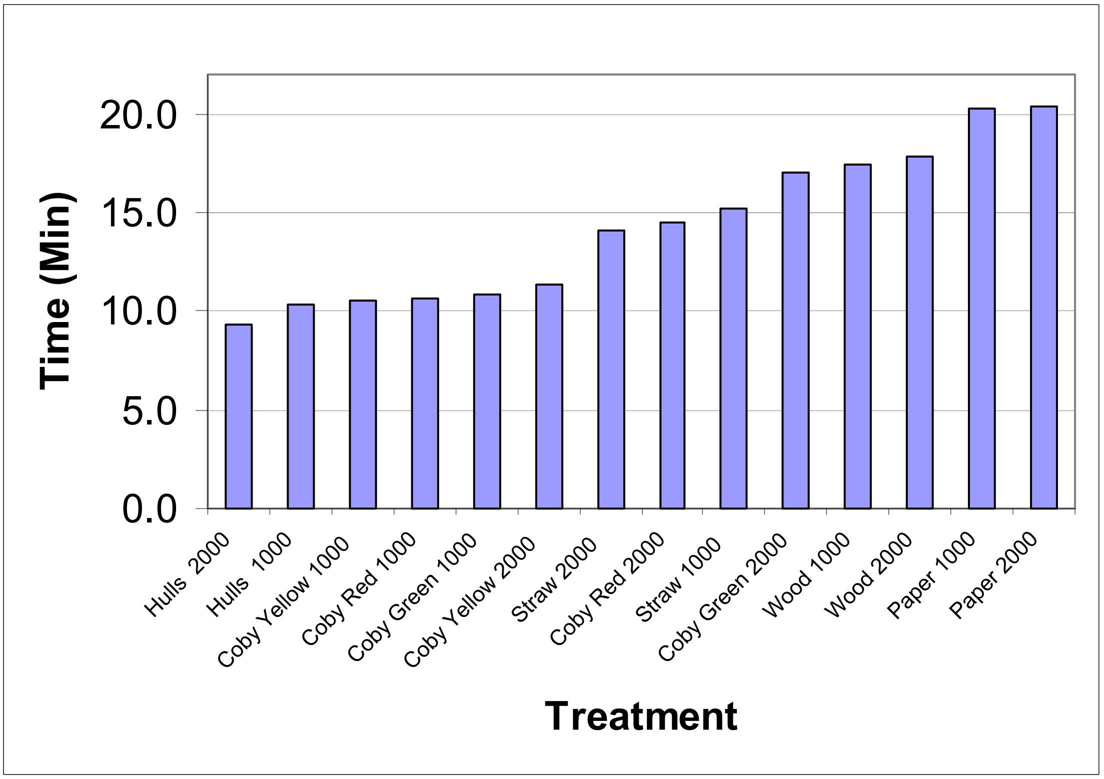

Figure 3. Average time before runoff began for all fourteen mulch treatments evaluated.