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SURFACE DETENTION ON CROPLAND, RANGELAND, AND CONSERVATION RESERVE PROGRAM AREAS

J. E. Gilley

ABSTRACT. *One of the factors contributing to overland flow on upland areas is water stored temporarily in a thin sheet on the soil surface as surface detention. This study was conducted to quantify surface detention on selected cropland, rangeland, and Conservation Reserve Program (CRP) sites. Surface detention was determined from the recession portion of runoff hydrographs corresponding with the period when rainfall had ceased but runoff continued. The hydrographs were generated from six previously reported rainfall simulation studies conducted on paired 3.7 m wide $\times$ 10.7 m long plots on which approximately 128 mm of rainfall was applied. Surface detention values were found to increase as crop residue or vegetative cover increased. Eleven fallow cropland sites in the eastern U.S. had surface detention values that varied from 1.7 to 4.6 mm. Surface detention on plots in southwestern Oklahoma containing Old World bluestem, no-till wheat, and conservation-till wheat was 9.4, 7.3, and 5.2 mm, respectively. No-till sorghum, tilled sorghum, no-till wheat, and tilled wheat plots in southeast Nebraska had surface detention values of 6.7, 4.5, 6.7, and 4.6 mm, respectively. Mean surface detention on no-till and tilled cropland sites in southwest Iowa containing corn residue was 7.2 and 5.9 mm, respectively. CRP study sites in southwestern Iowa had mean surface detention of 10.8 mm. When data from the six field studies were combined, mean surface detention values for fallow cropland, tilled cropland, no-till cropland, rangeland, and CRP areas were 3.1, 5.0, 6.9, 9.6, and 10.8 mm, respectively.*

Keywords. *Depressional storage, Hydrographs, Hydrologic modeling, Overland flow, Runoff volume, Surface detention.*

Precipitation must meet the demands of evaporation, interception, infiltration, and depressional storage before runoff can occur (Schwab et al., 1993). The rate and volume of runoff are influenced by rainfall duration, intensity, and areal distribution. Rainfall will begin to fill small depressions on the soil surface when the supply of water is larger than the soil infiltration capacity. Once a depression is filled, the surplus water moves downslope to fill additional depressions or produce runoff. The water temporarily stored in depressions will subsequently infiltrate or evaporate.

Depressional storage is created by surface micro-relief, which can be enhanced by various tillage practices (Onstad, 1984). Micro-relief can be quantified using variations in surface point elevations (Currence and Lovely, 1970; Saleh, 1993; Gilley and Kottwitz, 1995; Linden and Van Doren, 1986; Hansen et al., 1999). Paz-Ferreiro et al. (2008) quantified the effects of erosion and deposition processes on the breakdown of soil aggregates and resulting changes in micro-relief. Micro-relief measurements have been used to estimate maximum depressional storage (Mitchell and Jones,

1978; Borselli and Torri, 2010). Depressional storage decreases as slope gradient increases (Chahinian et al., 2006; Alvarez-Mozos et al., 2011).

Gayle and Skaggs (1978) found depressional storage on bedded cultivated fields to range from 1.1 to 33 mm. Depressional storage on unplowed and moldboard-plowed areas before rainfall addition were estimated by Moore and Larson (1979) to vary from 2.0 to 5.1 mm and from 5.0 to 21.0 mm, respectively. Kamphorst et al. (2000) determined maximum depressional storage on tilled soil surfaces to vary from 0 to 13 mm. Maximum depressional storage for simulated residue materials was found by Gilley and Kottwitz (1994) to vary from 5 to 24 mm.

Once depressional storage is satisfied, water is temporarily stored in a thin sheet on the soil surface as surface detention until the storage volume is large enough to result in runoff. Surface detention will increase until a steady-state discharge is reached if a constant water supply is available (Mwendera and Feyan, 1992). Surface detention will temporarily sustain runoff when rainfall has ended. Once rainfall ceases, the runoff rate will rapidly decrease until detention storage is depleted.

Determining surface detention is important in hydrologic simulations (Beasley et al., 1982; Jaber and Shukla, 2012; Duda et al., 2012). Significant factors influencing surface detention include surface micro-relief, vegetation, slope gradient, rainfall excess, and topography (Haan et al., 1982). Surface micro-relief controls the path that overland flow travels downslope. If existing overland flow paths enhance the downslope movement of water, surface detention is reduced. Plant stems and associated vegetation influence hy-

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draulic roughness. An increase in flow velocity results from a larger slope gradient; therefore, less detention volume is required to maintain a given flow rate. Surface detention is also influenced by topography because surface runoff is supplied by both rainfall and runoff from adjoining areas. The objective of this study was to quantify surface detention on cropland, rangeland, and Conservation Reserve Program (CRP) areas using runoff hydrographs from previous rainfall simulation studies (Gilley et al., 1990, 1996, 1997a, 1997b, 2000; Gilley and Eghball, 1998).

MATERIALS AND METHODS

DATA FROM PREVIOUS STUDIES USED TO CALCULATE SURFACE DETENTION

Data obtained from six previously reported field studies

were used in the present investigation to determine surface detention (table 1). The equipment used to generate runoff hydrographs at each of the study sites is shown in figure 1. Runoff hydrographs obtained from the previous studies, described below, were used to calculate the surface detention values reported in the present investigation.

Rill density and rill flow rates were identified during rainfall simulation tests conducted at eleven fallow cropland sites located throughout the eastern U.S. (Gilley et al., 1990). Soils at the sites, which were considered to be of regional or national importance, were selected to cover a broad range of physical, chemical, biological, and mineralogical properties. The soil series that were represented included Caribou, Cecil, Collamer, Gaston, Grenada, Lewisburg, Manor, Mexico, Miami, Miamian, and Tifton. Slope gradients at the fallow cropland locations varied from 3.7% to 10.2%, and sur-

Table 1. Title, citation, and experimental conditions of previously reported studies from which data were obtained to determine surface detention in the present investigation.

Study Title	Citation	Experimental Conditions
Hydraulic characteristics of rills	Gilley et al. (1990)	Tests conducted on eleven bare tilled soils.
Runoff, erosion, and soil quality characteristics of a former Conservation Reserve Program site in southwestern Oklahoma	Gilley et al. (1997a)	Experimental treatments included Old World blue stem, no-till wheat, and conservation-till wheat.
Runoff and erosion following field application of beef cattle manure and compost	Gilley and Eghball (1998)	Plots contained sorghum or wheat residue under till and no-till conditions.
Narrow grass hedge effects on runoff and soil loss	Gilley et al. (2000)	Plots contained corn residue under till and no-till conditions.
Grazing and haying effects on runoff and erosion from a former Conservation Reserve Program site	Gilley et al. (1996)	Rangeland site with treatments including twice-over rotational grazing, season-long grazing, hayed, and burned conditions.
Runoff, erosion, and soil quality characteristics of a former Conservation Reserve Program site	Gilley et al. (1997b)	Experimental treatments included Conservation Reserve Program sites located on Clearfield and Nira soils.

Figure 1. Rotating-boom rainfall simulator and paired experimental plots located near Salisbury, North Carolina.

face cover was 0%. Either corn or small grains had been planted the previous year. Surface residue was first removed, and the area was then moldboard-plowed 3 to 12 months before the rainfall simulation tests were performed. After plowing, the sites were disked lightly and maintained free of vegetation either by tillage or application of herbicide. The study areas were disked immediately preceding rainfall simulation testing, and the plots were raked by hand to provide a uniform surface. Rainfall simulation tests were conducted on two plots at each study location. The fallow cropland site located on a Collamer silt loam soil near Ithaca, New York is shown in figure 2a.

Gilley et al. (1997a) measured runoff, erosion, and soil quality characteristics of a former CRP site in southwestern Oklahoma. The treatments, which included Old World bluestem, no-till wheat, and conservation-till wheat, were established on adjacent areas. Rainfall simulation tests were conducted on two plots within each treatment. The study site, which was represented by a soil from the LaCasa series, was placed in the CRP in 1989 and seeded to Old World bluestem. The mean slope gradient at the study location was 2.2%, and mean surface cover values of 79%, 71%, and 42% were measured on the Old World bluestem, no-till wheat, and conservation-till wheat treatments, respectively. Disking operations were performed on the conservation-till wheat plots in July and October 1995. Clumps of Old World bluestem were visible on the soil surface following disking. Both the conservation-till and no-till plots were seeded to winter wheat in October 1995, and rainfall simulation tests occurred in June 1996. Figure 2b shows the site containing

Old World bluestem located near Duke, Oklahoma. The surface condition for the no-till plots containing wheat residue was similar to the site used by Gilley and Eghball (1998), which was also seeded to wheat under no-till conditions.

A study to measure the effects of a single application of manure and compost on runoff and erosion under no-till and till conditions was performed by Gilley and Eghball (1998). The study area was located on a Sharpsburg soil that contained sorghum or wheat residue. Data from the treatments that included the application of inorganic fertilizer and an untreated check were used to measure surface detention. Each experimental treatment was replicated three times. Mean slope gradients for the treatments containing sorghum and wheat residue were 6.6% and 5.7%, respectively. Residue cover values for the no-till sorghum, till sorghum, no-till wheat, and till wheat plots were 56%, 25%, 80%, and 16%, respectively. The study area had been cropped for several years as part of a no-till management system. A single disking operation up and down the slope to a depth of approximately 8 cm was used on the tillage treatments. Tests were performed on sites where sorghum or winter wheat had been harvested in the previous cropping season. Sorghum residue on the study sites near Lincoln, Nebraska, farmed under no-till and tilled conditions is shown in figures 2c and 2d, respectively. Figures 2e and 2f show wheat residue under no-till and till conditions, respectively.

Gilley et al. (2000) determined the effects of narrow switchgrass hedges on runoff and soil loss under no-till and till conditions. Data from the check and fertilizer plots without a narrow grass hedge were used to quantify surface de-

Figure 2a. Fallow cropland site on Collamer silt loam soil near Ithaca, New York (Gilley et al., 1990).

Figure 2b. Old World bluestem on LaCasa clay loam soil near Duke, Oklahoma (Gilley et al., 1997a).

Figure 2c. Sorghum residue on Sharpsburg silty clay loam near Lincoln, Nebraska, farmed under no-till conditions (Gilley et al., 1998).

Figure 2d. Sorghum residue on Sharpsburg silty clay loam near Lincoln, Nebraska, farmed under till conditions (Gilley et al., 1998).

Figure 2e. Wheat residue on Sharpsburg silty clay loam near Lincoln, Nebraska, farmed under no-till conditions (Gilley et al., 1998).

Figure 2f. Wheat residue on Sharpsburg silty clay loam near Lincoln, Nebraska, farmed under till conditions (Gilley et al., 1998).

tention. The study site, located in southwestern Iowa on a Monona soil, had been in continuous corn since 1964, and corn was last harvested in the fall of 1996. Mean slope gradient at the study location was 13.3%. The no-till and till treatments had mean surface cover values of 88% and 38%, respectively. Rainfall simulation tests were performed from May to July 1997. A single disking operation to a depth of approximately 8 cm was performed along the contour on the tilled treatments. Corn residue located on the sites near Treynor, Iowa, farmed under no-till and tilled conditions is shown in figures 2g and 2h, respectively.

A study was performed in July 1995 by Gilley et al. (1996) to determine the influence of selected grazing and haying practices on runoff and erosion from a former CRP site in central North Dakota. The research area, which was located on a Barnes soil, had been farmed using a crop-fallow rotation prior to 1987. Mean slope gradient at the study location was 8.4%, and surface cover on each of the experimental treatments was 100%. The site was enrolled in the CRP in 1986 and seeded in the spring of 1987. In 1992, vegetation consisted of approximately 40% intermediate wheat grass, 50% smooth brome grass, and 10% alfalfa. The area was not grazed or hayed until 1992. A twice-over rotational grazing system and season-long pasture were established in 1992. The average grazing season length was 125 days. Beginning in 1992, the vegetation in an ungrazed area was mowed and baled, leaving a stubble height of approximately 15 cm. A burned treatment was also imposed within the season-long grazing pasture. Two plots were located on each of the experimental treatments. Figure 2i shows the rangeland

study site near Streeter, North Dakota, grazed under season-long conditions.

Gilley et al. (1997b) measured runoff, erosion, and soil quality characteristics of a CRP site in southwestern Iowa near Bedford. Two plots were located on soils representing the Clearfield and Nira series. Mean slope gradient at the study site was 8.7%, and 100% surface cover was measured on each of the CRP plots. Prior to 1986, when the area was placed in the CRP, the site had been planted to corn and soybeans. Vegetation consisted of approximately 60% brome grass, 25% orchardgrass, 10% weeds, and 5% legumes. Rainfall simulation tests were performed in June and July 1994. The surface condition for the CRP plots near Bedford, Iowa, was similar to that shown in figure 2i for the rangeland study site near Streeter, North Dakota, grazed under season-long conditions.

RAINFALL SIMULATION PROCEDURES

The hydrographs used to determine surface detention were obtained using a rotating-boom rainfall simulator based on a design by Swanson (1965) (fig. 1). The same rainfall simulation procedures and data collection protocols were used in each of the six studies identified above to generate the runoff hydrographs from which surface detention values were calculated. The simulator applied rainfall to paired 3.7 m wide $\times$ 10.7 m long plots. An initial 1 h rainfall application at a design intensity of 64 mm h^{-1} occurred over the paired plots at existing soil water conditions. A second 1 h application (wet run) was conducted approximately 24 h

Figure 2g. Corn residue on Monona soil near Treynor, Iowa, farmed under no-till conditions (Gilley et al., 2000).

Figure 2h. Corn residue on Monona soil near Treynor, Iowa, farmed under till conditions (Gilley et al., 2000).

Figure 2i. Rangeland study site on Barnes soil near Streeter, North Dakota, grazed under season-long conditions (Gilley et al., 1996).

later. A trough extending across the bottom of each plot gathered runoff, which was measured using a flume with stage recorder. The hydrographs used to quantify surface detention were obtained during the second (wet run) rainfall simulation.

ANALYSIS OF DATA

A schematic of an equilibrium hydrograph showing hydrograph constituents is shown in figure 3. The infiltration rate (f_c) is assumed to be constant and is equal to the difference between the rate of precipitation (p) and the equilibrium flow rate, (q_e). The variables t_o , t_p , t_f , and t_e refer to the time rainfall began, runoff began, rainfall ended, and runoff ended, respectively. Detention storage (S_v), the depth of water stored on a surface, is estimated as:

$$S_v = \frac{\int_{t_e}^{t_f} [F(t) + Q(t)] dt}{A} \quad (1)$$

where F is the total volume of water that infiltrated between times t_f and t_e , Q is the total volume of runoff between t_f and t_e , and A is the plot area. The average runoff rate during 2.5 min intervals (the smallest time interval between lines appearing on the stage recorder charts) was multiplied by the appropriate time interval to calculate Q . In deriving equation 1, it was assumed that the infiltration rate during the recession portion of the hydrograph (t_f to t_e) remained constant and was equal to the steady-state infiltration rate at t_f .

RESULTS AND DISCUSSION

CALCULATED SURFACE DETENTION VALUES

Mean surface detention values for fallow cropland, tilled cropland, no-till cropland, rangeland, and CRP areas were 3.1, 5.0, 6.9, 9.6, and 10.8 mm, respectively (table 2). In general, surface detention was found to increase as residue or surface cover increased. Student's t-test was used to determine if mean surface detention calculated for the selected land uses shown in table 2 were significantly different. A probability level of <0.05 was considered significant. Surface detention values from each of the five reported land uses were found to be significantly different. The mean surface detention values shown in table 2 were obtained from measurements generated in the six studies described below.

Rill density and rill flow rates were determined during field rainfall simulation tests conducted at eleven fallow cropland sites located throughout the eastern U.S. (Gilley et al., 1990). Surface detention values ranged from 1.7 mm on a Grenada soil in northern Mississippi to 4.6 mm on a Lewisburg soil in northern Indiana (table 3). Mean surface detention for the fallow cropland sites was 3.1 mm.

Gilley et al. (1997a) measured runoff, erosion, and soil quality characteristics of a former CRP site in southwestern Oklahoma. Mean surface detention values on the plots containing Old World bluestem, no-till wheat, and conservation-till wheat were 9.4, 7.3, and 5.2 mm, respectively (table 4). Differences in surface detention values among study locations were influenced by surface cover, which was 79%, 71%, and 42% on the sites containing Old World bluestem,

Figure 3. Schematic of equilibrium hydrograph showing hydrograph constituents. The rate of precipitation is p , the equilibrium flow rate is q_e , and the steady-state infiltration rate is f_c . The variables t_o , t_p , t_r and t_e refer to the time rainfall began, runoff began, rainfall ended, and runoff ended, respectively. The total volume of runoff between t_r and t_e is Q .

Table 2. Mean calculated surface detention values for cropland, rangeland, and Conservation Reserve Program sites.

Land Use	Surface Detention (mm)	Standard Deviation (mm)	Surface Detention Range (mm)	Surface Cover Range (%)
Fallow cropland	3.1	0.8	1.7 to 4.6	0
Tilled cropland	5.0	1.3	2.8 to 7.1	28 to 71
No-till cropland	6.9	1.5	3.9 to 8.8	51 to 94
Rangeland	7.8	1.7	5.3 to 9.7	77 to 100
Conservation Reserve Program	10.8	1.9	8.8 to 13.3	100

Table 3. Experimental conditions for study of fallow cropland sites reported by Gilley et al. (1990). Surface cover at each site was 0%.

Soil	Replication	Slope (%)	Surface Detention (mm)
Caribou	1	6.3	3.7
	2	6.4	3.0
Cecil	1	6.5	4.5
	2	5.8	3.0
Collamer	1	8.7	2.9
	2	7.7	3.3
Gaston	1	5.9	2.6
	2	5.9	3.8
Grenada	1	6.5	2.3
	2	6.8	1.7
Lewisburg	1	10.1	4.6
	2	9.1	2.0
Manor	1	9.2	3.6
	2	10.2	3.7
Mexico	1	3.9	2.5
	2	3.7	2.6
Miami	1	6.0	2.3
	2	6.7	2.7
Miamian	1	9.2	2.7
	2	8.4	3.4
Tifton	1	5.7	2.8
	2	5.3	3.8

Table 4. Experimental conditions for study of cropland and rangeland sites reported by Gilley et al. (1997a).

Treatment	Replication	Slope (%)	Surface Cover (%)	Surface Detention (mm)
Old World bluestem	1	2.0	81	9.1
	2	1.5	77	9.7
No-till wheat	1	2.3	74	6.5
	2	2.3	67	8.1
Conservation-till wheat	1	2.5	40	5.1
	2	2.3	44	5.3

no-till wheat, and conservation-till wheat, respectively.

A study to measure the effects of a single application of manure and compost on runoff and erosion under no-till and till conditions was performed by Gilley and Eghball (1998). Mean surface detention on the no-till and till sorghum plots was 6.7 and 4.5 mm, respectively (table 5). For the plots containing wheat residue, mean surface detention values of 6.7 and 4.6 mm were found for no-till and till conditions, respectively.

Gilley et al. (2000) determined the effects of narrow switchgrass hedges on runoff and soil loss under no-till and

Table 5. Experimental conditions for study of cropland sites reported by Gilley et al. (1998).

Treatment	Tillage	Replication	Slope (%)	Residue Cover (%)	Surface Detention (mm)
Sorghum residue					
Check	No-till	1	8.5	51	8.3
		2	5.8	65	5.1
		3	5.9	51	4.3
Fertilizer	No-till	1	6.8	53	8.5
		2	6.3	55	5.8
		3	4.6	59	8.1
Check	Till	1	8.4	24	2.8
		2	6.3	20	5.8
		3	7.3	30	3.9
Fertilizer	Till	1	6.1	28	3.7
		2	6.7	16	4.0
		3	6.7	30	6.6
Wheat residue					
Check	No-till	1	6.7	76	8.6
		2	5.5	82	6.2
		3	5.8	83	6.9
Fertilizer	No-till	1	6.2	82	6.6
		2	5.0	84	7.7
		3	6.2	70	3.9
Check	Till	1	5.1	18	3.6
		2	5.7	22	6.8
		3	5.9	15	4.1
Fertilizer	Till	1	5.1	15	3.6
		2	6.0	12	6.0
		3	5.3	16	3.4

till conditions. Runoff hydrographs on the control plots that did not contain switchgrass hedges were used to calculate surface detention. Mean surface detention on the no-till and till cropland sites containing corn residue were 7.2 and 5.9 mm, respectively (table 6).

A study was performed in July 1995 by Gilley et al. (1996) to determine the influence of selected grazing and haying practices on runoff and erosion from a former CRP site in central North Dakota. Mean surface detention on the twice-over rotational grazing, season-long grazing, hayed, and burned treatments was 8.3, 5.5, 8.7, and 6.3 mm, respectively (table 7).

Gilley et al. (1997b) measured runoff, erosion, and soil quality characteristics of a CRP site in southwestern Iowa. Surface detention values of 11.6 and 10.0 mm were found for the plots established on Clearfield and Nira soils, respectively (table 8). Mean surface detention for the CRP study site was 10.8 mm.

Table 6. Experimental conditions for study of cropland sites containing corn residue reported by Gilley et al. (2000).

Treatment	Tillage	Replication	Slope (%)	Residue Cover (%)	Surface Detention (mm)
Check	No-till	1	12.8	94	5.9
		2	14.0	87	5.2
		3	13.8	80	8.4
	Till	1	11.6	57	7.1
		2	13.3	36	5.8
		3	15.3	32	5.2
Fertilizer	No-till	1	10.9	89	7.5
		2	16.2	88	8.8
		3	11.9	88	7.3
	Till	1	11.8	56	6
		2	14.0	12	6.9
		3	13.7	33	4.1

Table 7. Experimental conditions for study of rangeland sites reported by Gilley et al. (1996).^[a]

Treatment	Replication	Slope (%)	Surface Detention (mm)
Twice-over rotational grazing	1	7.6	8.3
Season-long grazing	1	8.3	5.3
	2	7.9	5.7
Hayed	1	8.3	8.7
Burned	1	9.1	7.6
	2	8.9	4.9

^[a] Surface cover at each study site was 100%.

Table 8. Experimental conditions for study of Conservation Reserve Program sites reported by Gilley et al. (1997b).^[a]

Treatment	Replication	Slope (%)	Surface Detention (mm)
Clearfield	1	8.8	9.9
	2	8.0	13.3
Nira	1	9.1	11.1
	2	8.9	8.8

^[a] Surface cover at each study site was 100%.

PREVIOUSLY REPORTED SURFACE DETENTION VALUES

Schiff (1951) identified surface detention during selected major storms occurring from 1940 to 1949 on six watersheds varying in size from 0.26 to 0.68 ha and having slope gradients ranging from 5.8% to 15.8%. A four-year crop rotation of corn, wheat, meadow, and meadow was used on the watersheds. Surface detention was also determined on three watersheds containing pasture or permanent meadow that ranged in size from 0.66 to 1.10 ha and had slopes varying from 15.3% to 21.7%. Total rainfall from the storms that were examined ranged from 1.63 to 7.70 cm, and the average rainfall amount was 4.90 cm (standard deviation of 1.73 cm). Surface runoff rate and flow velocity were used to calculate surface detention.

Surface detention on the cropland watersheds examined by Schiff (1951) ranged from 1.5 to 13.2 mm, and the mean value was 4.8 mm (standard deviation of 2.8 mm). In the present study, surface detention under tilled cropland conditions ranged from 2.8 to 7.1 mm, and the mean value was 5.0 mm. The percentage of the soil surface covered by plant canopies on the pastures examined by Schiff (1951) ranged from 55% to 95%, and the mean value was 81%. Schiff (1951) found that surface detention on the watersheds containing pasture or permanent meadow varied from 2.0 to 5.8 mm with a mean value of 4.1 mm (standard deviation of 1.4 mm). For identical runoff rates, average surface detention values were found by Schiff (1951) to increase as the vegetative cover became denser. Surface detention under rangeland conditions in the present study, which had a surface cover of 100%, ranged from 5.3 to 9.7 mm, and the mean value was 7.8 mm. The increased surface cover reported in the present study was thought to have contributed to the larger surface detention measurements.

Antoine et al. (2012) examined a bare silt loam soil in the loess belt of central Belgium that was initially tilled and then allowed to evolve under consecutive rainfall events. Ten 0.5 m wide × 1 m long footprints of the micro-topography of the soil were obtained using a molding technique. The molds were positioned in a laboratory at a 10% slope, and surface detention was measured under three or four constant rainfall

rates ranging from 5 to 60 mm h⁻¹ and three constant runoff rates ranging from 1 to 98 mm h⁻¹. Surface detention varied from 0.2 to 1.82 mm with a mean value of 0.77 mm (standard deviation of 0.37 mm). In the present investigation, surface detention under fallow cropland conditions varied from 1.7 to 4.6 mm, and the mean value was 3.1 mm. Nine of the molds examined by Antoine et al. (2012) were collected over a 3.5 month period; therefore, they were exposed to rainfall and weathering for a much longer time than the approximately 48 h study period used in the present investigation.

STUDY LIMITATIONS

Significant factors influencing surface detention include surface micro-relief, vegetation, slope gradient, rainfall excess, and topography (Haan et al., 1982). Slope gradients were reported in this study for each of the plots for which surface detention values were calculated. Development of a generalized procedure for estimating the effects of varying slope gradients on surface detention was not possible because of the limited range in slope gradients examined at a particular experimental site.

The effects of vegetative cover and land use on surface detention are much easier to identify if similar field tests are performed. There is no ideal set of experimental procedures that would work best for a wide range of vegetative cover and land use conditions. The hydrographs used to obtain the surface detention values reported in this investigation were generated using the same rainfall simulation and data collection procedures. For example, 3.7 m wide × 10.7 m long paired plots were established on relatively uniform slopes. Rainfall was applied at a design intensity of 64 mm h⁻¹ for a 1 h duration on two consecutive days, and hydrographs obtained on the second day were used to determine surface detention. Table 2 provides information on the relative differences in surface detention measurements among land uses for the given experimental conditions.

CONCLUSIONS

Surface detention values were obtained from runoff hydrographs generated during rainfall simulation tests conducted in six previously reported studies. The hydrographs were generated from rainfall simulation studies conducted on paired 3.7 m wide × 10.7 m long plots on which approximately 128 mm of rainfall was applied. Measurements from individual plots and mean values for selected land uses were presented in a tabular format. Photographs were provided showing surface conditions at selected sites. Surface detention was found to generally increase as crop residue or surface cover increased. Mean surface detention values for fallow cropland, tilled cropland, no-till cropland, rangeland, and CRP areas were 3.1, 5.0, 6.9, 9.6, and 10.8 mm, respectively.

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