Dairy Manure Compost Utilization

Efficacy of Using Dairy Manure Compost as Erosion Control and Revegetation Material

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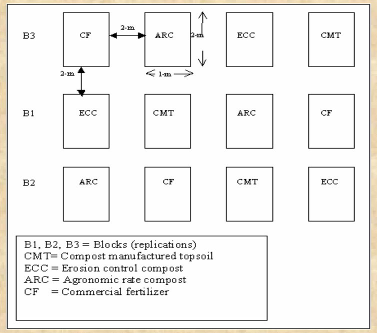
Abstract

In a simulated rainfall study, first flush (one liter) and the remaining runoff samples were collected from 12 non-vegetated and isolated field plots established on a 3:1 embankment constructed as a road right-of-way. These plots were assigned to four treatments namely compost manufactured topsoil (CMT); 2.5 cm of dairy manure compost (DMC) incorporated into 8-cm of topsoil, erosion control blanket (ECC); a 5-cm layer of DMC and woodchips blended (2.5 cm each mixed by volume) and applied on top of the undisturbed soil, agronomic rate compost (ARC); DMC broadcast at 39.5 t/ha, and commercial fertilizer (CF); broadcast at the rate of 112kg N /ha, 49 kg P /ha, and 83 kg K /ha, respectively. The ECC plots had smaller total runoff mass than all other treatments and significantly lower TS and TSS in the runoff as compared to those in the runoff from CF plots. Overall, plots amended with DMC or DMC/woodchips blend, though much higher in N, P and K, produced less runoff and sediment and nutrients in the runoff as compared to the mineral fertilizer plots without any organic amendment. It was concluded that ECC and CMT treatments established to control erosion and revegetate, respectively, a newly constructed road-right-of-way and shortly there after, subjected to rain (a worst case scenario) will be effective in erosion control. Even though compared to the CF treatment, generally smaller quantities of N, P and K were measured in the runoff from ECC and CMT treatment plots, N and P concentrations in the runoff were high from the standpoint of water quality.

Two rainfall simulators were used simultaneously to conduct rainfall simulation and runoff sampling experiments on experimental plots. Each simulator was designed and equipped with one HH-SS50WSQ nozzle.

On each plot, simulated rainfall of 92 mm h^{-1} (3.6" h^{-1}) average intensity (25-yr return frequency of a 1-h storm at the experimental site) was applied to cover a 4-m^2 footprint, which ensured complete coverage of the 1x2 m plot. Rainfall with this intensity was applied on each plot until 30-min of runoff was obtained.



Experimental plots and treatment set-up (dimensions are not to scale).

Materials and Methods

Twelve plots, each 1x 2m were established on an embankment with 3:1 side slope and constructed to mimic a road right-of-way. The embankment soil was clayey with an average pH of 8.13 from the 0-15-cm (0-6") depth and devoid of vegetation. Average sand, silt and clay contents from the 0-15 cm depth were 26%, 27%, and 47%, respectively. Each plot was isolated from overland flow using 15-cm (6") metal borders installed 10-cm above and 5-cm below the ground level. At the downstream end of each plot, a parabolic shaped gutter made from a 10-cm PVC pipe, spliced in half longitudinally, was installed to convey plot runoff to plastic buckets. Four treatments namely, erosion control compost {ECC, per TxDOT (2002) specifications}, compost manufactured topsoil {CMT, per TxDOT (2002) specifications}, agronomic rate compost (ARC) and commercial fertilizer (CF) were replicated (blocks) three times and randomly assigned to 12 plots, in a 'randomized block' design. For each CMT treatment plot, a 2.5-cm (1") layer of DMC was incorporated in to 8-cm (3") of the topsoil using a heavy duty garden hoe. For each ECC treatment plot, a blend of 50% DMC and 50% woodchips by volume was applied as a 5-cm (2") thick layer of erosion control blanket on top of the existing undisturbed soil. Dairy manure compost at a rate of 39.5 t/ha (16 t/ac) was applied on undisturbed soil of each ARC treatment plots. Each CF treatment plot received mineral fertilizer at the rate of 112kg/ha (100 lb/ac) for nitrogen (N), 49 kg/ha (44 lb/ac as P or 100 lb/ac as P_2O_5) for phosphorus (P), and 83 kg/ha (83 lb/ac as K or 100 lb/ac as K_2O) potassium (K), respectively.

Results

The total time to initiate runoff, total mass of runoff, TSS and TS, and their respective standard deviations for each treatment are plotted in Figure 1. The average time to initiate runoff from the CMT plots was significantly higher ($p \leq 0.05$) than that from all other treatment plots while it was statistically similar among the ECC, ARC and CF treatment plots. The average time to initiate runoff from the ECC plots was the shortest (3.66 min) of all treatments. In fact, as compared to the ECC plots, it took more than twice as much time for the runoff to begin from the CMT (7.7 min) plots. For the ECC plots, this may have been due to a lack of moisture absorption by the woodchips in the blanket (compost and woodchip mixture) as it was observed that at the beginning of the rainfall, this blanket was somewhat hydrophobic. On the other hand, the tillage induced conditions including reduced soil moisture, increased surface roughness and reduced crusting and sealing may have resulted in increased infiltration of the CMT treatment plots, thereby delaying runoff time.

Treatment	N, kg/ha (lb/ac)	P, kg/ha (lb/ac)	K, kg/ha (lb/ac)	Moisture % (v/v), n=15
CMT	1,635 (1,459)	545 (486)	3,493 (3,116)	21.35 ±4.07*
ECC	2,976 (2,665)	903 (806)	5,985 (5,340)	14.37 ±2.75
ARC	199 (178)	66 (59)	425 (379)	27.44 ±5.18
CF	112 (100)	49 (44)	93 (83)	27.21 ±3.6

Table 1. Nitrogen, P, and K application rate (kg/ha) and moisture content at 0-5 cm depth of treatment plots.

Figure 2. Post-rainfall plot surface conditions of each treatment.

Commercial Fertilizer CF

Agronomic Rate Compost ARC

Compost Manufactured Topsoil CMT

Erosion Control Compost ECC

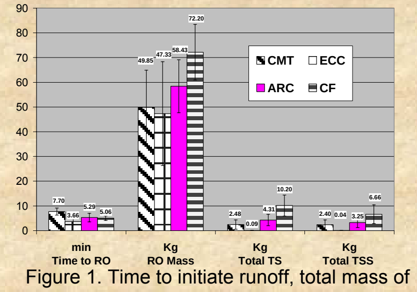


Figure 1. Time to initiate runoff, total mass of runoff and TS and TSS as affected by different treatments.

Total solids and TSS in the first flush from the ECC plots were significantly lower than those in the first flush from the CF plots while all other treatment had lower but statistically similar first flush TS and TSS than those in the first flush from CF plots. A similar trend for these parameters was observed in the remaining runoff from all treatment plots with the exception that the remaining runoff TS from the CF plots was significantly higher than that in remaining runoff from all other treatment plots. The TS and TSS in the first flush and the remaining runoff from all treatment plots followed a trend similar to the total mass of runoff. Most of the solids in first flush and remaining runoff from the CMT plots were measured as TSS and overall, plots amended with dairy manure compost or a compost/woodchip blend had lesser soil erosion than the CF treatment plots with no such amendments. Figure 2 shows most (CF) to least (ECC) eroded plot surfaces, post rainfall, for each treatment.

All forms of N, P and K as shown in Table 2 are total quantities determined from either the first flush (1-L) or remaining runoff from different treatment plots. As shown in Table 1, the highest rate of N, P and K was applied to the ECC plots followed by the CMT, ARC and CF plots. The TKN in the first flush and remaining runoff from the CF plots was significantly greater than that in the first flush and remaining runoff from all other treatments. The TKN in both forms of runoff from all other treatments was statistically similar. Despite much larger nitrogen applications to the ECC and CMT plots compared to the CAR and CF plots, the TKN, NO3-N and NH4-N in runoff from the ECC and CMT treatment plots were always lower than those in the runoff from the CF plots. This is attributed to the significantly higher solids and higher runoff mass from the CF treatment plots. Though highly variable within treatments and statistically similar among treatments, NO3-N and NH4-N in the first flush and the remaining runoff from the CF treatment plots were generally higher than those in the runoff from all other treatment plots. If NO3-N in the first flush (1-L volume) and the remaining runoff from all treatment plots were converted to mg/l (total NO3-N, mg divided by the remaining runoff mass, L), then with the exception of the first flush from the CMT plots, NO3-N in runoff from all treatments will be above the 10 mg/l limits for the drinking water quality standards set by the US Environmental Protection Agency (EPA, 1994).

Table 2. Total amounts of physicochemical constituents in runoff from different treatments.

	First Flush			
PARAMETERS	CMT	ECC	ARC	CF
pH	7.15^{ab*} (±0.92)**	7.0^{a} (±0.17)	7.53^{ab} (±0.23)	7.7^{b} (±0.36)
TS (Kg)	0.024^{ab} (±0.02)	0.003^{a} (±0.00)	0.032^{ab} (±0.02)	0.06^{b} (±0.04)
TSS (Kg)	0.019^{ab} (±0.02)	0.001^{a} (±0.00)	0.024^{ab} (±0.01)	0.04^{b} (±0.02)
TKN (mg)	13.95^{a} (±11.38)	17.73^{a} (±3.93)	18.6^{a} (±12.49)	54.73^{b} (±26.38)
NO_3-N (mg)	2.9^{a} (±0.89)	24.7^{a} (±32.2)	29.1^{a} (±5.08)	30.9^{a} (±22.27)
NH_4-N (mg)	0.4^{a} (±0.4)	2.9^{a} (±4.7)	0.7^{a} (±0.3)	9.4^{a} (±9.8)
P (mg)	3.85^{a} (±3.36)	5.91^{a} (±1.05)	6.4^{a} (±3.03)	17.9^{b} (±8.71)
DP (mg)	0.36^{a} (±0.03)	3.84^{a} (±3.31)	1.83^{a} (±1.33)	6.5^{a} (±6.38)
K (mg)	267^{a} (±204)	498.5^{a} (±20.02)	348.2^{a} (±84.37)	476.2^{a} (±177.2)
DK (mg)	4.1^{a} (±2.16)	75.6^{a} (±119.79)	120.5^{a} (±106.39)	68.9^{a} (±102.13)

	Remaining Runoff			
PARAMETERS	CMT	ECC	ARC	CF
pH	7.95^{a} (±0.21)	7.27^{b} (±0.15)	7.83^{a} (±0.12)	7.97^{a} (±0.12)
TS (Kg)	2.46^{a} (±1.88)	0.09^{a} (±0.04)	4.28^{a} (±2.29)	10.14^{b} (±4.25)
TSS (Kg)	2.38^{ab} (±1.98)	0.043^{a} (±0.02)	3.23^{ab} (±1.98)	6.62^{b} (±3.78)
TKN (mg)	$1,649^{a}$ (±1,517)	673^{a} (±276)	$1,806^{a}$ (±756)	$5,801^{b}$ (±1947)
NO_3-N (mg)	$1,556^{a}$ (±400)	873^{a} (±1,007)	871^{a} (±475)	$1,588^{a}$ (±974)
NH_4-N (mg)	205^{a} (±257)	6.7^{a} (±4.69)	16.1^{a} (±12.63)	430^{a} (±404)
P (mg)	515^{a} (±317)	258^{a} (±115)	582^{a} (±166)	$1,998^{b}$ (±883)
DP (mg)	57.07^{a} (±62.61)	66.26^{a} (±65.59)	69.52^{a} (±74.62)	516.65^{a} (±528.8)
K (mg)	$24,297^{ab}$ (±12,868)	$16,400^{a}$ (±7,052)	$24,545^{a}$ (±1,478)	$50,883^{b}$ (±16,914)
DK (mg)	560^{a} (±419)	$2,152^{a}$ (±3,275)	$2,437^{a}$ (±3,519)	465^{a} (±72)

*Averages in rows followed by different letters are different at 5% level.

**Standard deviation

Conclusions

Despite the shortest time to initiate runoff, the ECC plots had smaller total runoff mass than all other treatments and significantly lower TS and TSS in the runoff (first flush and the remaining) as compared to those in the runoff from CF plots. In the remaining runoff, TS from the CMT and ARC plots and TS and TSS from the CMT plots were also significantly lower than those from the CF plots. Overall, plots amended with DMC or DMC/woodchips blend produced less runoff and sediment in the runoff as compared to the mineral fertilizer plots without any organic amendment. All plots amended with organic materials received greater amounts of N, P and K as compared to the mineral fertilizer plots. Application rates for N, P and K for the ECC and CMT plots were generally one to two folds higher than those for the CF plots. Despite these very high application rates, TKN in runoff (first flush and the remaining) from the ECC, CMT and ARC plots was significantly lower than that in runoff from the CF plots. Also, statistically similar but lower NO3-N and NH4-N were measured in runoff from these treatment plots than those in the runoff from the CF plots. Total P in the CF plots' runoff was significantly higher and DP in runoff from the same plots was higher than but statistically similar to that in the runoff from all other treatments. Significantly higher K in the remaining runoff from the CF plots compared to that in the remaining runoff from the ECC and ARC plots was measured. Dissolved K in the first flush and the remaining runoff was statistically similar for all treatments but generally higher for ARC and ECC as compared to CMT and CF.

The ECC plots had smaller total runoff mass than all other treatments and significantly lower TS and TSS in the runoff as compared to those in the runoff from CF plots. Overall, plots amended with DMC or DMC/woodchips blend, though much higher in N, P and K, produced smaller runoff, and lesser sediment and nutrients in the runoff, as compared to the mineral fertilizer plots without any organic amendment. It was concluded that the ECC and CMT treatments established to control erosion and revegetate, respectively, a newly constructed road-right-of-way and shortly there after, subjected to rain (a worst case scenario) will be effective in erosion control. Although compared to the CF treatment, generally smaller quantities of N, P and K concentrations were measured in the runoff from the ECC and CMT treatment plots, N and P concentrations in the runoff were high from the standpoint of water quality.