Influence of Weft Density on Runoff Erosion Control Performance of Rolled Erosion Control Systems

Vinay Kumar Midha and S. Suresh Kumar

1 Introduction

Landscapes disturbed by human activities commonly have erosion rates accelerated by several orders of magnitude over pre-disturbance conditions. New approaches to effectively decrease soil erosion rates from disturbed lands are essential and adopted in the recent past to protect major environmental damages. One such best management practice (BMP) combines the application of rolled erosion control systems (RECSs), composed of either natural or synthetic fibers, with seeding of hill slopes to enhance biomass production. This synergistic approach is one of the most appropriate practices for mitigating excessive soil erosion on disturbed non-agricultural hill slopes [1–4]. However, RECSs effectively mitigate runoff erosion, but limited studies are reported yet on the characteristics of RECSs that are beneficial for the potential reduction in erosion or enhancement of grass production (Vegetation growth) [5–8]. Commercial RECSs are not engineered or tailored products for onsite conditions. The various designs of commercial RECSs that are marketed today by the Erosion control Industries have probably been developed through a combination of trial-and-error and some knowledge of those properties that may influence water erosion processes. In a critical review paper, it is suggested that without a more detailed understanding of the influence of various physical attributes of RECSs on soil erosion processes and production of vegetation, there is little chance that major advances can be made in the future design of RECSs [9, 10].

To understand the physical attributes of RCESs, it is necessary to understand its structural construction. Commercial biodegradable RECSs are generally woven structures with two set of yarns, namely vertical “warp yarns” and horizontal “weft

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yarns." During onsite application, RECSs are rolled down the slope in such a way that the vertical warp yarns lies toward the direction of slope, whereas the horizontal weft yarn lies against the direction of slope [11–14]. At this condition, the weft yarn lays against the direction of slope reduces the velocity of surface runoff by creating more number of micro-barriers due its three-dimensional structure. Hence, the variation in physical and structural construction of cross-laid weft yarn (yarns/meter) would improve the erosion control performance of RECSs. Based on onsite laying conditions (ideal conditions), a geometrical model is proposed to calculate the storage volume of RECSs to evaluate its performance [7, 8]. In the proposed model, Sanyal considered the diameter of weft yarns of RECSs as circular cross section, then the hindrance (micro-barriers) created by the weft yarns against the slope was expected to be a triangular storage effect. In accordance with his model, Sanyal increased the diameter of jute RECSs and achieved an improved erosion control performance. However, increase in diameter of yarns leads to increase in flexural rigidity of RECS, which reduces the contact of the RECS with the soil, and therefore may reduce the erosion control performance. Increase in weft yarn density (weft yarns per meter) of RECSs can also increase the storage volume and hindrance against the overland flow and is expected to improve the performance of RECSs (Fig. 1).

But till date no such study has been reported regarding such structural modification of RECSs. Therefore, in this study 15 different RECSs (Coir and Jute) with different weft density (weft yarns per meter) are tested for erosion control performance at different slope angles (i.e., 15°, 30° and 45°) and germination performance.

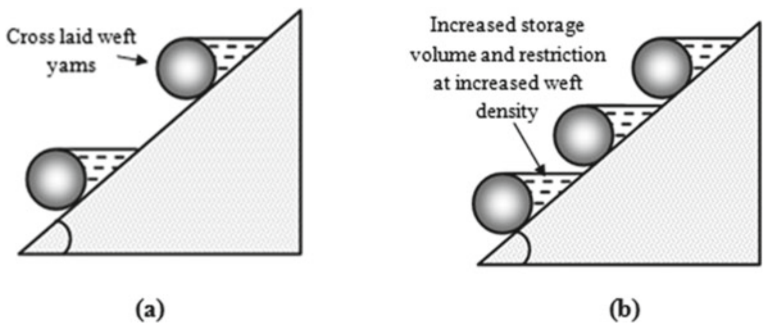

Fig. 1 Storage effect and restriction created by cross-laid weft yarns of RECs at different weft density: **a** minimum weft density; **b** increased weft density

2 Materials and Methodology

2.1 Materials

Commercial coir and jute yarns with different linear density are selected and woven to prepare 15 different RECSs samples with different weft density (Table 1). At increased weft density, weft per meter increases and the distance between the successive weft yarns decreases. So, weft density for different yarn counts is maintained constant by maintaining distance between the adjacent weft yarns. In case of coir RECSs distance of 17, 19, and 21 mm are maintained between adjacent weft yarns, to weave different RECSs of different weft density. Whereas in jute RECSs distance of 8, 12, and 16 mm is maintained between adjacent weft yarns. Flexural rigidity, an important property of RECSs that influences its erosion control performance, is expected to change as the weft yarn density changes. Therefore, flexural rigidity of all RECSs is measured according to ASTM D1388 (wider width of 25 cm) at dry and wet conditions [9].

2.2 Runoff Erosion Test

To perform runoff erosion control test, RECS samples are subjected to simulated rainfall conditions in a runoff erosion control tester (bench-scale), which is designed based on ASTM D 7101 standards with certain modification in the ramp size (Fig. 2a) [15, 16].

Since RECSs are open weave structures with larger mesh opening size (19 X 19 cm and 10 X 12 cm), the test core of 20 cm diameter used in ASTM D7101 is substituted with ramp size of 50 cm length and 25 cm width [17]. V-jet nozzles are used in the rainfall simulators to simulate rainfall intensity 100 mm/hr. Runoff erosion test for different RECSs samples is carried out at three different slope angles of 15°, 30°, and 45° by changing the slope angle of ramp in the runoff erosion setup (Fig. 2b, c) carried with soil (soil infiltration condition) and without soil (zero-infiltration condition) conditions.

2.2.1 Runoff Test at Soil Infiltration Condition

In soil infiltration condition, soil from Shivalik/lower Himalayan regions (31° 37′ 48.2″ N latitude 76° 00′ 47.5″ E longitude) is filled in test core/soil tray of dimension 50 cm length, 25 cm width, and 25 cm depth [18, 19] (Fig. 2b). Based on ASTM D 698 standards soil is compacted in test tray at 15% moisture content by dropping 5.50-lbf (24.5-N) rammer from the height of 30 cm [20]. Prepared soil trays are positioned at different slope angles on the runoff erosion setup (covered with RECS) and subjected to required rainfall intensity for 3 min in each trial and

Table 1 Specifications of coir and jute RECSs

Material	Sample code	Linear density of warp and weft yarn (Tex)	Diameter of warp and weft yarn (mm)	Yarn density (ends/m)	Yarn density (picks/m) PPM	Mesh opening Size (mm)	Distance between adjacent weft yarns (mm)	Weight per unit area (g/m^2)	Fractional cover	Flexural rigidity (μNm)			
										Dry		Wet	
										Warp	Weft	Warp	Weft
Coir	C1	4794	4	43	40	19 × 21	21	397.90	0.30	4451	4270	1654	1503
	C2	4794	4	43	43	19 × 19	19	412.28	0.31	4380	4380	1581	1581
	C3	4794	4	43	48	19 × 17	17	436.25	0.33	4268	4429	1498	1624
	C4	6765	5	42	38	19 × 21	21	541.20	0.36	5842	5641	2054	1872
	C5	6765	5	42	42	19 × 19	19	568.26	0.38	5759	5759	1987	1987
	C6	6765	5	42	45	19 × 17	17	588.56	0.39	5610	5799	1903	2068
	C7	7614	6.5	39	36	19 × 21	21	571.05	0.43	6621	6452	2584	2451
	C8	7614	6.5	39	39	19 × 19	19	593.89	0.44	6501	6501	2492	2492
	C9	7614	6.5	39	43	19 × 17	17	624.35	0.46	6403	6608	2431	2561
Jute	J1	2961	2.5	80	54	10 × 16	16	396.93	0.31	923	712	232	56
	J2	2961	2.5	80	69	10 × 12	12	441.09	0.34	861	668	189	72
	J3	2961	2.5	80	95	10 × 8	8	518.88	0.39	742	509	151	84
	J4	4773	3.9	72	50	10 × 16	16	583.51	0.42	1021	804	243	59
	J5	4773	3.9	72	63	10 × 12	12	643.84	0.46	972	718	196	81
	J6	4773	3.9	72	84	10 × 8	8	744.75	0.52	954	792	156	108

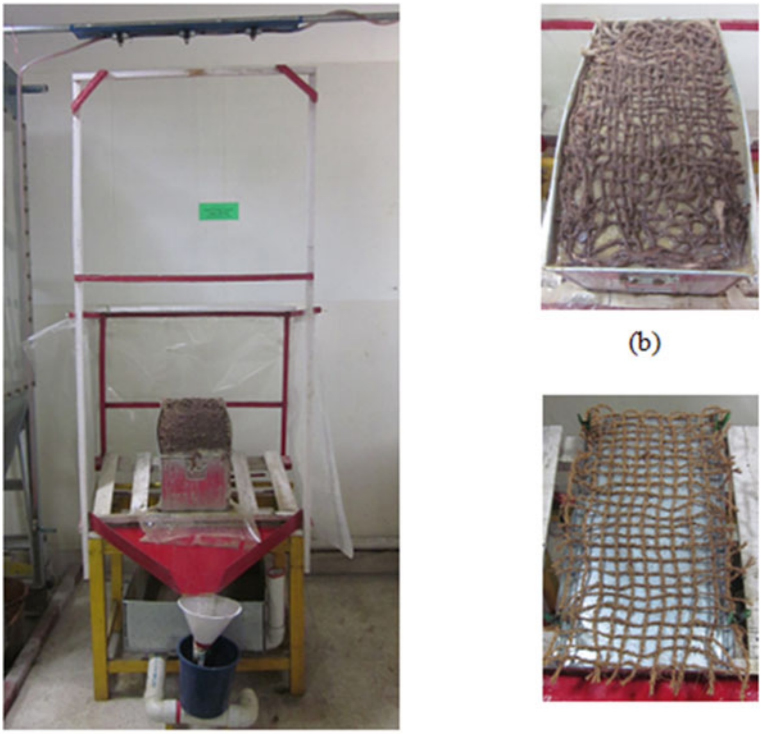
(a) (b) (c)

Fig. 2 Runoff erosion test at different infiltration condition: **a** runoff erosion setup; **b** soil infiltration condition; **c** zero-infiltration

runoff water with eroded soil is collected. Eighteen such trials are repeated for each sample, and results of initial three trials are not considered in those results to avoid initial error that may be generated due to the initial absorption of water by the soil and RECSs. Similarly testing is performed in uncovered soil trays (without RECSs), to evaluate control test performance. The same procedure is repeated for different samples at different slope angles; however, newly prepared test trays are used for each sample, slope angle, and rainfall intensity. The eroded soil from the runoff water is separated by sedimentation process, and the erosion control % of each sample is calculated using Eq. 1 [15, 16].

$$\text{Erosion control }\% = \frac{(E - C)}{E} \times 100 \tag{1}$$

Where,

E Eroded soil without RECSs (gms).
C Eroded soil with RECSs (gms).

2.2.2 Runoff Test at Zero-Infiltration Condition

Since, performing runoff erosion test at soil infiltration conditions is influenced by the water restriction behavior of RECSs, due to the absorption of water by the soil, and the runoff erosion test is also performed at zero-infiltration (without soil) condition for better understanding of the influence of weft yarn diameter on the reduction in runoff velocity. To perform runoff erosion test at zero-infiltration condition, soil tray is replaced with a metallic ramp with uniform smooth surface (Fig. 2c) [17]. RECS sample is laid over the metallic ramp and subjected to simulated rainfall for 3 min to collect runoff water volume. Subsequently rainfall is ceased for 3 min to collect the culmination discharge. Similar procedure is repeated for evaluating the performance of different RECSs at different slope angles.

2.3 Germination Test

Germination test is performed according to ASTM D 7322 by using earthen pots filled with site soil, and sown with equal number of wheat seeds (60 seeds/pot). The pots are covered with RECSs at surface of the soil as shown in the Fig. 3a, and 1 pot is left uncovered for the control test. The test pots are kept at uniform temperature and lighting conditions, and watered until the 21st day. At the end of the 21st day, percentage of vegetation in each pot is calculated using Eq. 2 with reference to the number of plants germinated in the control test pot.

$$\%\ \text{of vegetation} = \left(\frac{\text{Number of plants germinated in the pot with RECS}}{\text{Number of plants germinated in the pot without RECS}}\right) \times 100 \tag{2}$$

Other important factors that affect the soil stability and germination of plants are the number and length of roots; so total rooting is also calculated at the end of 21st

(a) (b)

Fig. 3 Germination test: **a** germination earthen pots; **b** uprooted vegetation at 21st day for evaluation of rooting day. Primary roots in wheat plants germinate in 10 days and secondary roots start appearing after 20 days [21–23]. After 21 days, the average primary root length and average number of roots/plants are measured in each pot by uprooting 10 plants randomly (Fig. 3b). Total rooting after 21 days is calculated using Eq. 3 [15, 16].

$$\text{Total rooting(cm)} = N \times n \times L \tag{3}$$

where,

N Total number of plants germinated after 21 days,
n Average number of primary roots/plants,
L Average primary root length (cm).

3 Result and Discussion

3.1 Influence of Weft Density on Erosion Control Performance

Erosion control performance of coir and jute RECSs at different weft density, slope angle, and infiltration is tabulated in Table 2.

3.1.1 Erosion Control Performance at Soil Infiltration Condition

At soil infiltration condition, coir RECSs with finer yarns (4794 and 6765 Tex) show lower runoff volume and improved erosion control percentage at increased weft yarn density (lower distance between weft yarns), at all slope angles (15º, 30º and 45°) (Table 2 and Fig. 4).

It is due to the higher storage volume and more restriction offered by higher number of weft yarns against the runoff water running down the slope [12, 13]. However, in coarser yarns (7614 Tex) RECSs, increased weft density results in initial increase in erosion control percentage, but further increase in weft density resulted in reduced erosion control percentage at steeper angle of slope (45°). It is due the increased flexural rigidity of coir RECSs (Table 1) and higher rate of erosion at steeper slope. At steeper slopes "gully erosion" with deeper contours would be formed [24]. It is difficult for the high flexural rigidity coir RECSs with coarser yarns (7614 in both warp and weft direction) to drape (Fig. 5) properly over these contours. This reduces the contact between soil surface and RECSs, and results in reduced erosion control performance at steeper slopes.

At soil infiltration condition, Jute RECSs with higher weft density (minimum distance between weft yarns) result in reduced runoff volume and improved erosion control performance, at all slope angles (15°, 30° and 45°) (Table 2). This is due to increased storage volume and restriction against runoff water at increased weft

Table 2 Erosion control performance of coir and jute RECSs at soil and zero-infiltration condition

Material	Sample code	Warp and weft yarn linear density (Tex)	Mesh opening size (mm)	Soil infiltration						Zero-infiltration					
				Runoff volume (ml)			Erosion Control %			Runoff volume (ml)			Culmination discharge (ml)		
				15°	30°	45°	15°	30°	45°	15°	30°	45°	15°	30°	45°
Coir	C1	4794	19 × 21	423	441	472	44.2	38.2	34.2	552	574	589	42	52	56
	C2	4794	19 × 19	402	424	454	52.3	42.9	38.7	543	542	575	51	59	64
	C3	4794	19 × 17	385	397	429	57.2	48.7	43.5	518	531	568	62	68	71
	C4	6765	19 × 21	401	417	443	58.2	49.7	46.3	567	578	594	47	59	69
	C5	6765	19 × 19	378	408	430	61.7	53.3	50.2	560	558	571	56	68	62
	C6	6765	19 × 17	362	383	418	63.2	56.9	52.9	544	529	541	65	74	78
	C7	7614	19 × 21	377	391	449	62.7	60.1	36.9	563	585	572	51	56	65
	C8	7614	19 × 19	360	376	441	64.9	62.4	48.5	554	580	564	49	58	73
	C9	7614	19 × 17	342	354	428	66.2	56.4	37.2	550	578	589	52	59	69
Jute	J1	2961	10 × 16	361	385	402	71.8	67.3	64.2	402	422	447	162	173	185
	J2	2961	10 × 12	345	367	388	76.2	71.5	68.5	379	410	435	171	180	206
	J3	2961	10 × 8	318	336	369	81.3	77.8	72.3	354	381	412	183	194	228
	J4	4773	10 × 16	348	369	378	72.8	69.7	67.1	372	389	414	162	178	195
	J5	4773	10 × 12	309	322	341	79.1	74.6	71.3	358	375	390	209	220	228
	J6	4773	10 × 8	262	294	327	85.9	79.4	74.3	331	347	362	225	237	242

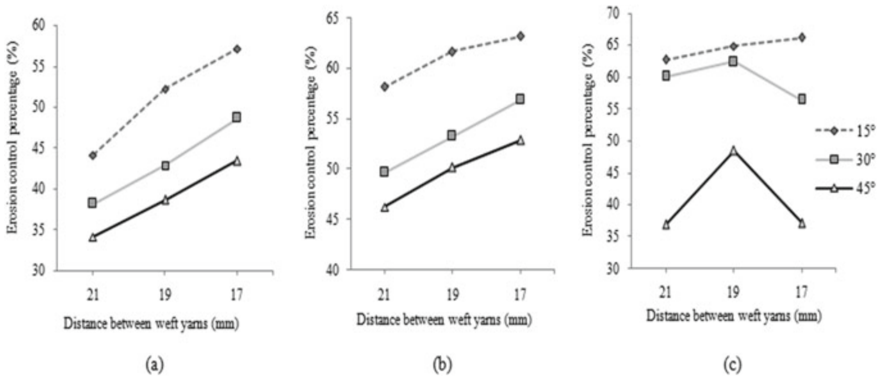

Fig. 4 Erosion control percentage of coir RECs at different weft density and slope angle: **a** yarn count of 4794 Tex; **b** yarn count of 6765 Tex; **c** yarn count of 7614 Tex

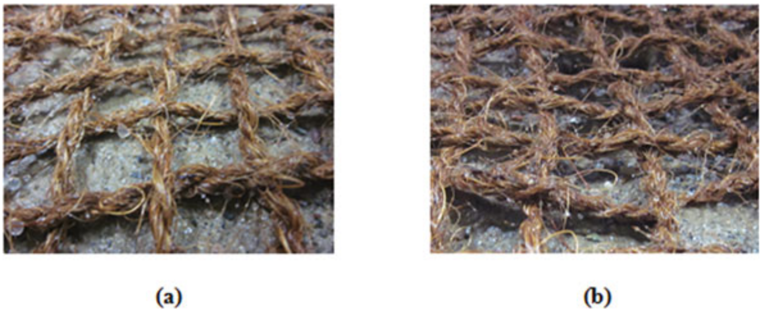

Fig. 5 Drapability of coir RECSs at different slope angle: **a** sheet erosion and lower slope angle; **b** gully erosion at steeper slope angle

density, and also due to the better drapability of jute RECSs. Even at increased weft density, Jute RECSs has lower flexural rigidity as compared to the coir RECSs (Table 1), due to finer and softer jute fibers. Further, flexural rigidity of jute RECSs reduces significantly under wet conditions, as compared to coir RECSs [25, 26]. Weft directional flexural rigidity of jute RECS J1 is 712 µNm and 56 µNm under dry and wet conditions, respectively. It is due to higher water absorbing capacity and finer fibers of jute RECSs, which facilitate better contact between jute RECSs and soil surface and results in better erosion control performance as compared to coir RECSs.

Influence of weft density on erosion control percentage of coir and jute RECSs is statistically analyzed using Analysis of Variance (ANOVA). In coir RECSs, it is observed that the slope angle has the maximum influence on erosion control percentage with a contribution of 47.29%, and it is followed by the yarn count and weft density with a contribution of 27.39% and 7.28%, respectively (Table 3).

Table 3 ANOVA analysis of erosion control percentage of coir RECSs

Type of RECSs	Source	DF	Seq ss	Contribution %	Adj SS	ADj MS	F-value	P-value
Coir RECSs	Yarn linear density (Tex)	2	654.29	27.39	654.29	327.145	63.60	0.000
	Weft density (distance between weft yarn) (mm)	2	173.98	7.28	173.98	86.991	16.91	0.000
	Slope angle (degree)	2	1129.51	47.29	1129.51	564.757	109.80	0.000
	Yarn tex * weft density	4	122.23	5.12	122.23	30.556	5.94	0.007
	Yarn tex * slope angle (degree)	4	246.86	10.33	246.86	61.715	12.00	0.000
	Error	12	61.72	2.58	61.72	5.144		
	Total	26	2388.60	100.00				
Jute RECSs	Yarn linear density (tex)	1	30.161	5.72	30.161	30.161	34.65	0.004
	Weft density (distance between weft yarn) (mm)	2	281.363	53.37	281.363	140.682	161.60	0.000
	Slope angle (degree)	2	203.853	38.67	203.853	101.927	117.08	0.000
	Yarn tex * weft density (mm)	2	0.568	0.11	0.568	0.284	0.33	0.739
	Yarn tex * slope angle (degree)	2	0.164	0.03	0.164	0.082	0.09	0.912
	Weft density (mm) * slope angle (degree)	4	7.553	1.43	7.553	1.888	2.17	0.236
	Error	4	3.482	0.66	3.482	0.871		
	Total	17	527.145	100.00				

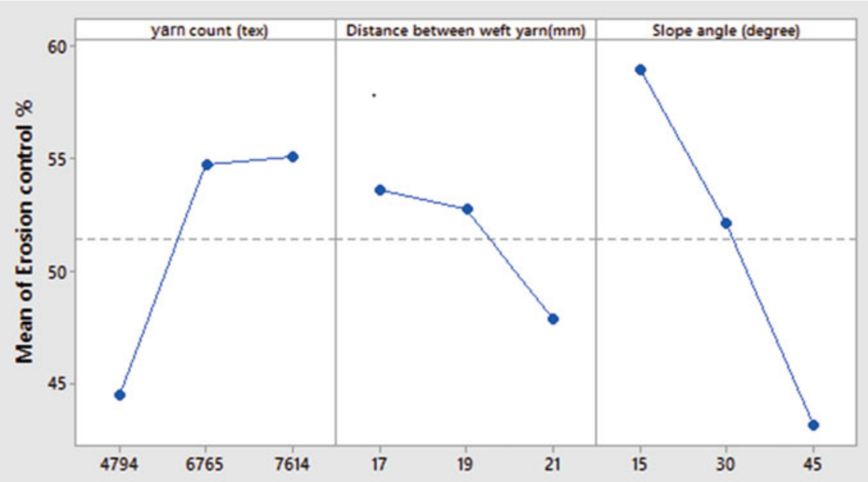

Fig. 6 Main effect plot of erosion control % (ANOVA analysis of coir RECSs)

From the main effects plot (Fig. 6), it is observed that increase in weft density (i.e., lower distance between weft yarns), increases the erosion control percentage of RECSs, whereas increase in slope angle reduces its erosion control percentage. Also, it is observed that the increase in yarn linear density (Tex) initially increases the erosion control percentage significantly, but further increase in yarn count results in marginal increase in erosion control percentage.

In jute RECSs, it is observed that the increase in weft density has the maximum influence on erosion control percentage with contribution percentage of 53.37%, and it is followed by the slope angle and yarn count with contribution of 38.67% and 5.72%, respectively (Table 3).

3.1.2 Erosion Control Performance at Zero—Infiltration Condition

At zero-infiltration condition, overall runoff volume of all coir RECSs is observed to reduce at increased weft density; however, the rate of reduction in runoff volume at different slope angles is inconsistent. The runoff volume of C3 coir RECS at 30° slope angle is 529 ml, whereas at same condition at 15° slope angle the runoff volume is 544 ml. In general, runoff volume increases at increased slope angle due to faster flow of water down the slope, but the results are inconsistent in coir RECSs at different slope, all though an overall reduction of runoff volume is observed at increased weft density. It is due to the stiffer protruding coir fibers on the surface of coir RECSs. The stiffer protruding fibers reduces the contact between coir RECSs and rigid metallic ramp (Fig. 7) [27–29].

Hence the storage effect and restriction created by the cross laid weft yarns are inconsistent and resulted in inconsistent runoff volume and culmination results.

(a) (b)

Fig. 7 Coir RECSs laid at different infiltration condition: **a** soil infiltration condition (soil trays); **b** zero-infiltration condition (metallic ramp)

However, this problem is not observed in soil infiltration condition, because the rigid protruding fibers penetrate into the wet soft soil surface and minimize the problem of reduced contact.

Similar to soil infiltration condition, increase in weft density results in better performance in Jute RECSs at zero-infiltration condition at all slope angles (15°, 30°, and 45°). It is due to the better drapability of jute RECSs [30]. It is observed that the runoff volume and culmination discharge of J1 jute RECS at 30° slope angle is 422 ml and 173 ml, respectively, at zero-infiltration condition. Whereas at same conditions, jute RECS (J3) with higher weft density resulted in lower runoff and higher culmination volume of 381 ml and 194 ml, respectively. This is due to the higher storage volume and higher restriction offered by higher weft density RECSs.

3.2 Influence of Weft Density on Germination Performance

Table 4 shows the germination performance of coir and jute RECSs. It is observed that the increased weft density influences the germination pattern of vegetation due to the variation in fractional cover and flexural rigidity of RECSs.

At increased weft density, fractional cover (surface cover) of RECSs increases (Table 1); this offers more restriction to the growth of vegetation. Hence, at the end of 21st day the percentage of vegetation of coarser yarn coir RECSs (6765 Tex and 7614 Tex) is observed to be lower at increased weft density (Table 4). However, coir RECSs with finer yarn count (4794 Tex) have marginal increase in percentage vegetation, due to its lower flexural rigidity. At lower flexural rigidity, RECSs offer lower restriction to the growth of vegetation even when the fractional cover is high, because the yarns are flexible. Similar trend is observed in jute RECSs, having lower flexural rigidity, percentage of vegetation of jute RECSs is observed to be higher than the coir RECSs, even at higher fractional cover. It is also observed that the jute RECSs facilitate faster initial growth as compared to coir RECSs due to finer and

Table 4 Germination performance of coir and jute RECs

Material	Sample code	Warp and weft yarn linear density (Tex)	Mesh opening Size (mm)	Average number of plants germinated							Vegetation (%)	Average number of roots	Average length of roots (cm)	Total rooting (cm)
				Day 3	Day 6	Day 9	Day 12	Day 15	Day 18	Day 21				
Coir	Control			0.0	12.3	20.7	26.0	28.0	29.0	29.0	100.0	4.0	14.8	1751.6
	C1	4794	19 × 21	0.0	8.0	20.0	24.3	27.0	27.3	27.3	94.8	4.0	14.5	1595.0
	C2	4794	19 × 19	0.0	8.0	18.7	24.0	26.0	27.0	28.0	96.6	4.0	14.5	1624.0
	C3	4794	19 × 17	0.0	7.0	14.0	22.0	25.7	26.0	28.0	96.6	4.1	14.4	1653.1
	C4	6765	19 × 21	0.0	8.0	19.7	24.0	26.0	27.0	27.0	93.1	4.1	13.2	1461.2
	C5	6765	19 × 19	0.0	7.3	17.0	22.0	24.0	25.0	26.3	90.8	4.3	13.2	1494.5
	C6	6765	19 × 17	0.0	6.3	15.0	18.7	21.0	24.0	26.0	89.7	4.2	13.4	1463.3
	C7	7614	19 × 21	0.0	5.0	10.7	21.0	24.0	24.0	24.7	85.0	5.0	11.6	1430.3
	C8	7614	19 × 19	0.0	6.0	17.0	21.0	22.0	23.3	24.0	82.8	5.0	11.5	1380.0
	C9	7614	19 × 17	0.0	5.0	11.3	20.0	21.3	23.0	23.0	79.3	5.0	11.5	1322.5
Jute	J1	2961	10 × 16	1.0	7.0	18.0	24.3	28.0	28.0	28.7	98.8	5.0	12.2	1748.3
	J2	2961	10 × 12	1.0	7.0	18.0	24.0	27.3	29.0	29.0	100.0	5.6	11.7	1900.0
	J3	2961	10 × 8	0.0	6.3	17.7	23.0	26.0	27.0	29.0	100.0	6.0	11.2	1948.8
	J4	4773	10 × 16	2.0	10.7	20.3	24.0	27.0	27.0	28.0	96.6	5.6	11.1	1740.5
	J5	4773	10 × 12	1.0	11.0	17.0	22.0	25.3	26.0	27.3	94.2	6.3	10.1	1739.0
	J6	4773	10 × 8	1.0	9.0	16.7	22.0	25.0	27.0	27.0	93.1	6.6	9.8	1746.4

Fig. 8 Germination test in coir and jute RECSs: **a** high restriction for vegetation growth in coir RECSs; **b** less restriction for vegetation growth in jute RECSs and germination vegetation pass across the jute RECS yarns

softer jute fibers. In jute RECSs, it is observed that the germinating vegetation is able to pass across the jute yarns easily due to its finer and softer fibers, but in coir RECSs with rigid coir fibers, initial vegetation has to face higher restriction while germinating (Fig. 8).

At the end of 21st day, average number of primary roots is observed to be higher for the RECSs with higher weft density, and it is due to its better surface cover and moisture-holding capacity. Due to the same reason and due to additional advantage of lower flexural rigidity, jute RECSs show higher number of primary roots as compare to coir RECSs. At the end of 21st day, average root length is observed to be longer for the lower weft density RECSs; it is due to the non-availability of water on soil surface (lower moisture-holding capacity). Among different RECSs, it is observed that the coir RECSs has the longest root length at the end of 21st day. It is due to its higher flexural rigidity and lower moisture-holding capacity. Due to the poor availability of water on the soil surface, roots penetrate deeper into the soil. At increased weft density, total rooting of finer yarn coir RECSs and all jute RECs is higher due to higher percentage cover and better rooting, whereas in coarser yarn count RECSs total rooting reduces at increased weft density.

4 Conclusion

Influence of weft density on erosion control performance of coir and jute RECSs is studied at different slope angles and infiltration conditions along with its germination performance evaluation. From the study, it is observed that the increase in weft density results in decreased runoff volume and improved erosion control performance of jute RECSs at all slope angles (15°, 30° and 45°), at soil infiltration condition. It is due to the increased storage volume and higher restriction against the runoff water, and also due to the better drapability of jute RECSs. However, in coir RECSs, increase in weft density resulted in better performance at lower slope angles, but at higher slope angles erosion control percentage reduces in case of coarser weft yarn counts, it is due to its higher flexural rigidity. Similar to soil infiltration condition, jute RECSs with higher weft density has shown better performance at zero-infiltration condition, but the results of coir RECSs are inconsistent at slope angles due to the rigid protruding coir fibers on its surface. Weft density influences the germination performance of RECSs by varying the fractional cover and flexural rigidity of RECSs. Percentage of vegetation is observed to be higher at increased weft density in finer count RECSs, whereas at coarser count RECSs percentage of vegetation decreases at higher weft density, due to higher fractional cover and higher rigidity. At increased weft density, average number of roots germinated per plant are higher, but the average length of roots is lower. Therefore, at the end of 21st, total rooting of finer yarn count RECSs and jute RECSs is observed to be higher at increased weft density, whereas in coarser yarn count RECSs total rooting is observed to be lower at increased weft density. Among coir and jute RECSs, jute RECSs with soft and finer jute fibers facilitate better and faster growth of vegetation as compared to rigid coir RECSs.

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