Assessing the yield response to deep ripping in the northern Albany Port Zone, Western Australia. 2018 Harvest Update

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Key messages

1. Removing subsurface soil compaction can provide benefits over many years.
2. Deep ripping provides the opportunity to address other soil constraints such as sub surface acidity

Aims

To assess the impact of deep ripping on crop yield over a two year period in the northern Albany port zone.

Method

A lime by tillage trial was established by the Cusack family in April 2016 to assess the impact of tillage treatment and lime application on crop yield. The trial was located on a poor performing acidic deep yellow sand soil type.

The trial was designed as a fully randomised block trial with four replicates of 11 treatments plus control (Figure 1). Each plot was 18m wide and 250m long and aligned with existing guidance lines. Lime was spread using the growers Marshall Spreader at a 9m width. Deep ripping was carried out by a local contractor using a 6m Bednar Terraland at a 450mm working depth. Spading was carried out by a contractor using a 4m Farmmax spader after the plots had been deep ripped.

Figure 1: Deep ripping demonstration sites were established on the Cusack's farm north of Hyden in 2016. The trial consisted of fifty, 18 metre wide plots of different lime rates and tillage treatments.

The paddock was sown to peas in June 2016 which was spray topped in September 2016 and then brown manured with a Kelly Chain in April 2017. This was done to allow the trial 12 months to settle and provide a good seedbed for the subsequent crop. Canola was sown in May 2017 and wheat in May 2018 with the growers DBS seeder as part of the normal seeding operations.

Harvesting of the plots was carried out by the grower with a 15m header width and plots were harvested separately from the rest of the paddock. Yield data was recorded through the harvester's yield monitor and cleaned and calibrated in Quantum GIS (QGIS 3.6) and statistical analysis carried out in PAST 3 software (Hammer *et al*, 2001).

The costs of the treatments were calculated to determine the overall cost of each treatment (Table 1). Limesand was sourced from Lancelin and costs were a combination of product ($11/t), freight ($42/t) and spreading ($4/t). Deep ripping costs of $39/ha as charged by the contactor. Spaded plots were deep ripped prior to spading and were therefore a combination of ripping and spading, which the contractor charged out at $75/ha for this job to total ($114/ha).

Table 1: The cost of each treatment as applied in this trial.

	Treatment Cost ($/ha)		
Treatment	**Lime**	**Tillage**	**Total**
Control	0	0	6.5
3 t/ha lime	188.6	0.0	188.6
3 t/ha lime + disc	188.6	11.0	199.6
3 t/ha lime + rip	188.6	38.5	227.1
3 t/ha lime + rip + spade	188.6	113.7	302.2
6 t/ha lime	377.1	0.0	377.1
6 t/ha lime + disc	377.1	11.0	388.1
6 t/ha lime + rip	377.1	38.5	415.6
6 t/ha lime + rip + spade	377.1	113.7	490.8
Disc only	0.0	11.0	11.0
Rip only	0.0	38.5	38.5
Rip + Spade only	0.0	113.7	113.7

Soil and plant measurements

A number of soil and plant measurements were collected during the 2017 and 2018 season in addition to yield.

Soil penetration resistance was measured at multiple locations along each plot using a Rimick CP300 Cone Penetrometer at 3 locations along each plot. This allowed differences in soil compaction before the trial was established in 2016 and after treatment in September 2018.

Figure 2: Cone penetrometer used to measure soil strength (left) and shears used t measure plant biomass (right)

Soil testing was carried out at two locations in each plot to assess the soil pH variation and benchmark the starting soil acidity level at the site before the treatments in 2016 and then again in February 2019. Soil was collected in 10cm intervals to 50cm and soil pH carried out on each of the 480 samples at both times of sampling.

Crop plant density and plant biomass (g/m^2) was also carried out at each soil penetrometer recording site to assess crop establishment differences. Normalised Difference Vegetation Index (NDVI) was collected using an Un-manned Aerial Vehicle (UAV) to assess differences in above ground plant biomass and plant greenness between plots.

Results and Discussion

Soil and Plant Measurements

Soil strength was reduced in the deep ripping and spaded plots when compared to the plots that did not receive deep ripping and was maintained into the 2018 season (Figure 7). The control plots consistently reached 2500kpa between 100 – 150mm soil depth and increased to peak at 4000-5500kpa at 200mm depth. Deep ripping plots maintained compaction levels below 2500kpa to 700mm depth were measurements stopped.

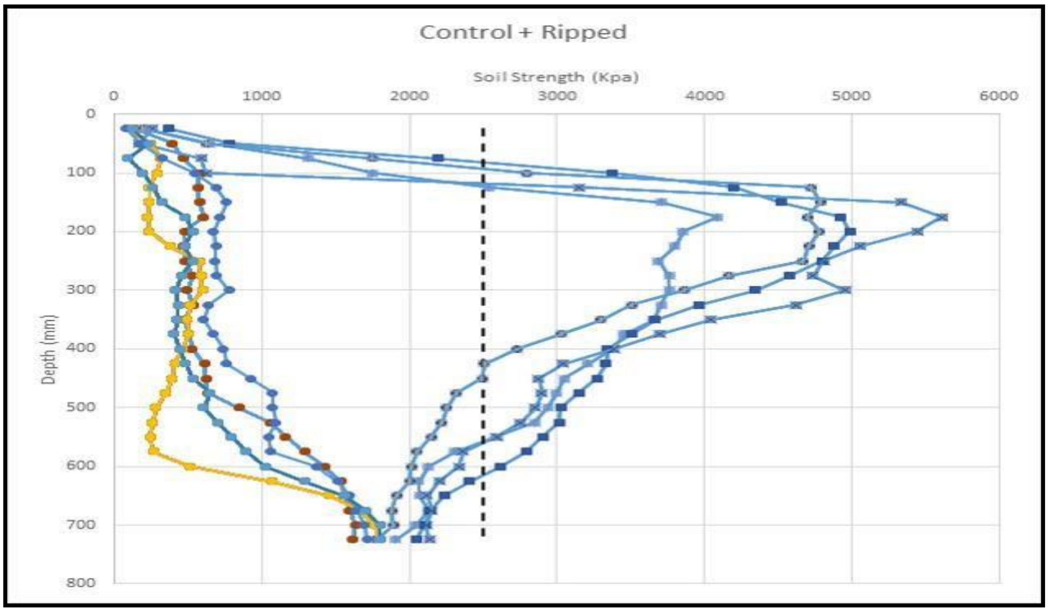

Figure 3: Comparison of soil strength measurements from ripped and control plots measured in 2017 (solid lines) and 2018 (dashed lines).

Previous research has found 2500kpa to be the compaction level where plant root growth begins to be inhibited and indicates that the deep ripping fully removed compaction as a constraint in these areas. The compaction in the un-ripped plots is very likely to cause a severe constraint to root growth.

The trial plots were soil tested in February 2019 in the same locations as sampled pre-treatment to examine soil pH changes against the benchmark values.

Soil pH had changed in the lime treatments proportional to rates of lime applied. The high rates of lime had an interaction with tillage treatments with ripping and ripping + spading treatments showing increases in soil pH below the top 20cm of soil (Figure 4). All samples 0-10cm soil pH above pH5.5 though all remain severely acidic (pH <4.5) below 30cm.

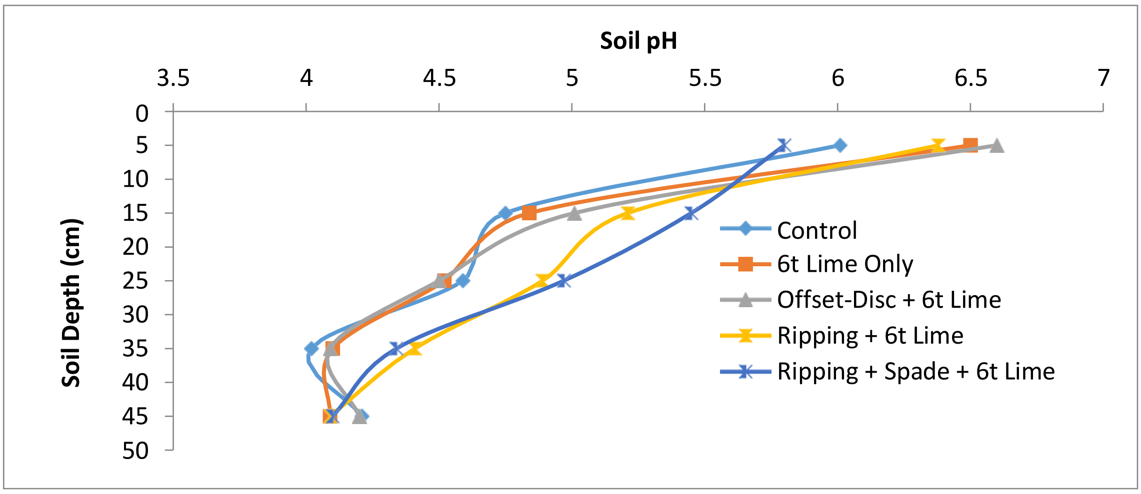

Figure 4: Soil pH average for each treatment after amelioration in 2019.

Crop Establishment and Yield

The 2017 canola crop was negatively impacted by the dry start to the 2017 season which resulted in very different crop establishment across the trial (Figure 3). The biggest differences were seen in the spaded plots which had significantly less canola plant density than all other plots, having an average of 3 plants/m^2. Some ripped plots also had a reduced number of plants than the control though density was still high enough to achieve a reasonable yield. Site inspection in June 2017 showed that the canola in the spaded plots was planted deeper than the other plots in a layer of dry soil. No difference in plant density was seen in the 2018 wheat crop.

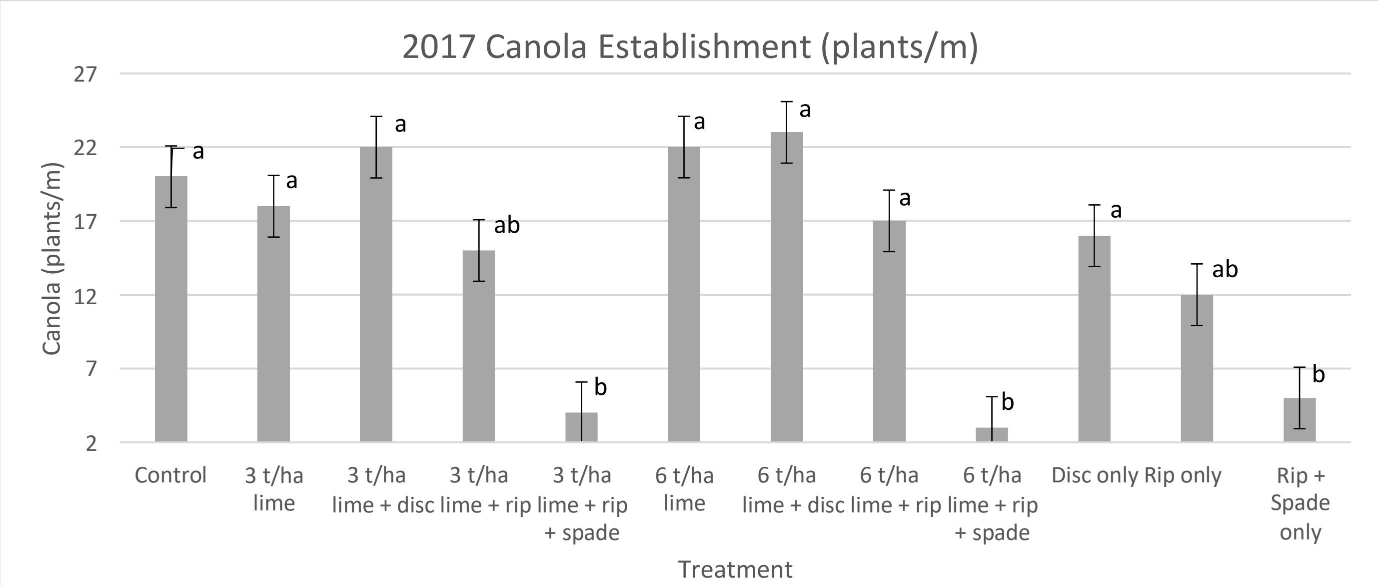

Figure 5: Differences in plant density in the 2017 canola crop showed a large reduction in the spaded plots.

There were large differences in plant greenness in the spaded treatments throughout the 2017 season caused by the variation in plant density which the UAV NDVI imagery shows very clearly (Figure 6).

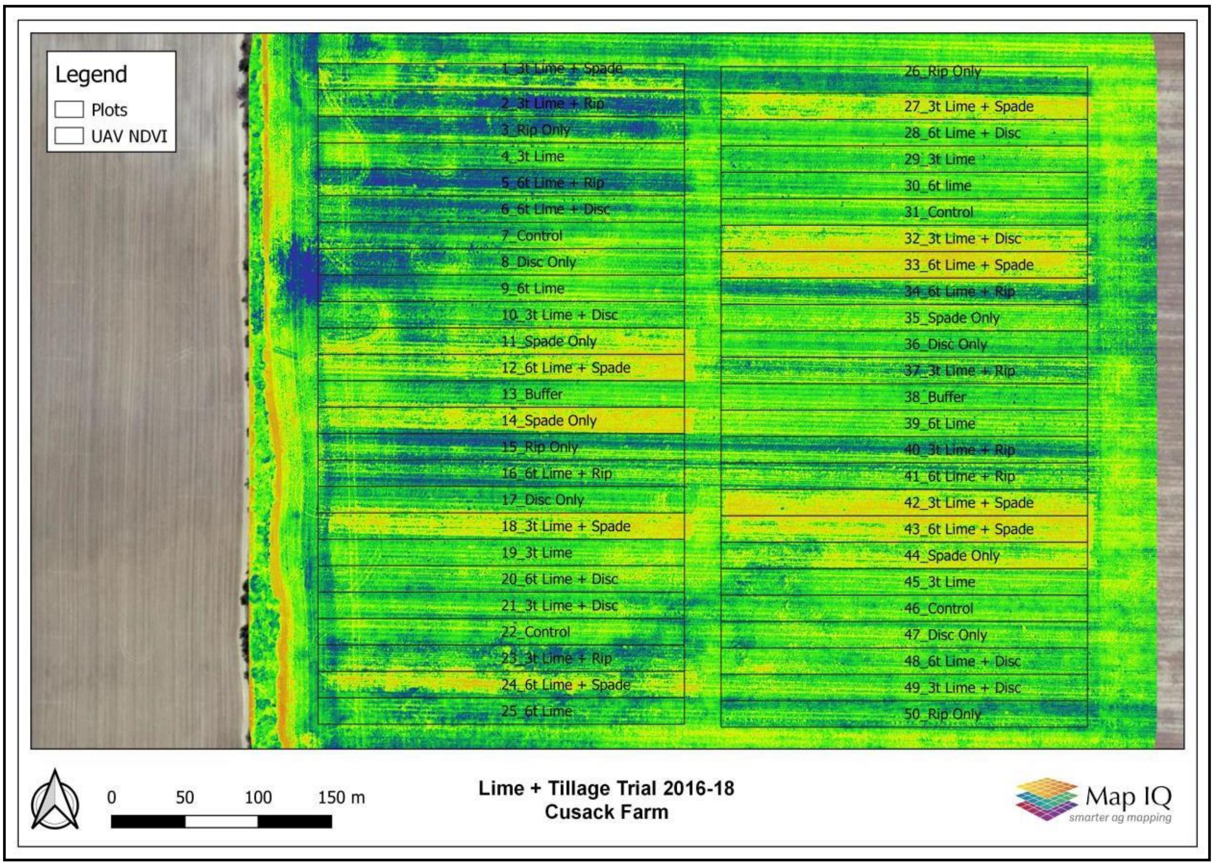

Figure 6; UAV NDVI imagery showing very poor establishment and subsequent low plant density in the spaded treatments.

Significant yield differences were seen in the 2017 yield data (Figure 4) with all the ripping and ripping plus lime treatments returning the highest yield increases when compared to the control. Any of the spaded treatments, with or without lime, gave the lowest yields averaging 350kg/ha less than the Control treatment. The largest yield increase was provided by the Ripping + 6t/ha lime treatments and gave an average 800kg/ha increase in yield.

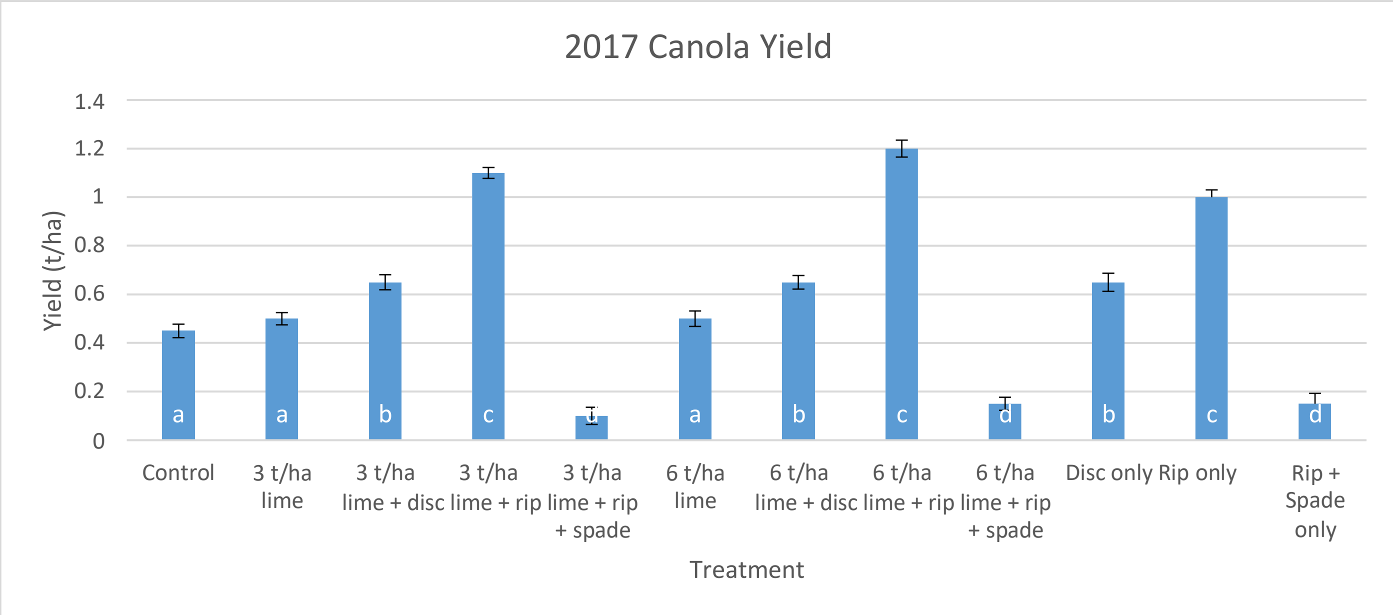

Figure 7: Average yield of treatments form the canola crop in 2017

In 2018, the highest yielding treatment was again the Ripping + 6t/ha lime which had similar average yields to the Rip only and Rip + Spade only treatments and provided 970kg/ha more wheat than the Control (Figure 5). There was no difference in yield between the Control and any of the non-tillage or disc tillage treatments, regardless of lime application though. In contrast to this, any of the ripped or ripped + spaded treatments performed significantly better than the non-tillage or disced treatments, regardless of lime application.

This indicates that soil compaction is likely to be the main constraint at this site and not soil acidity as first thought.

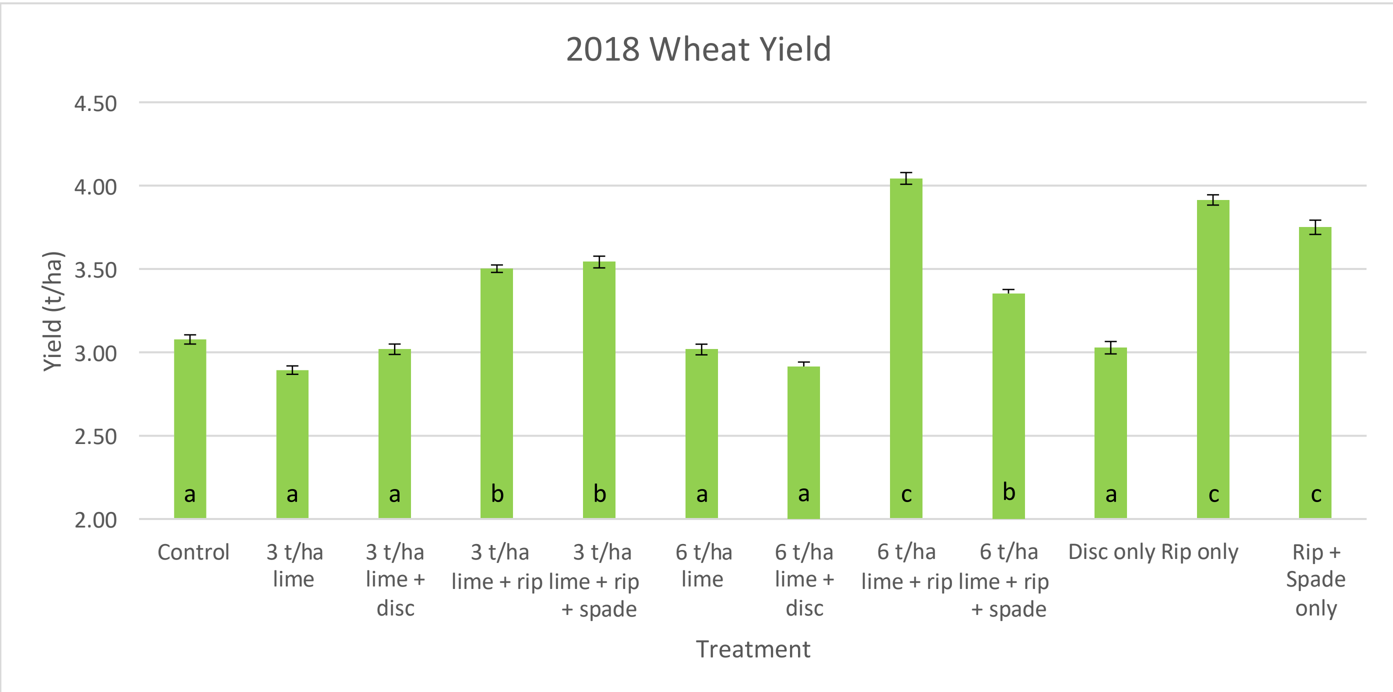

Figure 6: Average yield of treatments form the wheat crop in 2018

Returns of Deep Ripping

There was a very large range in overall economic returns from the treatments with the largest benefit being $655/ha for the Rip Only treatment and the greatest loss of -$505/ha coming from the Rip + Spade + 6t/ha lime treatment (Table 2). The surface applied lime treatments and lime with discing or spading treatments made an average loss of approximately -$300/ha. The only limed treatments to have a positive return were combined with ripping which gave an average $376/ha benefit.

Table 2: Economic return of the treatments for the 2017 and 2018 season.

Treatment	Treatment Cost ($/ha)	Amortised Treatment Cost over two years ($/ha/yr)	Benefit from Ripping 2017 ($/ha) Canola @ $500/	Benefit from Ripping 2018 ($/ha) Wheat @ $350/t	Net Return minus Costs of Investment over two years ($/ha)
Control	0	0	0	0	0
3 t/ha lime	189	94	25	-92	-256
3 t/ha lime + disc	200	100	100	-29	-129
3 t/ha lime + rip	227	114	325	212	310
3 t/ha lime + rip + spade	302	151	-175	232	-245
6 t/ha lime	377	189	25	-30	-382
6 t/ha lime + disc	388	194	100	-82	-370
6 t/ha lime + rip	416	208	375	483	442
6 t/ha lime + rip + spade	491	245	-150	136	-505
Disc only	11	6	100	-25	64
Rip only	39	19	275	418	655
Rip + Spade only	114	57	-150	337	73

The very high cost of the treatments meant the yield benefits needed to be high in both years of the trial for there to be a profit returned in the two years of the trial. The failure to get the 2017 canola crop established resulted in some very large losses (average loss of $-162/ha) in addition to already high cost of treatments.

This may be a good example of the risk that is taken when undertaking amelioration practices such as ripping or spading. Not only is there a large investment being made in terms of lime and tillage costs, but the practices themselves may actually cause a negative impact on yield which can cost just as much as the activity itself, effectively doubling the economic impact of the activity.

Conclusion

The result of deep ripping was varied in this situation and showed the risk that is present when carrying out high cost amelioration activities.

Significant yield increases and large economic returns have been achieved through deep ripping in the two seasons this trial has been run. The negative consequences of not using the tillage type, failing to get a successful crop establishment or not getting the high returns required to be profitable have also been demonstrated in this trial.

Ongoing yield increases from deep ripping are likely to continue and will provide a positive return on investment to the farm business. The longevity of the deep ripping effect will determine how large the economic benefit will become though it has already provided a profit.

Acknowledgments

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