

Optimizing mechanical and crop physical factors for sugarcane trash recovery at farm

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Increasing fuel prices in international market and depletion of fossil fuel resources are reasons to find new and cheap energy resources to meet increasing energy demands throughout the world. Potential energy resources include wind, solar, geothermal, tidal and biomass. Biomass can be collected from wheat, rice and sugarcane fields. Sugarcane is most abundant cultivated crop in world providing trash (leaves and tops) and baggas as renewable energy resource for power generation which can replace 50% use of fossil fuels. Because of poor sugarcane mechanization status in Pakistan, traditional practice to get rid of this extraneous material is to burn the trash in standing crop or by manual means which is hectic due to decreasing labour availability for agricultural practices. 20-30% trash is delivered to mill along with stalk due to poor cleaning efficiency resulting deduction in farmer payment and lowering mill sugar recovery efficiency. Sugarcane stripping machine was developed for small scale farmers and different mechanical and crop physical factors were investigated to improve trash recovery and to reduce labour dependence and in field burning practice on local farms during 2018-2019 at University of Agriculture Faisalabad. The investigating crop physical factors included crop varieties (V_1 =US-658, V_2 =HSF-240, V_3 =CPF-249), moisture content in trash (MC_1 =8.2, MC_2 =17.6) and mechanical factors included velocity ratio between intake rollers (VR_1 =1.3, VR_2 =1.7, VR_3 =1.9), cleaning element speeds (CE_1 =660 rpm, CE_2 =763 rpm, CE_3 =1033 rpm) and intake roller combinations types (C_1 , C_2 , C_3). Three replications for each factor were recorded and data was statistically analyzed under factorial design. Results revealed that by combining V_1 , MC_1 , VR_2 , CE_3 and C_3 factors, trash recovery efficiency of 97% can be achieved.

Keywords: Sugarcane, energy, trash, stripping, mechanization. optimization of stripper.

INTRODUCTION

Pakistan is fronting serious energy crisis since last decade. Energy shortage in form of electricity, natural gas and oil not only influenced the normal life but the industry is also in decline situation. Renewable energy resources are best suited solution to meet these energy crises including biomass, solar energy, wind energy and tidal energy. Total biomass production in country is estimated about 69 million tons. Biomass is used by direct combustion, gasification, pyrolysis, trans esterification, fermentation and an-aerobic digestion for energy generation [Mahar, 2012; Kamran, 2018]. Sugarcane provides biofuel and sugar beside fiber and fertilizer contributing key part in agricultural residues production (Chandel *et al.*, 2012; Bastin and Sharidar, 2014).

It has global reflexion for energy generation due to balance between greenhouse gases and energy production (Macedo *et al.*, 2008; Renouf *et al.*, 2008; Smeets *et al.*, 2009). During 2019-2020, the crop was sown on 1040 thousand hectares with an average of 64 ton/hectare (ESP, 2019-20). Crop residue includes trash (leaves+tops) and bagasse which comprises hemicellulose, cellulose, protein and lignin (Zhao *et al.*, 2009; Canilha *et al.*, 2011; Diedericks *et al.*, 2012; Zhang *et al.*, 2013). Trash amount vary from 6-30 ton/ha depending upon crop variety and climate conditions providing estimate of minimum 6.2 million tons trash per year in country (Trivelin *et al.*, 1995; Vitti *et al.*, 2011; Fortes *et al.*, 2012, Chandel *et al.*, 2012). Trash from one hectare generates energy equivalent to 10 ton of coal reflecting country energy potential equal to 10400 thousand ton of coal (Devi *et al.*,

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2020). Deepchand (1986) reported that 100 GJ energy can be recovered per hectare from sugarcane trash. Net calorific value (NCV) for trash can be calculated by following formula (Deepchand, 1986)

$$NCV (BTU lb^{-1}) = GCV \frac{f}{100} + 7120 \frac{S}{100} + 7380 \frac{i}{100} - 630 \frac{100-w}{100} - 1080 \frac{w}{100}$$

Where, f= fiber (%), S=sugar (%), i=impurity (%) and w=water (%)

Sugarcane harvesting is labor intensive and time-consuming process which takes nearly 45% of total cultivation cost (Bastin and Sharidar, 2014). The harvesting of sugarcane includes cutting of stalk and removal of trash. Trash removal takes 65% of total harvesting time (Ikram *et al.*, 2019). As local farmers are not capable to buy expensive large-scale harvester due to socio-economic issues, conventional practice to get rid of trash is burning in field or by manual operation (Dawson and Boopathy, 2007). 75% of total trash is burnt and 25% is left on the field as waste (Maues, 2007). Burning action not only deplete this renewable energy resource (trash) but also generates particles (<10µm) which cause bronchitis, asthma and other lung diseases (Dawson and Boopathy, 2006). Cansee (2010) found this burning depletes sugarcane sweetness, weight, sugar recovery and soil organic matter. Manual removal left 20-30% trash with cane stalk due to unskilled labor which cause operational problems at mill. Presence of trash causes up to 10% deduction in selling price for farmer by sugarcane mill (Ashfaq *et al.*, 2014).

Therefore, it is required to develop mechanical mean for small scale farmer for trash removal and finding best suited parameters for efficient trash recovery. The hypothesis for experiment was to develop local technology which should facilitate the farmers by mean of lowering labour dependence and recover maximum sugarcane trash.

MATERIALS AND METHOD

The experiment was carried out at farm fields of University of Agriculture Faisalabad, Pakistan during 2018-19. The fabricated trash removing machine was consisted of intake rollers, cleaning element, outlet rollers, power source and power transmission system (Table 1).

To adjust roller spacing, the maximum and minimum diameters of sugarcane stalk, 12 common sugarcane varieties were selected and diameter of 10 sugarcane stalk from top, middle and bottom for each variety was recorder. The mean values of stalk diameters are given in Table 2.

Experimental Procedure for Performance Evaluation of Sugarcane Stripping Machine: The trash amount depends upon climate conditions, crop variety, harvesting method and moisture contents (Romero, 2009). Thereby following factors were selected to find most suited interaction level for trash recovery

1. Crop variety
2. Moisture content in trash
3. Vlocity ratio between input rollers
4. Cleaning element speed
5. Intake Roller Combinations

Table 1. Specifications of Trash Removing Machine.

Particular	Specifications
Engine Power	13hp
Engine RPM	3200
Engine Shaft Pulley	2 inch diameter (B-type)
Main shaft RPM	700
Main shaft Pulley	9 inch diameter (B-type)
Main shaft Sprocket	17 teeth
Main shaft Pulley for cleaning element	3 inch diameter (B-type)
Diameter of intake/outlet rollers	120 mm
Diameter of cleaning element	120 mm
Intake/outlet rollers RPM	260
Intake/outlet roller Sprockets	46 teeth
Cleaning element RPM	650-1100
Pulley attached with cleaning element	1.75 inch diameter (B type)
Spring specifications	L _s = 44 mm L _t = 88 mm N _a = 11 d = 4 mm

Table 2. Mean Sugarcane Stalk Diameter (cm).

Sugarcane Varitiety	Diameter _(mean)	
	D _{min}	D _{max}
HSF-240	3.1	2.2
CPF-246	3.4	2.2
CPF-247	3.2	2.3
CPF-248	3.1	2.2
CPF-249	3.7	2.2
US-127	2.9	1.9
US-633	3.2	1.7
US-778	3.3	1.9
US272	3.6	2.6
US-658	4.1	2.7
US-54	3.4	2.2
AUS-190	3.8	2.4

Crop Variety: Locally grown varieties have intensive trash amount which make it difficult to remove this extraneous material more efficiently (Ashfaq *et al.*, 2014). The morphological study of sugarcane drscribed that leaves at top have greater anti-crushing ability while lower leaves have less anti-crushing strength (Xiangwei *et al.*, 2006). Three sugarcane varieties (V₁=US-658, V₂=HSF-240, V₃=CPF-249) were selected according to recommendations of Sugarcane Research Division of Ayub Agriculture Reseach Institute, Faisalabd, Pakistan. The stalk to trash ratio was also calculated as given in Table 3.

Table 3. Sugarcane Trash to Stalk Ratio for Selected Varieties.

Sugarcane Variety	10 Stalk Weight (kg)	Trash Weight (kg)	Trash to Stalk Ratio
US-658	14.74	5.32	0.36
HSF-240	13.97	3.62	0.26
CPF-249	10.05	3.74	0.37

Moisture in Leaves: Mou *et al.*, (2013) stated that with more trash moisture, trash removal becomes difficult. For efficient removal of stalk leaves it is compulsory that moisture level should be low. On the other end long standing of stalk in field may cause reduction in cane weight. To investigate this effect, sugarcane stalks were taken during month of December and March. The calculated moisture in March 2019 (MC₁) and December 2018 (MC₂) month was 8.2% and 17.6% respectively.

Velocity Ratio between Intake Rollers: The intake rollers provide pressing action to pass sugarcane forward which also make trash soft. Along with softening of trash by pressing action, the rubbing action was also applied by provision of velocity ratio among intake rollers using different combinations of gears. Three levels of velocity ratio (VR₁=1.3, VR₂=1.7, VR₃=1.9) were selected for machine efficiency calculation.

Cleaning Element Speed: Tyre ply was used as cleaning material on cleaning element due to flexible nature and easily available material. Jin *et al.*, (2016) found flexible materials are best suited for leaf stripping process because they cause less stalk damages. Two cleaning elements were provided in the machine aligned with intake rollers. Three cleaning element speeds (CE₁=660 rpm, CE₂=763 rpm, CE₃= 1033 rpm) were selected to investigate the cleaning efficiency. The cleaning material was adjusted at spiral angle of 30° and top feeding was adopted for efficient trash removal (Xiao *et al.*, 2009, Bastin and Sharidar, 2014).

Intake Rollers Combinations: Intake rollers were responsible to pass the sugarcane stalk and provide facility to hold the stalk when cleaning element is removing trash. Two intake rollers were fabricated with lower roller was fixed in design and upper roller was changed with three different options. The basic purpose of these combinations was to grip the stalk effectively and provide facility to cleaning element by softening the grip of trash by pressing action. The three roller designs included the following

1. Intake roller with straight bars (C₁)
2. Intake rollers with spring supported continuous bars (C₂)
3. Intake rollers with spring supported discontinuous bars (C₃)

The third combination was selected for individual pressing of each sugarcane stalk beneath each spring.

Machine Efficiency: Machine efficiency was calculated in terms of trash removal. To calculate the machine efficiency, initial weight of the cane was recorded and after

passing through the machine the cane weight was again recorded. To calculate the total trash present, the leaves left on the cane stalk were removed manually to find out the total amount of trash and hence to calculate the leaf stripping efficiency. The machine efficiency was calculated using the following formula given by Bastin and Sharidar (2014).

$$\eta = \frac{M_1 - M_2}{M_2 - M_3}$$

Where, M₁ was the mass of de-topped cane stalk, M₂ was the mass of de-trashed cane stalk and M₃ was mass of clean cane stalk.

Machine Capacity: The capacity of sugarcane stripping machine was projected by determining weight of sugarcane stalk de-trashed by machine and total time taken in operation. Ashfaq *et al.*, (2014) offered equation to make machine capacity calculations.

Table 4. Experimental Setup.

Particular	Levels	Specifications
Moisture Content	MC ₁	8.2%
	MC ₂	17.6%
Crop Variety	V ₁	US-658
	V ₂	HSF-240
	V ₃	CPF-249
Velocity Ratio	VR ₁	1.3
	VR ₂	1.7
	VR ₃	1.9
Cleaning Element Speed	CE ₁	660
	CE ₂	763
	CE ₃	1033
Intake Roller Combinations	C ₁	-
	C ₂	-
	C ₃	-

Statistical Analysis: The data was recorded for described levels of chosen factors and was analyzed using factorial design using Statistics-8.1 software. The table 5 is presenting the significance of individual factor.

RESULTS

Effect of Moisture Content, Sugarcane Crop Variety, Cleaning Element Speed and Intake Roller Combinations (MC×V×CE×C) on Leaf Stripping Efficiency: Interactional effect of MC, V, CE and C is presented in figure 2. MC₁ unveiled better dry leave stripping efficiency than MC₂ for nearly all levels V, C and CE. MC₂ unveiled better dry leave stripping efficiency for all levels of CE and C in contrast with V₁. Dry leave removal for V₁ was more in MC₁ than V₂ and V₃. CE₂ and CE₃ had 96% and 95% dry leave efficiency respectively for C₂. The contrast of MC₁, V₁, CE₂ and C₂ had maximum (96%) leave removing efficiency following by MC₁, V₁, CE₃ and C₂ combination. Lowest dry leave stripping efficiency (42%) was unveiled by MC₂, V₃, CE₂ and C₂

contrast. The results are also illustrating that C_2 has maximum efficiency only for V_1 with MC_1 . All other results are illustrating C_3 as most effective combination for dry leave stripping for all contrasts of MC, V and CE.

Effect of Moisture Content, Velocity Ratio, Cleaning Element Speed and Intake Roller Combinations ($MC \times VR \times CE \times C$) on Leaf Stripping Efficiency: The interactional effect of MC, VR, CE and C is shown in the figure 3. In this contrast MC_1 gave the highest dry leave stripping efficiency as compared to MC_2 with all levels of other parameters. Results are indicating that VR_2 has better dry leave stripping efficiency for MC_1 and MC_2 as compared with VR_1 and VR_3 . The cleaning element speed had direct relation with dry leave stripping efficiency that with increase in cleaning element speed the stripping efficiency had improved except for MC_2 where in relation to VR_3 , the CE_2 has less leaf stripping efficiency than CE_1 . C_3 had unveiled better leaf stripping efficiency than C_1 and C_2 for all levels of MC, CE and VR. In this contrast the maximum leaf stripping efficiency (94%) was observed for $MC_1 \times VR_2 \times CE_3 \times C_3$ and lowest leaf stripping efficiency (47%) was observed for $MC_2 \times VR_3 \times CE_2 \times C_2$.

Effect of Sugarcane Crop Variety, Velocity Ratio, Cleaning Element Speed and Intake Roller Combinations ($V \times VR \times CE \times C$) on Leaf Stripping Efficiency: The interactional effect between V, VR, CE and C is shown in the figure 4. The results are revealing that V_1 has highest sugarcane dry leaf stripping efficiency than V_2 and V_3 . On the same side VR_2 had better performance than VR_1 and VR_3 for all levels of CE and C. the highest impact of VR_2 was found for V_1 and lowest was found for V_2 and CE_1 with C_1 . The cleaning element speed had direct impact for leaf stripping efficiency as followed other contrasts. The CE had shown the direct relation with leaf stripping efficiency that with increase in speed the stripping efficiency was increased for all combinations of VR, CE and C. The factor C_3 had also better leaf stripping efficiency for all combinations of VR, CE and V. The figure results also indicated that highest and lowest cleaning efficiency was 97% and 49% for $V_1 \times VR_2 \times CE_2 \times C_3$ and $V_3 \times VR_3 \times CE_2 \times C_2$ interactional combinations respectively.

Effect of Moisture Content, Velocity Ratio, Sugarcane Crop Variety and Intake Roller Combinations ($MC \times VR \times V \times C$) on Leaf Stripping Efficiency: The results in the figure 5 are presenting the leaf stripping efficiency for different levels of MC, VR, V and C. The results unveiled that MC_1 had better leaf stripping efficiency than MC_2 . VR_2 was found more effective to strip dry leaves for both MC_1 and MC_2 but its effect was more significant with MC_1 . Crop Variety V_1 had better leaf stripping efficiency than V_2 and V_3 for all levels of MC, VR and C. V_2 had shown least efficiency and had lowest value with VR_1 and MC_2 . The C_3 had better cleaning efficiency than C_1 and C_2 for all levels of other parameters. Only C_2 had better stripping efficiency for V_1 , VR_2 and MC_1 .

C_3 had better leaf stripping efficiency than C_1 and C_2 . The maximum efficiency for this was observed for MC_2 , VR_2 and V_1 . On average better results were observed for MC_1 . C_2 on the other had showed better leaf stripping efficiency (97%) only for MC_1 , V_1 and VR_2 contrast. Lowest cleaning efficiency was 42% for $MC_2 \times V_3 \times VR_1 \times C_1$ interactional combinations.

Effect of Moisture Content, Velocity Ratio, Sugarcane Crop Variety and Cleaning Element Speed ($MC \times VR \times V \times CE$) on Leaf Stripping Efficiency: The effect of interaction between MC, VR, V and CE is shown in the figure 6. The results are indicating that MC_1 had more dry leaf stripping efficiency than MC_2 . For MC_2 highest leaf stripping efficiency was for V_1 only with all levels of VR and C. VR_2 had unveiled better dry leaves stripping efficiency for MC_1 and MC_2 in contrast with all levels of V. V_1 showed the maximum leaf stripping efficiency for all levels of MC, VR and C. The peak dry leaf stripping efficiency (97%) was noted for $MC_1 \times V_1 \times VR_2 \times CE_2$ and lowest stripping efficiency (45%) was recorded for $MC_2 \times V_3 \times VR_1 \times CE_1$ interactional combination.

Table 5. Effect of Individual Factor on Trash Removal Efficiency (E) %

Factor/Levels	(%) E_{mean}	LSD
CE	CE ($p \leq 0.05$)	
3	77.063 A	2.19
2	73.467 B	
1	73.386 B	
MC	MC ($p \leq 0.05$)	
1	82.840 A	1.79
2	66.438 B	
C	C ($p \leq 0.05$)	
3	82.438 A	2.20
2	71.803 B	
1	69.675 B	
V	V ($p \leq 0.05$)	
1	87.721 A	2.19
2	68.098 B	
3	68.098 B	
VR	VR ($p \leq 0.05$)	
2	80.272 A	2.20
3	74.588 B	
1	69.057 B	

Means within a column followed by same letters are not significant at $p \leq 0.05$.

Cost Analysis of Mechanical and Manual Detrashing particulars: Ashfaq *et al.*, (2014) had developed a tractor operated sugarcane detrasher with 79% leaf stripping efficiency. The newly developed sugarcane stripper had 97% leaf stripping efficiency and has an 8hp engine instead 50hp tractor which saves the farmer cost. The cost analysis of tractor operator leaf stripper, engine operated leaf stripper and

Table 6. Cost analysis of tractor operated and engine operated trash removal machine

Specifics	Tractor Operated Sugarcane Leaf Stripper (Ashfaq <i>et al.</i> , 2014)		Engine Operated Sugarcane Leaf Stripper (Ikram <i>et al.</i> , 2019)
	Tractor (MF-240)	Sugarcane Stripper	
Purchase Price, P	897750	35000	60,000
Salvage Value (S), 10% of P	89775	3500	6000
Life of Machine (Year) L	10	10	10
Working Hours (Annual)	1200	500	600
Fixed Cost			
Depreciation (D) Rs. /hr ; $D = (P-S)/L$	67.33	6.3	9
Interest (I)/hr ; $I = [(P+S)/2] * i$	49.37	4.62	6.6
Shelter, insurance and Taxes (2% P)/hr	14.96	-	2
Variable Cost			
Maintenance and Repair (15% P)	112.21	10.5	1.25
Fuel Cost/hr (6L/hr)	600	-	370
Lubrication Cost (15% of Fuel Cost)	90	-	55.5
Driver Charges/hr	87.5	-	-
Helper Charger/hr	-	62.5 x 2 = 125	62.5 x 3 = 187.5
Total Cost (Rs./hr)	1021.37	146.42	
	1021.37 + 146.42 = 1167.79 Rs/hr		631.85 Rs/hr
Cost Comparison			
Working hrs/day	16	-	16
Machine Capacity (ton/day)	57	-	57
Operation Cost/ha	16342	-	10109
Conventional Leaf Stripping			
Capacity of Stripping Dry Leaves/day/labor	1 ton		
Leaf Stripping Cost Rs. /ton	350		
Production (ton/ha)	55 ton		
Time Required (Days/ha)	55		
Total Cost Pay to Labor	19250		
Cost Benefit over Manual Stripping			
Rs. /ha	19250–16342 = 2908		19250–10109 = 9141

*1 US Dollar = 166 Rupees

cost paid to manual labor is done in the Table 6.

The cost analysis shows that the mechanical detashing is cost effective as tractor operated machine saved 2908 rupees and engine operated leaf stripper saved 9141 rupees/ha as compared with manual leaf stripping.

DISCUSSION

Sugarcane is important cash crop in Pakistan. The sugarcane juice is used for synthesis of sugar and drug (Singh *et al.*, 2015) while its baggass and dry leaves are used by sugar mills for power generation (To *et al.*, 2018). Before harvesting the dry leaves of sugarcane stalks are removed mechanically, manually or by burning method (Dawson and Boopathy, 2007). Mechanical harvesting includes use of large-scale harvesters which are not common among local farmers due to social and economic situations (Ikram *et al.*, 2019). Therefore farmers are forced to manual harvesting or using burning technique. They are facing up to 10% deduction in selling

price of sugarcane crop by sugar mills due to presence of impurities after manual harvesting because sugarcane trash then contaminates the sugar juice and lower the sugar quality in mill. (Ashfaq *et al.*, 2014).

Currently, Pakistan is facing serious energy deficit. 57.9 million ton of oil equivalent was energy requirement of country in 2006 and is increasing at rate of 11-13% per year. In 2020 local energy requirement is 179 million ton of oil equivalent which will be three times more in 2050 (Din *et al.*, 2019). To mitigate these needs, attentions to renewable energy resources should be paid. Pakistan is enriched with wind, solar, biomass and biogas energy resources (Kamran, 2018). Sugarcane trash is important source of biomass material. Conventionally these leaves are burnt in the field which waste this energy source. Sugarcane stalk consists of 70% mill able stalk, 8% tops, 15% green and 7% dry leaves (Rozeff, 1994). The trash after drying can also be used for power generation (Devi *et al.*, 2020).

To avoid deductions in farmer selling price and provision of dry leaves for power generation, a small-scale sugarcane leaf stripping machine was fabricated and interactional effects between different mechanical and sugarcane physical parameters were investigated in this study for maximum recovery of sugarcane trash. The selected parameters included two levels of moisture content, three sugarcane crop varieties, three levels of velocity ratio between intake rollers, three type of intake roller combinations and three levels of cleaning roller speed namely MC₁, MC₂, V₁, V₂, V₃, VR₁, VR₂, VR₃, C₁, C₂ and C₃ respectively. The results indicated that MC₁, V₁, VR₂, C₃ and CE₃ gave the maximum leaf stripping efficiency up to (97%).

The results indicated that lower moisture contents provide ease to leaf stripping process. This was due to fact that as the leaves got dried the strong grip of leaves on sugarcane stalk become loose and this fact provides ease for cleaning element material to remove the dry leaves more easily. Sugarcane crop varieties are also important in this regard. Conventional crop varieties in Pakistan are enrich in leaves and it became difficult for machine and labor to remove these leaves because of their abundant amount. The crop variety V₁ had leaves which were not tightly gripped with sugarcane stalk as were gripped for V₂ and V₃. This fact made ease for sugarcane stripping machine to remove leaves more effectively. The same results were reported by Mou *et al.*, (2013) that moisture content level has direct relation with trash stripping. The cleaning element roller speed had shown direct relation to leaf stripping efficiency. As the roller speed increased, number of impacts with cane stalk increased which ultimately improved the cleaning efficiency. But this point is to be considered that cleaning element increased speed beyond limit may damage the germination eyes on stalk or stalk itself. The roller speed in this experiment was adjusted that there was maximum 5 strikes on the stalk between two nodes. Same results were reported by Bastin and Sharidar (2014).

The concept of velocity ratio was also used in this experiment. The velocity ratio between two rotating rollers produced a rubbing effect on sugarcane stalk. This rubbing effect was cause of losing the grip of leaves on sugarcane stalk and hence removed the dry leaves more efficiently. Observations during experiments indicated that the VR₃ was not good for sugarcane stalks with more diameters. As the speed and torque are in inverse relation so as the speed of roller increased the necessary torque for push of sugarcane stalk was not provided by the roller and the roller stop there. The experimental observations concluded that velocity ratio should not be too high. The intake roller combinations played a vital role in leaf stripping process. The C₃ roller had small segments with spring which helped the rolled to press the sugarcane stalk individually and hence improved the sugarcane leaf stripping efficiency. The experimental observations concluded that roller having straight bars were not fully effective to press and pass all sugarcane feed stalks

because of difference in stalk diameters. A large diameter stalk caused the no-press action for other stalks.

The cost analysis for tractor operated, manual leaf stripping operation and newly developed engine operated machine revealed that mechanical harvesting is less time and labor consuming with more efficiency and less cost over manual leaf stripping process.

Conclusion: Sugarcane trash is highly valuable energy resource producing in abundant in Pakistan. Lack of knowledge about its benefits, non-availability of mechanical means for harvesting and socio-economic conditions of farmers force them to use conventional manual or field burning method to get rid of this extraneous material. Use of mechanical means in form of small machinery can facilitate the farmers in terms of labour dependence and cost. Trash recovery depends upon physical and mechanical parameters of crop and trash removing machine including leaf moisture, crop variety, intake roller type, cleaning element speed and velocity ratio between rollers. Maximum trash recovery will facilitate in terms of energy production and less deduction in selling price for farmers. Government needs to pay serious attention for 1. Aware the farmers about benefits of trash 2. promote mechanical harvesting of sugarcane by means of providing large scale harvesters on rent or promoting small scale machinery 3. instalment of power plants operating on this trash to limit the dependence on fossil fuels and avoid depletion of this renewable energy resource.

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