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Factors affecting the performance of cutting mechanism for agricultural crops-A review

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ABSTRACT

The process of cutting agricultural materials stands as one of the pivotal operations, primarily employed in harvesting and threshing to achieve the necessary separation and subsequent fragmentation of plant components. Essential fodder preparation tasks such as straw chopping, baling, and mulching also heavily rely on cutting processes, demanding a substantial amount of energy. This article provides a comprehensive overview of research factors, operational parameters and crop properties that influence the performance of cutting mechanisms for crops, offering valuable insights to design engineers for crafting suitable incentives to adapt to crop variations.The velocity of cutting and the configuration of blades emerge as critical factors in crop harvesting. The proportion of energy consumption during crop harvesting and threshing ranges from 7.9 to 35.9 percent of the total operational energy expended. Cutting velocity and blade angles directly impact the power demands and efficiency of harvesting machinery. Optimizing these parameters can lead to energy savings during cutting while simultaneously enhancing cutting quality.Furthermore, energy consumption during cutting is closely linked to bending forces. Sharpness and blade material composition significantly influence wear resistance and durability, making it imperative to select appropriate materials that can sustain prolonged use in varying crop conditions. High power requirements are observed with blunt blades, resulting in inefficient cutting. Hence, this paper is expected to significantly aid design engineers, researchers, and other stakeholders in developing efficient cutting mechanisms for new machinery and tailoring cutting mechanisms to suit new species and varieties. It is anticipated that the findings of this study will contribute to the modification of existing harvesters as well.

Keywords: *Agricultural materials, Crop stalk, Cutting mechanism, Harvesting,Physio-chemical characteristics,Cutting Energy, Design.*

Introduction

Cutting of agricultural materials is one of the most significant operations and is generally used in harvesting and threshing in which separation and subsequent comminution of plant components are required. The main operations in fodder preparation and other operations also require cutting like straw chopping, baling, mulching, etc. These operations require a significant amount of energy.Share of energy for harvesting and threshing operations of some important crops is presented in Table 1.

Table1: Share of energy for harvesting and threshing operations of some important crops

Sl.No.	Crops	Total operational energy (MJ/ha)	Energy in harvesting and threshing (MJ/ha)	Share of energy in harvesting (%)
1	Paddy	19800.0	1560.0	7.9
2	Wheat	9000.0	3200.00	35.5
3	Cotton	6400.0	560.0	8.7
4	Maize	4700.0	580.0	12.3
5	Sugarcane	21000.0	3100.0	14.8
6	Potato	12400.0	980.0	7.9

Source: Sharma and Jain, 2019[1]

The proportion of energy consumed during the harvesting and threshing of crops varies widely, ranging from 7.9 to 35.9 percent of the total operational energy expenditure (see Table 1). Different crop stalks exhibit diverse characteristics such as biomass properties and significant throughput [2]. Research institutions are actively exploring harvesting systems and equipment for cutting, conditioning, windrowing, and baling to enhance equipment efficiency[3]. Physico-mechanical characteristics of crops play a crucial role in the design and operation of various harvesting, threshing, fodder preparation, and other machinery. Among these characteristics, bending, compression, density, shearing, and friction are pivotal factors influencing the cutting of crops. These attributes are heavily reliant on factors such as species, variety, stalk diameter, maturity, moisture content, and cellular structure [4][5]. Conducting compression, blending, and cutting tests are essential to optimize cutting efficiency[6]. Additionally, mechanical experiments can aid in refining machine manufacturing processes and reducing energy consumption. For instance, comprehensive mechanics investigations into leaf sheaths for sugarcane harvesting can improve machinery design for stripping leaves from stalks [7].

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This research studied factors such as blade speed, bevel angle, sharpness, thickness, oblique angle, serrations, clearance between cutting edges, material moisture content, depth and density of material, as well as properties like Young's modulus, dynamic coefficient of friction, and maximum shear strength, which are associated with cutting mechanisms and their interaction with external and internal factors. Young's modulus, for example, serves as a mechanical indicator of stalk rigidity [8], while lodging resistance is closely linked to stem diameter and plant height, as reported by[9]. This overview of current studies on physio-mechanical characteristics and factors influencing cutting mechanisms will aid design engineers in developing and modifying efficient cutting mechanisms such as harvesters, straw choppers, mulchers, balers, etc., tailored to new species and varieties. Implementing necessary modifications in these machines will alleviate the manual labor involved in harvesting, chopping, baling, and mulching operations, thus significantly contributing to the advancement of efficient cutting mechanisms for new machines and specific crop varieties.Required modifications in these machines will help to get rid of the drudgery involved in manual harvesting, chopping, baling, and mulching operations. Thus this will help to a great extent in the efficient cutting mechanism of new machines and the development of particular cutting mechanisms as per new species, variety.

2.1 Cutting and Cutting Mechanism

2.1.1 Cutting

The cutting process of crop materials and reported that failure in shear impact or both is possible when a system of forces acts on the material[10]. Before shear failure, the material is invariably first compressed then bend which increases the work required in a cutting operation

A meaningful mathematical model for the cutting process of plant material with a shear-finger cutting unit was studied by[11]. The model divided the cutting process of crops into three stages namely stage I–the approach of the stalk to the counter-cutting edge; stage II–the deformation of the stalk cross section; and stage III–the separation of the stalk(Fig. 2.1).The mathematical model was verified to be adequate by the experimental results on a test stand.

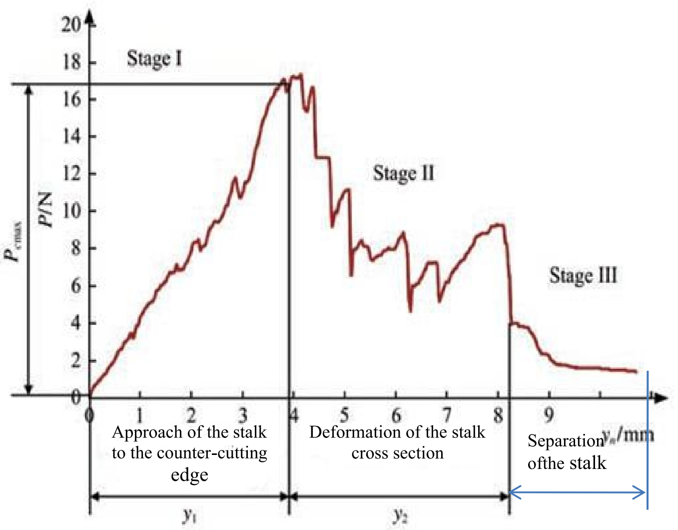

Fig. 2.1: showing cutting mathematical model of cutting process

2.1.2 Cutting Mechanism

The operational principles underlying cutting elements utilized in various harvesting tools, equipment, or machines can be broadly classified into two categories: cutter-bar cutting systems (CCS) employing a scissor shearing method and rotating cutting systems (RCS) utilizing an impact and shear method. CCS is typically employed for cutting thin stalks of annual plants, employing a back-and-forth movement of the blade, also known as counter-edge cutting. RCS, on the other hand, is more commonly used for thicker stalks with greater cutting resistance, employing impact cutting. RCS utilizes inertia and impact forces for stalk cutting, while CCS relies on the reciprocating motion of the blade. RCS mechanisms are further subdivided into three categories: Saws Cutting Mechanism (SCM), Coulter Cutting Mechanism (CCM), and Disk Cutting Mechanism (DCM). SCM faces challenges in operating under conditions of harvester vibration during movement, while CCM consists of two small disks with sharp edges functioning as scissors, suitable for stalks up to 2 cm in diameter. DCM is the only mechanism capable of cutting all types of thick stalks exceeding 2 cm in diameter, employing various blade shapes, numbers, and angles tailored to different plants with varying stalk thickness and cutting resistance.

Sickle cutter bars operate with a reciprocating motion of knife sections and a counter shear, utilizing the crop material itself to provide support for the rotating cutting system to cut the stem. Power-operated harvesters commonly employ Rotating Cutting Systems (RCS), exemplified by manually operated swinging tools such as cradles, scythes, and long-bladed hoes. Study noted that serrated blades demand less energy and force compared to flat blades, suggesting their potential for achieving the desired cut quality[12].

[13] studied a cutting mechanism for crop harvesters and evaluated the maximum cutting energy and cutting energy needed using either reciprocating or rotary cutter bar mechanisms. Their findings indicate that the type of mechanism significantly influences maximum cutting energy and the energy required for crop cutting. Reciprocating blades demonstrated superior cutting force and energy consumption reduction compared to ordinary rotary blades.

2.2. Physico-mechanical characteristics of Plant material affecting Cutting Process

The physical characteristics of crops and plants play a crucial role in the design of machinery for their harvesting. Study by [14] highlighted the significance of hardness, tension, shearing, compression, and detaching forces in the design of harvesters.They [15] examined the section modulus in bending for cotton stalks, noting its variation with the third power of the diameter, ranging between 7 and 16 mm, with a modulus of elasticity between 600 and 3500 MPa. [16] studied the modulus of rigidity of green lucerne, reporting mean values of 0.225 and 1.45 GPa for green and oven-dried specimens, respectively.

[17] reported that the required force for cutting stretched stalks was 50% less than for unstretched ones.They [18] measured bending stress for sorghum, reporting 40-53 MPa at the seed stage and 45-65 MPa at the forage stage. [19] concluded that cutting energy and maximum cutting force was influenced by cross-sectional area and moisture content, findings corroborated by[20].

Mechanical properties of alfalfa stems were studied by [12], who found that maximum shearing stresses varied from 0.4 to 18.0 MPa depending on moisture content. Study by [21] conducted shearing experiments on field grasses, reporting shearing stress and energy of 16 MPa and 12.0 $mJmm^{-2}$, respectively.[22] found the maximum force and total cutting energy for hemp to be 243N and 2.1J respectively.

[23] investigated the bending and shearing characteristics of sunflower stalk residues, reporting specific shearing energy ranging from 1.86 to 11.0 $mJmm^{-2}$.) [19]studied mechanical properties of maize stalks, concluding that certain knife angles and velocities optimized cutting efficiency. [24] observed stress-strain relationships in whole-plant corn, noting increased stress with faster deformation rates.

[25] analyzed safflower stalk properties, reporting decreasing bending stress with increased moisture content, and higher stress values at lower stalk regions. [26] studied wheat straw properties across maturity stages, noting shear strength, tensile strength, Young's modulus, and rigidity modulus variations. [2] investigated wheat straw properties with moisture content and decomposition effects, noting changes in shearing and bending strength.[28] analyzed reed stalk properties, finding variations in bending, stretching, compressing, and shearing stresses. [29] determined coefficients of friction for wheat straw and green barley. [30] measured the maximum shear strength of alfalfa stems, noting location-dependent variations[62]studied mechanical properties of sugarcane stalks, reporting Young's modulus and resistance values.

[31] analyzed wheat stalk shearing stress, noting moisture content and cutting height effects. [32] studied wheat straw properties at different internode positions and moisture contents, observing changes in shear strength and specific shearing energy. [33] examined the physical properties of ground wheat straws from different regions.[34] investigated wheat and rice straw mechanical properties under various loading rates.[35] studied maize stalk properties across different cultivars and stalk sections. [36] assessed wheat straw shear strength at varying moisture contents and cutting speeds.

These studies collectively offer insights into the physico-mechanical characteristics of various crop stalks under different conditions, aiding in the development of appropriate harvesting machinery. The physico-mechanical characteristics of some crop stalks are given in Table 2.

Table 2: Physico-mechanical characteristics of some crop stalks

Crops	Tensile strength, MPa	Young's modulus, GPa	Compressive strength, MPa	Shear strength MPa	Bending strength, MPa	References
Wheat	21.0 to 31.2	4.76- 6.58	-	4.91 to 7.26	13.70-19.31	[26][60]
Wheat		3.3-3.75				[31]
Sugar cane		0.086				[62]
Barley	-	0.33 -0.62	-	3.90-4.49	8.14-8.55	[32][60]
Safflower	-	0.86 - 3.33	-	2.98 - 6.04	25.9 - 47.71	[25][61]
Reed	118	0.321	26	22	152	[28]
Rape	-	0.172	11.9	-	-	[63]
Miscanthus	288.1	4.6 - 11.3	-	65	-	[12]
Bluestem	25	-	-	7.33	-	
Cotton		0.6-3.5				[15]
Field grass				16.0		[21]
Alfalfa	16.8-36.0	0.79-3.99	-	0.4-18.0	-	[20][30][61]
Sorghum					45-65	[18]
Green lucerne		0.225-1.45				[16]
Maize stalk		10.04- 673.84		3.636- 2 .107		[19][35]

3. Factors Affecting the Performance of Cutting Mechanism

The factors affecting the performance of cutting mechanism are described in following heads:

3.1 Blade speed

[37] noted that, based on an extensive review of papers, there was either no change or a slight increase (10 to 15%) in cutting energy requirements when blade speed was doubled for devices cutting between two elements. Generally, the cutting efficiency of these devices was found to be independent of blade speed within a quasi-static range of up to 60 m/s, although the specific device was not specified.[38] examined the impact of cutting speed on cutting torque and power for various diameters of kenaf stems at different moisture levels to enhance the efficiency of kenaf harvesters. They observed that increasing rotational speed from 400 rpm to 700 rpm reduced cutting torque from 1.91 Nm to 1.49 Nm.

[39]investigated the influence of blade oblique angle and cutting speed on cutting energy for impact-type cutting mechanisms designed for energy-cane stems. They reported that specific cutting energy increased with cutting speed.[40] explored the effects of peripheral cutting velocity of rotary cutting discs, stem diameter, and moisture content on torque requirements for cutting black gram. Their findings indicated that up to a critical peripheral cutting velocity of 30 m/s, cutting torque increased with stem diameter, but decreased beyond this critical velocity. Additionally, they found that torque requirements decreased with increasing moisture content.[41] investigated the torque requirement and ascertained optimum peripheral cutting velocity of rotary cutting disc based on varying stem diameter and moisture content of green gram.

3.2 Blade Angle

[5] conducted a study on the impact of bevel angle on cutting force, cutting energy, and blade longevity across various cutting devices and plant materials. He observed that a smaller bevel angle necessitated less cutting force. Persson recommended a bevel angle as small as 20° for optimal cutting energy efficiency; however, he noted that such a small angle compromised blade durability. In some instances, blades with bevel angles of 45° were employed for cutting forage materials, sacrificing cutting efficiency but significantly enhancing blade lifespan.[42] analyzed the influence of bevel angle on cutting force, cutting energy, and blade lifespan across a broad spectrum of plant materials. He concluded that for cutting a wide range of plant materials, a bevel angle of 20 to 30° was optimal.

Decreasing the bevel angle below 20° resulted in a slight reduction in cutting energy but a significant increase in blade wear. Conversely, higher cutting forces and increased energy consumption were observed with bevel angles exceeding 30°, with angles of 70 to 80° requiring nearly double the energy compared to a 25° bevel angle. [42] further noted that the impact of the bevel angle was more pronounced as the thickness or depth of the plant material being cut increased.

3.3 Blade Sharpness

[43] compared the effect of blade sharpness on the cutting process of plant materials. He found that a blade with a 0.25-mm edge radius required twice the force and energy compared to a blade with an edge radius of 0.05 to 0.10 mm. [44][45][46] conducted a study on the power requirements of mowers and reported that the specific cutting energy per unit field area was 1.5 kJ/m^2 for a sharp blade and 2.1 kJ/m^2 for a worn blade. This observation aligned with [43] findings that dull blades consumed more energy to cut plant material compared to sharp blades.

[47] investigated the energy requirements for cutting plant materials and concluded that the energy required for a dull blade was double that of a sharp blade when the clearance between the cutting edges was small (0.05 mm) and tripled for a larger clearance (0.41 mm).

3.4 Blade Thickness

[42] investigated the relationship between energy requirements, layer thickness, and blade thickness. He found that for a 100-mm thick layer of corn stalks, the cutting energy requirement was 46% higher when using an 8-mm thick blade compared to a 2-mm thick blade. [42]concluded that blade thickness had little effect on cutting thin layers but increased the amount of energy used to cut thick layers due to the greater displacement of material.

3.5 Oblique Angle

[48] evaluated the effect of oblique angle on the cutting process of plant materials and suggested that oblique angles of 27 to 34° were necessary to retain straw between smooth shearing surfaces. He also reported that angles of 32 to 40° were required to retain grass between the same smooth shearing surfaces. [39] investigated the effect of blade oblique angle on cutting energy for energy cane stems and found that specific energy varied with different oblique angles, with the lowest observed at a 600 oblique cut. [5] studied the impact of oblique angle on cutting force and blade type, recommending an oblique angle of approximately 15 to 60 degrees to reduce peak cutting forces. Additionally, serrated blades required an oblique angle approximately twice that of smooth blades to prevent material expulsion. [49] analyzed the effect of cutting speed and blade oblique angle on miscanthus harvesting power consumption and found that differences between blade mountings had a negligible effect.[3] conducted laboratory and field studies on blade oblique angles and reported that angles up to 60° resulted in lower cutting energy compared to conventional straight blades. They also observed variations in energy consumption based on different oblique angles.

3.6 Blade Serrations

Serrated blades were found to require less than half the energy of smooth blades for slicing hay, although slicing force was approximately 40% greater for smooth blades.[42] noted that while serrated blades resulted in higher cutting forces and energy consumption overall, they were more effective for slicing action due to the increased clearance between shearing surfaces and longer cut length through the material.

3.7Moisture content and Diameter

It has been reported that a major decrease in plant moisture content causes cutting forces to increase slightly. For example, several researchers observed a 20 to 50% increase in cutting forces when the plant moisture content was decreased from 80 to 10% wet basis (w.b.) [42].

[50] studied the effect of the cross-sectional area, moisture content of the crops and cutter bar speed over cutting energy requirement. It was reported that the peak cutting energy requirement was directly proportional to stalk diameter and inversely proportional to moisture content of the stalk and cutter bar speed.

[51] investigated the cutting energy requirement of canola stems at different levels of cutting height and moisture content. The maximum and minimum cutting energy were 1.1 kJ and1 .76 kJ at the moisture content of 25.5 percent (w.b.) and 100 mm cutting height and moisture content of 11.6 percent (w.b.) and 300 mm cutting height, respectively at a cutting speed 2.64 m/s.

[38] experimented to evaluate the effect of moisture content over cutting torque for knee stem. They reportedthat the cutting torque was higher at lower moisture levels of less than 35%. Moreover, the moisture content was increased to values greater than 35%, the torque decreased considerably. For black gram at 30.6 % stem moisture content the cutting force increased from 296.0 N to 645.0 N as stem diameter varies from 4.0 mm to 6.0 mm at blade speed 400 mm/min. [52].

3.8 Depth and density of material

[43] studied the relationship between the depth of corn stalks and the energy requirement. He reported that as the depth of corn stalks increased from 25 to 120 mm, the portion of the total energy used to compress the corn increased from 35 to 69%.

[53] reported that the total energy to process corn and alfalfa by a forage harvester cutter head increased with depth of material increased. The rise in total energy was attributed to acceleration of the particles, an increase in the energy to compress the material, and air and mechanical friction.

From the current references, the summarized Impact cutting velocity required for different crops stalk and Impact cutting velocity, force and cutting energy required for different crop stalk as presented in Table 3 and4, respectively. It is observed that the parameters for the same crop stalk may be different in consequence of different testing conditions, varieties, and individual difference.

Table 3: Impact cutting velocity required for different crops stalk

Sl. No.	References	Type of rig	Measuring device	Max.cutting velocity (m/s)	Plant tested	Stem form
	Novikov, 1957[69]	Rotating blade	Strain gauges on blade	18.90	Hemp	Single
	Okamura, 1958[70]	Rotating stems,	Stem support	17.80	Rice, orchard grass	Groups
	Fe11er, 1959[71]	Stationary blade	Strain gauges on blade	9.75	Alfalfa, Sudan grass	Groups
	Prince,1969[16]	Pendulum	Pendulum displacement	60.00	Alfalfa	Single
	Prasad and Gupta. 1975[19]	Pendulum	Pendulum displacement	3.95	Maize	Single
	McRandal, D., & McNulty, P. (1978).[21]	Rotating blade	Strain gauges on blade	60.00	Grass, oat straw stem	Groups
	Sushiledra, 2016[72]	Pendulum	Pendulum displacement	3.10	Chickpea	Groups
	Maharana*et al,* 2018 [50]	UTM	Data acquisition system	0.0067	Black gram Green gram	Single
	Sushiledra*et al*,, 2020[73]	Pendulum	Pendulum displacement	3.10	Black gram	Groups

Table 4: Impact cutting velocity, force and cutting energy required for different crop stalk

Sl. No.	References	Types of blades	Diameter of stem (mm)	Cutting velocity (m/s)	Cutting force(N)	Sp. cutting Energy(kJ/m²)	Plant tested	Stem form
	Sushiledra, 2016 [72]	Smooth	24	1.50	702.80	37.28	Chickpea	Groups
	Sushiledra, 2016 [72]	Smooth	12	3.10	173.33	18.40	Chickpea	Groups
	Sushiledra, 2016[72]	Serrated	24	1.50	619.17	32.80	Chickpea	Groups
	Sushiledra, 2016 [72]	Serrated	12	3.10	140.00	14.8	Chickpea	Groups
	Sushiledra*et al*, 2020 [73]	Smooth	24	1.50	752.50	39.95	Black gram	Groups
	Sushiledra*et al*, 2020 [73]	Smooth	12	3.10	248.33	26.40	Black gram	Groups
	Sushiledra*et al,* 2020[73]	Serrated	24	1.50	626.67	33. 29	Black gram	Groups
	Sushiledra*et al*, 2020 [73]	Serrated	12	3.10	210.00	22.30	Black gram	Groups
	Bastian & shridhar,2014.[59]	-	35-40	-	750 -1530	*1764.56-957.48kPa	Sugar cane stalk	Single

** denotes specific cutting resistance*

4. Power/energy requirement

[37] made a studied on different parameters for the shear energy requirement. He reported that energy required shearing forage materials influenced by size, maturity, moisture content of material ,blade sharpness, clearance between edges and bevel angle. Moreover, he concluded that the energy required to cut the Timothy stem varied from 0.3 - 1.8 kW h/ ton of dry matter having chopped length 12.7 mm.

[54] studied the relationship between the moisture content and the specific energy requirements for a forage harvester. He informed me that there was no effect on specific cutting energy of the moisture content, when the specific energy was computed on a dry material basis.

[55] investigated the impact cutting performance of forage crops. It was observed that the power consumption was mainly influenced by crop density.More than 50 percent of total energy was consumed in crop acceleration and conveyance normally at the mower rotor shaft whereas energy consumed in shearing stems was normally less than 3 percent..

[44][45][46] analyzed the power requirements of mowers. He informed that the specific cutting energy per unit field area for a sharp and worn blade was 1.5 kJ/m^2 and 2.1 kJ/m^2, respectively.

[5] made a study for the cutting process of plant materials. An increase in blade velocity often increased the power losses, so even if the cutting power stayed relatively constant, the total power requirement of the cutter was likely to increase with increased cutting speed. The power losses influenced by several factors including: accelerating the material to exit velocity, overcoming friction between the material and the housing while still being pushed by the cutting device, sustaining air movement in the cutting device and overcoming mechanical friction in the driving mechanism. [56] designed, built and tested a rotary counter shear mower. It consisted of two concentric counter-rotating discs. He reported that the increase of forward speed will improve the cutting performance. Cutting speed with this type of rotors was less than other type of rotary disc cutters. [57] reported that a total power requirement per meter of cutter bar width of sickle-bar mower was 0.890 kW to cut mixed hay at a forward speed of 2.1 m/s. Out of 0.89 kW/m, 66% (0.59 kW/m) was required to run the mower in idle condition.

[58] evaluated that the energy requirement for cutting alfalfa with a sickle-bar mower varied from 0.078 and 0.139 kJ/m^2 in field test.[59] reported the total power requirement to propel the tractor and run the sickle-bar mower was 4.25 kW per meter of cutter bar for cutting alfalfa at a forward speed of 2.2 m/s. Out of which 1.6 kW/m was delivered to the power-take-off while crop was being cut and 0.3 kW/m required to run the mower in

the idle condition which indicates that only 1.3 kW/m was used for the cutting process.
From the current references, the impact cutting velocity, force and cutting energy required for different crop stalk as presented in Table 5.

Table 5 :Power requirement for cutting different crops given below

Sl. No.	Machine	Cutter bar Types	Forward Speed ms^{-1}	Crops	Power/Energy Requirement	References
1	TD mower	CCS	2.2	alpha	4.25 kW/m	[59]
2	Mower	CCS	-	alfalfa	0.078-0.139 kJ/m^2	[58]
3	Mower	CCS	2.1	mixed hay	0.890 kW	[57]
4	Mower	CCS	-		1.2	[65]
5	Mower	RCS	-		5.0	[65]
6	Concentric disc Mower	RCS		Tangled crops and crops mixed with residue.	1.6 kW/m	[56]
7	Reaper	RCS		Rice	1.132 kW/m	[66]
8	Electric Reaper	CCS	o.228	Rice	1.45 kW/m	[67]
9	Battery operated Reaper	CCS	0.58	Rice	1.83 kW/m	[68]

Conclusions

The cutting speed and blade configurations play a crucial role in crop harvesting. The share of energy consumption in harvesting and threshing of crops varies from 7.9 to 35.9 percent of the total operational energy of the crops. The cutting speed and blade oblique angle are directly related to the power requirements and efficiency ofharvesting machinery. Optimization of cutting speed and blade oblique angle can result in significant savings in cutting energy, whilst simultaneously improving the quality of cut. A serrated blade can be approximately two times the oblique angle of a smooth blade was required to ensure no material will be expelled. The energy consumption was correlated to the bending force.

Future Scope of Study

This paper is expected to significantly aid design engineers, researchers, and other stakeholders in developing efficient cutting mechanisms for new machinery and tailoring cutting mechanisms to suit new species and varieties.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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