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Studies on performance parameters and residue management of maize crop by maize-cob harvester

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Abstract

In India, maize is a widely produced cereal and one of the most important crops after wheat and rice. Just 2.4% of global production comes from maize. India produced 43-44 MT of maize on 12.02 million hectares. In 2025-2026, the average output per acre was between 3590 and 3600 kg. A maize cob harvester may sprinkle mulch on the ground, break the stem into tiny pieces, and harvest the entire cob one row at a time. The effect of three independent parameters forward speed of operation (1.7 km/h, 1.9 km/h, 2.1 km/h), snipper speed (55 m/min, 62 m/min, 68 m/min), variety of maize crop (Dhania-9965, Sartaj-765, D-9081) on various dependent parameters, such as stripping loss, ratio of stem length before and after harvesting, number of cobs per hour, weight of cob cutting length, and machine parameters, such as actual field capacity, field efficiency, and fuel consumption. The machine performed best at forward speeds of 1.9 km/h and snipper speeds of 62 m/min. The machine's crop parameters showed that the ratio of stem length before and after harvesting was 825 mm and 113.33 mm, respectively, with stripping losses of 0.197%. Additionally, it was discovered that the machine's actual field capacity was 0.081 ha/h, field efficiency was 75.7%, fuel consumption was 1.22 l/h, and the number of cobs per hour was 2965, the weight of cobs per hour was 565 kg, and the length of cut (stalk) was 13 mm.

Keywords: Maize harvester, stripping loss, snipper speed, field efficiency, stem length, length of cut (stalk)

Introduction

Maize is a native crop of America. Portuguese traders brought it to India in the 17th century. In different regions of the nation, it is grown all year round. In northern India, the kharif (monsoon) season is the primary growing season. However, as the climate is consistently warm, maize can be sown there at any time between April and October. 21°C is the best temperature for germination, and 32°C is the best temperature for growth. It ascends to a height of 3000 meters above sea level. It may also be grown in a range of climates. A staple food in many developed nations, maize (*Zea mays* L.) is a coarse cereal. Additionally, it is a crucial component of numerous industrial items. In India, 9.705 million hectares are planted with maize, yielding 28-29 million tons of output (Anonymous, 2025-26) [1]. In Chhattisgarh during the Kharif season, the area and yield of maize come right behind that of paddy. In Kharif 2020-2021, it generated 5.76 t/ha on 0.206 million hectares of land. [Anonymous, 2022]. The Baster plateau region (Baster, Bijapur, Dantewada, Sukma, Kondagaon, and Kanker districts), the central portion of the Chhattisgarh plain (Durg, Rajnangoen, and Gariyaband districts), and the northern hilly regions of the state (Korea, Korba, Surajpur, Balrampur, and Sarguja districts) are the main areas in Chhattisgarh where maize is grown. A small-sized maize cob harvester is a crucial piece of equipment for lowering harvesting costs and labor-intensive tasks. To assist small-scale farmers in cutting their crops faster, a portable harvester with low power consumption was created. The maize harvesting machine is a small type of corn cob harvester; it can harvest corn in a single row; it can be used with a tiller and walk tractor to support the collection of the full bucket; we can remove the filling beg; it has an adjustable height of stay; the tension clutch operates safely; and it has a small turning radius. The corn harvesting machine is capable of simultaneously crushing straws and gathering maize. To fertilize the field, the corn straws are directly ground. Additionally, the designed harvester will help reduce time consumption, expenses, and drudgery.

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2. Material and Methods

The maize cob harvester's performance evaluation studies were carried out in the field at various forward speeds. In April and May of 2023, the assessment was carried out in Agronomy Field, IGKV, Raipur. Three distinct factors were chosen: the type of maize crop, the forward speed of operation, and the snipper speed

(rolling speed), represented by the letters V, F, and S, respectively, with three levels of each factor. Table 1 presented the specifics of the independent and dependent parameters for the research. A factorial randomized block design was used to analyze the observed data.

Table 1: Different independent and dependent parameter for the performance evaluation of maize cob harvester.

S. NO.	Independent parameters		Dependent parameters
	Factors	Levels	
1.	Variety (V)	a) Dhania-9965 b) Sartaj-765 c) D-9081	Crop parameters a) Stripping loss, (%) b) Length of stem before and after harvesting, (mm) c) Number of cobs per hour d) Weight of cobs per hour, (kg) e) Length of cut, (mm) Machine parameters a) Actual field capacity, (ha/h) b) Field efficiency, (%) c) Fuel consumption, (l/h)
2.	Forward speed (F)	a) 1.7 km/h b) 1.9 km/h c) 2.1 km/h	
3.	Snipper speed (S)	d) 55 m/min e) 62 m/min f) 68 m/min	

2.1 Independent parameters

2.1.1 Variety

To test and assess the machine's performance, various varieties of maize are used. The maize crop varieties Dhania-9965, Sartaj-765, and D-9081 were large, medium, and tiny cob varieties, respectively.

2.1.2 Forward speed

The three forward speeds 1.7, 1.9, and 2.1 km/h that the machine could achieve when operating in the field at low and high gears with various throttle positions were chosen for the investigation.

2.1.3 Snipper speed

Snapping roller speed rises as the machine moves forward. Snapping roller peripheral speeds were found to be 55, 62, and 68 m/min for the corresponding forward speeds of 1.7, 1.9, and 2.1 km/h.

2.2 Dependent parameters

2.2.1 Stripping loss

The number of maize cobs that are lost or damaged during harvesting is known as the stripping loss. The entire number of cobs in a single row of the plant prior to harvesting divided by the total number of cobs following harvesting yields the stripping loss.

$$\text{Stripping loss(\%)} = \frac{S_1 - S_2}{S_1} \times 100$$

Where,

S_1 = Number of cobs in plant in one row before harvesting.

S_2 = Number of cobs after harvesting.

2.2.2 Length of stem before and after harvesting

The distance between the tassel branches and the base of the plant on the ground is the length of the maize stem prior to harvesting, and the distance between the top of the cut edge of the stem and the base of the plant on the ground is the length of the maize stem following harvest.

2.2.3 Number of cobs per hour

The total number of cobs is the amount of maize that can be collected in an hour.

2.2.4 Weight of cobs per hour

The weight of the cobs is the total weight of the cobs harvested in an hour. The average values were noted after measuring the maize cobs.

2.2.5 Length of cut (stalk)

After harvesting, the length of a randomly chosen maize stalk is measured, and the average results are noted.



Fig 1: Stripping loss during harvesting.



Fig 2: Measuring length of stem.



Fig 3: Number of cobs obtained after harvesting.



Fig 4: Weight of cobs.



Fig 5: Length of cut.



Fig 6: Measuring length of cut.

2.2.6 Actual field capacity

By calculating the time spent on actual labor and the time lost on additional tasks like turning, filling up the fuel tank, and emptying the cobs from the collection bin, the effective/actual field capacity was ascertained.

$$\text{Actual field capacity, } \left(\frac{\text{ha}}{\text{h}}\right) = \frac{\text{Actual area covered}}{\text{Total time required to cover area}}$$

2.2.7 Field efficiency

The ratio of theoretical field capacity to effective field capacity is

known as field efficiency.

$$\text{FE} = \frac{\text{EFC}}{\text{TFC}} \times 100$$

Where,

FE = Field efficiency, %;

EFC = Effective field capacity, ha/h; and

TFC = Theoretical field capacity, ha/h.



Fig 7: Field operation by machine.



Fig 8: Crop residue management.

2.2.8 Fuel consumption

The self-propelled maize harvester's fuel consumption at various forward speeds was computed using the fuel tank top filling method.

3. Results and Discussion

The following part provided a detailed presentation and discussion of the experiment results. There was also discussion of how different independent parameters affected the maize cob harvester's performance metrics.

3.1 Effect of forward speed, snipper speed and different variety, on stripping loss by maize cob harvester

Table 2 showed how stripping losses were affected by forward and snipper speeds for various maize crop varieties. It was shown that none of the three had a significant impact on stripping loss ($p < 0.05$). It has little bearing on the stripping losses and could be caused by a range of different sizes of maize cobs. Additionally, at forward speeds of 2.1 km/h, snipper speeds of 68 m/min, and variety Dhanja-9965, stripping loss was found to be significantly higher (0.342%). It was found that the stripping loss increased with forward speed. increased forward speed could be the cause of the increased stripping losses at higher snipper speeds.

Table 2: Effect of forward speed, snipper speed and variety, on stripping loss and effect of length of stem before and after harvesting.

Particulars			Stripping loss(%)			Length of stem after harvesting		
Forward speed	Snipper speed	variety	R1	R2	R3	R1	R2	R3
1.7	55	Dhanja-9965	0.269	0.275	0.257	120	126	124
		Sartaj-765	0.228	0.236	0.245	160	165	168
		D-9081	0.251	0.265	0.249	210	215	213
	62	Dhanja-9965	0.245	0.238	0.254	130	137	139
		Sartaj-765	0.211	0.224	0.206	170	175	178
		D-9081	0.233	0.243	0.229	190	192	194
	68	Dhanja-9965	0.278	0.285	0.264	110	116	114
		Sartaj-765	0.239	0.249	0.223	140	144	143
		D-9081	0.255	0.248	0.232	180	182	186

1.9	55	Dhania-9965	0.247	0.2531	0.239	125	126	128
		Sartaj-765	0.2201	0.2195	0.225	140	145	141
		D-9081	0.2334	0.242	0.226	190	191	193
	62	Dhania-9965	0.229	0.2276	0.2198	140	143	141
		Sartaj-765	0.192	0.2043	0.196	165	161	163
		D-9081	0.216	0.223	0.205	175	172	171
	68	Dhania-9965	0.262	0.257	0.2682	185	180	181
		Sartaj-765	0.236	0.241	0.229	195	192	194
		D-9081	0.2501	0.2534	0.2652	190	192	195
2.1	55	Dhania-9965	0.291	0.298	0.2829	148	145	144
		Sartaj-765	0.263	0.2672	0.2579	137	134	132
		D-9081	0.275	0.2765	0.2655	168	165	167
	62	Dhania-9965	0.282	0.2796	0.2835	176	174	172
		Sartaj-765	0.232	0.2346	0.252	186	184	183
		D-9081	0.267	0.2431	0.275	189	186	182
	68	Dhania-9965	0.341	0.3394	0.3462	180	181	179
		Sartaj-765	0.307	0.2954	0.3091	215	216	211
		D-9081	0.3238	0.326	0.3159	220	218	213
Factors			CD	SE(d)	SE(m)	CD	SE(d)	SE(m)
F× S × V			NS	0.006	0.005	2.873	1.428	1.01

Note: F = Forward speed, S = Snipper speed, V = Variety

3.2 Effect of forward speed, snipper speed and different variety, on length of stem before and after harvesting by maize cob harvester

Table 2 shows how forward speed and snipper speed at various maize crop varieties affect stem length after harvest. All three were found to have a substantial impact on stem length following harvesting ($p = 0.05$). The length of the stem after harvesting may be affected by the diversity of different sizes of maize crops. Additionally, at 2.1 km/h forward speed, 68 m/min snipper speed, and variety D-9081, the length of stem after harvesting was found to be significantly highest (217 mm). The effect of stem length after harvesting was shown to be greater at higher forward speeds. The longer stem after harvesting at a faster snipper speed could be the result of a higher forward speed.

3.3 Effect of forward speed, snipper speed and different variety, on actual field capacity by maize cob harvester

The effect of forward speed and snipper speed at different maize crop variety, on actual field capacity was given in Table 3. All three were shown to have a substantial impact on the actual field capacity ($p = 0.05$). The actual field capacity may be impacted by the varying sizes of maize cobs, forward speed, and snipper speed. Additionally, at forward speeds of 1.7 km/h, snipper speeds of 62 m/min, and variety D-9081, actual field capacity was found to be much maximum (1.072 ha/h). The real field capacity was found to be greater at higher forward speeds. It could be because a faster forward speed increases the real field capacity at a faster snipper speed.

Table 3: Effect of forward speed, snipper speed and variety, on actual field capacity and field efficiency.

Particulars			Actual field capacity, ha/h			Field efficiency(%)		
Forward speed	Snipper speed	variety	R1	R2	R3	R1	R2	R3
1.7	55	Dhania-9965	0.9468	0.954	0.9612	81.38	81.25	81.33
		Sartaj-765	0.9648	0.9684	0.9792	82.57	82.37	82.43
		D-9081	1.062	1.0656	0.9468	83.45	83.8	83.75
	62	Dhania-9965	0.9504	0.9648	0.9396	82.81	82.7	82.62
		Sartaj-765	1.026	1.0188	1.026	83.9	83.26	83.51
		D-9081	1.0656	1.0728	1.0764	84.71	84.62	84.74
	68	Dhania-9965	0.954	0.9756	0.9684	83.6	83.71	83.9
		Sartaj-765	1.0332	1.0188	1.0368	84.61	84.7	84.26
		D-9081	1.0728	1.0692	1.0656	85.32	85.46	85.37
1.9	55	Dhania-9965	0.9612	0.9684	0.9828	91.4	91.56	91.32
		Sartaj-765	1.0368	1.0404	1.0548	92.66	92.74	92.3
		D-9081	1.0764	1.062	1.0656	93.51	93.56	93.72
	62	Dhania-9965	0.9576	0.9684	0.9612	92.5	92.61	92.72
		Sartaj-765	1.0008	0.9936	0.9864	93.65	93.9	93.78
		D-9081	1.0512	1.0584	1.062	94.23	94.45	94.63
	68	Dhania-9965	0.9792	0.99	0.9864	93.12	93.25	93.58
		Sartaj-765	1.0404	1.0368	1.0332	94.52	94.41	94.53
		D-9081	1.0728	1.0656	1.0548	95.71	95.62	95.51
2.1	55	Dhania-9965	0.9828	0.99	1.0008	73.66	73.5	73.81
		Sartaj-765	1.0044	0.9936	0.9864	74.2	74.59	74.35
		D-9081	1.0332	1.0296	1.0368	75.82	75.83	75.7
	62	Dhania-9965	0.9936	0.9828	0.9864	74.32	74.42	74.57
		Sartaj-765	1.0188	1.0332	0.9864	75.64	75.72	75.86
		D-9081	1.0584	1.0728	1.062	76.84	76.55	76.92
	68	Dhania-9965	1.0152	1.0296	1.0116	75.83	75.72	75.63
		Sartaj-765	1.0368	1.0296	1.0224	76.71	76.85	76.45
		D-9081	1.0332	1.0404	1.0512	77.5	77.81	77.3
Factors			CD	SE(d)	SE(m)	CD	SE(d)	SE(m)
F× S × V			0.026	0.013	0.009	0.272	0.135	0.096

Note: F = Forward speed, S = Snipper speed, V = Variety

3.4 Effect of forward speed, snipper speed and different variety, on field efficiency by maize cob harvester

Table 3 shows how forward speed and snipper speed at various maize crop varieties affect field efficiency. All three were shown to have a substantial impact on field efficiency ($p = 0.05$). It has an impact on field efficiency and could be caused by a range of different sizes of maize cobs, forward speed, and snipper speed. Additionally, field effectiveness was shown to be much higher (95.613%) at forward speeds of 1.9 km/h, snipper speeds of 68 m/min, and variety D-9081. The field efficiency was found to be higher at lower forward speeds. It might be because different sizes of maize crops have required faster snipper speeds than slower forward speeds.

Table 2 shows that the stripping loss, length of stem before and after harvesting and actual field capacity, field efficiency are presented in Table 3. Table 4, shows that Effects of performance

parameters. The stripping loss and fuel consumption were observed no significant difference at 5% level of all three independent parameters. The length of stem before and after harvesting, number of cobs per hours, weight of cobs per hours, length of cut(stalk) and actual field capacity, field efficiency, fuel consumption was observed significant difference at 5% level with CD value of 16.406, 2.873, 4.055, 4.542, 3.749, 0.026, 0.272, respectively. At forward speeds of 1.9 km/h and snipper speeds of 62 m/min, the machine operates satisfactorily. Crop parameters include stripping losses of 0.197%, stem length before and after harvesting of 825 mm and 113.33 mm, respectively, number of cobs per hour of 2965 cobs, weight of cobs per hour of 565 kg, length of cut (stalk) of 13 mm, and machine parameters such as actual field capacity of 0.081 ha/h, field efficiency of 75.7%, and fuel consumption of 1.22 l/h. The machine produces 75 q/ha in total.

Table 4: Effects of performance parameter of the machine.

Particulars	C.D	SE(d)	SE(m)
Stripping loss	NS	0.006	0.005
Length of stem before harvesting	16.406	8.158	5.769
Length of stem after harvesting	2.873	1.428	1.01
Number of cobs per hours	4.055	2.016	1.426
Weight of cobs per hours	4.542	2.258	1.597
Length of cut(stalk)	3.749	1.864	1.318
Actual field capacity	0.026	0.013	0.009
Field efficiency	0.272	0.135	0.096
Fuel consumption	NS	0.029	0.021

4. Conclusion

It was discovered that the crop and machine parameters chosen had an impact on the maize cob harvester's performance. Additionally, the machines were found to operate satisfactorily at forward speeds of 1.9 km/h and snipper speeds of 62 m/min.

In summary, the maize cob harvester is capable of covering a single row at a time, harvesting the entire cob, chopping the stem into small pieces, and spreading mulch on the ground. To fertilize the field, the corn straws are directly ground. The findings of the result suggest that crop residues can partially (if not fully) compensate for the low fertility status of the agricultural soils caused due to high cost of chemical fertilizer. A combination of chemical fertilizer and crop residues is termed as an ideal technique to maintain the fertility of soil in both short and long terms. Although chemical fertilizer resulted in best results, it seems logical to conclude that a combination of crop residues with it will have more benefits in the long run due to slow decomposition of residues which will ensure nutrients availability in the following years.

A small-scale maize cob harvester is a device that lowers harvesting expenses and labor-intensive tasks. The machine's operating costs, breakeven point, and payback period were determined to be approximately Rs. 337.65 per hour, 149.64 hours, and 2.5 years, respectively.

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