RESEARCH ARTICLE

PERFORMANCE EVALUATION OF SELF-PROPELLED SUGARCANE HARVESTER

Vaibhav Suryawanshi[1]*, Surinder Singh Thakur[2] and Sushil Sharma[2]

Abstract

In the present study, a guide bar was developed as on attachment on a self-propelled sugarcane harvester in order to reduce the time and labour required in the rope method. ,. The performance of the self-propelled sugarcane harvester (8 hp diesel engine) was evaluated with two different methods (rope method and the novel guide bar method) for windrowing the cut sugarcane, three levels of cutter bar speed to cut the sugarcane (550, 800 and 1020 strokes per min) and two forward speeds (1.0-1.4 km/h and 1.5- 1.9 km/h). The novel guide bar on the machine worked satisfactorily in trench planting in paired rows. In guide bar method, the fuel consumption, field capacity and material capacity were 1.533 l/h, 0.065 ha/h and 9.872 t/h, respectively, at forward speed of 1.0-1.4 km/h. The guide bar method of collection consumed more fuel than rope method but the labour requirement (5 man-h/ha for rope method and 3 man-h/ha in guide bar method) was reduced up to 66 %. The sugarcane harvester tested in the present study performed best at forward speed of 1.0-1.4 km/h with guide bar method at cutter bar speed of 1020 strokes per minute in trench planting.

Keywords : Sugarcane, self-propelled harvester, guide bar method, fuel consumption, field capacity and material capacity.

Introduction

In India, 345 million tonnes of sugarcane is being produced annually from an area of 4.4 million hectares with an average productivity of 68 tonnes/ ha. Sugarcane industry sustains about 6 million farmers in the country, majority of them are small and marginal. About 50 % of the area under sugarcane cultivation has small size of land holding (0.5 to 5 ha). Sugarcane is a labour intensive crop, which requires about 250 to 400 labour mandays per ha of which harvesting alone requires about 70 mandays per ha (Anonymous 2011). It is a major commercial crop in many countries many of which are developing nations that have ample labour for manual harvesting (Meyer 1997a). However, with the manufacturing sector providing higher wage jobs, labour is becoming scarce (De Beer, 1974). Since harvesting is the single most expensive operation in sugarcane farming, a shift towards mechanization of this operation is needed to make sugarcane cultivation sustainable (Meyer 1997b). However, the shift has to be gradual to facilitate complete understanding of mechanization and to meet the local needs without the pressures associated with the drastic and necessary change in the practice (Freyou 1999). Sugarcane harvesters currently in use in countries like Australia and America are broadly of two types, namely sugarcane combines and whole stalk harvesters. While the combines perform detopping, base-cutting, chopping, trash removal, conveying and loading, whole stalk harvesters detop,

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base cut and windrow the cane; loaders subsequently pick up the windrowed cane manually or mechanically. These harvesters are expensive and beyond the affordability of growers of developing countries such as India where a majority of sugarcane farmers (83 %) belong to small and marginal group (Sharma et al. 2006). Besides, mechanical harvesters can cause soil compaction and root damage to sugarcane far more severely and frequently than manual harvesters. In response to industry pressures, some mechanical harvesters are being engineered to be lighter, and fitted with special tyres which reduce soil compaction. Therefore, there is a need to develop harvesters to suit local conditions and evaluate their performance. In this study, we developed and evaluated a modification for a commercially available self-propelled walk-behind type harvesting machine.

Materials and methods

An attachment of guide for windrowing of cut sugarcane rows was developed for a self-propelled walk-behind type sugarcane harvesting machine operated by an 8 hp air-cooled diesel engine, manufactured by BCS Company. The performance of machine with and without the developed guide was evaluated on the research farm of Department of Farm Machinery and Power Engineering, Punjab Agricultural University, Ludhiana, during 2008-2010.

Description of the machine

The machine cuts sugarcane crop by using single acting cutter bar of 1 m length having 12 serrated blades. The power transmission to the cutter bar is obtained by means of a pitman shaft which connects to the engine through clutch and gear box. The cutter bar speed is regulated by the accelerator which is placed on the handle. The cutter bar works on the principle of shearing action of cutter blade and cuts the cane very close to the ground to minimize losses. As the machine moves along the row, cut cluster of cane stalks and windrow are obtained by using rope and guide bar method. For stability of the machine during the operation, double wheels (1473 mm) are used. The power to the wheel is provided from the engine through clutch and gear box. The machine is controlled by using clutch, brake, accelerator, and reverse and forward directions, all located on the handle for easy and safe operation. The stationary view of the machine is shown in Fig. 1.

Fig.1. Sugarcane harvester machine fitted with developed guide bar

Method of collection

Rope method is most commonly used for cutting rows of sugarcane and spreading in windrows. The placement of the rope inside the row to be harvested requires additional time for placement. Besides this, it requires five labourers for its operation. In order to reduce the time and labour required, a guide bar was developed as an attachment on self propelled sugarcane harvester. This guide bar (Fig. 2) comprises a MS flat (75 X 6 mm) and “B” class high pressure pipe (1500 mm). This guide bar helps in windrowing the cut sugarcane in rows without damaging the harvested material.

Planting method

The self propelled sugarcane harvester was evaluated in field grown sugarcane crop of the variety CoJ 87 at the Research Farm, Department of Farm Machinery and Power Engineering, PAU, Ludhiana.

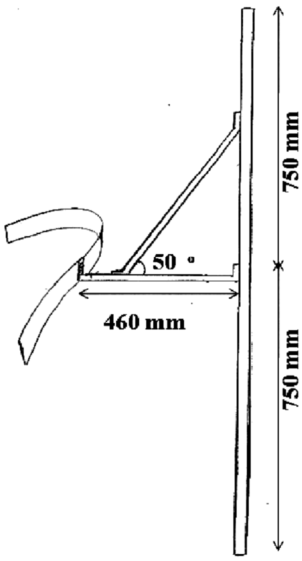

Fig. 2. Schematic diagram of developed guide bar

The testing field was planted in trench planting of paired rows with an inter pair-row spacing of 0.90 m and 0.30 m within the paired rows.

Performance evaluation

The performance of self propelled sugarcane harvester was evaluated with two different methods for windrowing the cut sugarcane (rope method and guide bar method), two forward speeds (1.0-1.4 km/h and 1.5-1.9 km/h) and three levels of cutter bar speed (550, 800 and 1020 stroke per min) to cut the sugarcane. The performance parameters like fuel consumption (l/h), field capacity (ha/h), material capacity (t/h) and labor requirement were evaluated. The machine was operated on paired row harvesting to assess the easiness of cutting the sugarcane without clogging.

A 20 m row was selected for every trial. The fuel consumption, time to cut a row and weight of cut sugarcane were measured adopting detopping method, using a digital stop watch and electronic platform balance in all the treatments. The labour requirement was kept constant for rope method (five labourers) and guide bar method (three labourers). In the rope method two additional labourers were used for inserting the rope inside the row so that the speed of the harvester is not affected. The machine was run at the required speed in the chosen gear to cut the row. Similar experiments were conducted with different levels of parameters for cutting every row of cane with three replications. The statistical analysis has been done through SAS 9.3 software provided under NAIP-Component I entitled Strengthening Statistical Computing for National Agricultural Research Scientists (NARS).

Results and discussion

The data pertaining to the effect of forward speed (Factor A in km/h), method of collection (Factor B) and cutter bar speed (Factor C in strokes/min) on fuel consumption (l/h), field capacity (ha/h) and material capacity (t/h) of sugarcane harvester are given in Table 1.

Fuel consumption

The data indicated that the fuel consumption (l/h) increased with the increase in forward speed and cutter bar speed (strokes/min). In general, fuel consumption (l/h) was more in guide bar method than rope method. The fuel consumption (l/h) of harvester was registered significantly to be the lowest at 1.0-1.4 km/h forward speed (1.224 l/h) and 550 stroke/min cutter bar speed (1.208 l/h), collected through rope method (1.534 l/h). In the three factors (A, B and C) interaction studies, the lowest fuel consumption was recorded in case of A2xB2 (1.850 l/h), B1xC2 and B2xC2 (1.496-1.499 l/h) and A1xC1 (0.905 l/h), while its highest values were observed with A2xB1 (2.015 l/h), B1xC3 (2.135 l/h) and A2xC3 (2.433 l/h). The combination of AxBxC failed to exert any significant effect on fuel consumption; however, its highest (2.266 l/h) and lowest (0.889 l/h) values were noticed with A2xB2xC3 and A1xB2xC1, respectively. Moontree et al. (2012) reported fuel consumption of 20.03 l/h at a forward speed of 0.25 km/h with 1,090.5 rpm rotation speed of stalk cutting blades for small engine operated sugarcane harvester.

Table 1. Effect of forward speed (km/h), method of collection and cutter bar speed (stroke/min) on fuel consumption (l/h), field capacity (ha/h) and material capacity (t/h) of sugarcane harvester.

		Fuel Consumption (l/h)						Field Capacity (ha/h)						Material Capacity (t/h)					
		C1	**C2**	**C3**	**Mean (A)**	**Mean (AxB)**	**Mean (B)**	**C1**	**C2**	**C3**	**Mean (A)**	**Mean (AxB)**	**Mean (B)**	**C1**	**C2**	**C3**	**Mean (A)**	**Mean (AxB)**	**Mean (B)**
A1	B1	0.922	1.103	1.669		1.231		0.055	0.060	0.083		0.066		11.409	12.166	17.349		13.641	
	B2	0.889	1.176	1.587		1.217		0.053	0.063	0.076		0.064		11.227	13.188	15.489		13.302	
	Mean (AxC)	0.905	1.140	1.628	1.224			0.05	0.06	0.08	0.065			11.318	12.677	16.419	13.471		
A2	B1	1.558	1.888	2.600		2.015		0.076	0.083	0.108		0.089		14.866	16.991	23.225		18.361	
	B2	1.463	1.822	2.266		1.850		0.070	0.078	0.094		0.081		14.255	16.177	18.939		16.457	
	Mean (AxC)	1.510	1.855	2.433	1.933			0.07	0.08	0.10	0.085			14.561	16.584	21.082	17.409		
BxC	B1	1.240	1.496	2.135			1.623	0.065	0.072	0.096			0.078	13.138	14.578	20.287			16.001
	B2	1.176	1.499	1.927			1.534	0.061	0.071	0.085			0.072	12.741	14.683	17.214			14.879
	Mean (C)	1.208	1.498	2.031				0.063	0.071	0.090				12.939	14.630	18.750			
	$CD_{(0.05)}$																		
	A						0.062						0.001						0.695
	B						0.062						0.001						0.695
	C						0.076						0.002						0.851
	AxB						0.087						0.002						0.983
	AxC						0.107						NS						NS
	BxC						0.107						0.002						1.204
	AxBxC						NS						NS						NS

A_1 - Forward speed (1.0-1.4 km/h); A_2 - Forward speed (1.5-1.9 km/h); B_1 - Guide bar method; B_2 - Rope method; C_1 - Cutter bar speed (550 stroke/min); C_2 - Cutter bar speed (800 stroke/min); C_3 - Cutter bar speed (1020 stroke/min)

Field capacity

The sugarcane harvester tested in the present studies showed significantly highest field capacity (ha/h) statistically at 1.5-1.9 km/h forward speed (0.085 ha/h) and 1020 strokes/min cutter bar speed (0.090 ha/h) with guide bar method of collection (0.078 ha/h). The combinations of A2xB1 (0.089 ha/h) and B1xC3 (0.096 ha/h) proved best significantly in respect of showing highest field capacity of sugarcane harvester. The interactions among AxC and AxBxC were found statistically similar in relation to field capacity of sugarcane harvester. In general, field capacity increased with the increase in cutter bar speed at method of collection and forward speed of the machine. Gupta et al. (1996) reported an average field capacity of 0.13 ha/h for a self propelled single axle sugarcane harvester.

Material capacity

Almost similar trends were noticed in case of material capacity of harvester and its highest values were recorded while performing at 1.5-1.9 km/h forward (17.40 t/h) and 1020 strokes/min cutter bar (18.750 t/h) speeds collected through guide bar method (16.001 t/h). The combinations of A2xB1 (18.361 t/h) and B1xC3 (20.287 t/h) excelled over others in respect of material capacity of sugarcane harvester in trench planting tested during the course of investigation. The interactions among AxC and AxBxC were found statistically similar in relation to material capacity of sugarcane harvester.

Conclusions

Whole stalk harvesting or cut chop harvesting system is being used in developed countries for harvesting sugarcane. A few machines were developed in the past to harvest sugarcane and to economize the most labour intensive operation in sugarcane harvesting. However, these machines are very large and costly to operate under small holdings. This study deals with a self propelled 8 hp diesel engine operated sugarcane harvester manufactured by BCS. An attachment of guide for windrowing was developed and evaluated so as to enhance the net returns from sugarcane cultivation. This machine was evaluated for fuel consumption (l/h), field capacity (ha/h), material capacity (t/h) and labour requirement as dependent parameters, while forward speed (2 level), method of collection (viz. guide bar and rope method) and cutter bar speed (3 level) were independent parameters.

The conclusions drawn from the present investigation are as follows:

1) The modified machine worked satisfactory with both the methods of collections (guide bar method and rope method).

2) In guide bar method, the fuel consumption, field capacity and material capacity were 1.534 l/h, 0.065 ha/h and 9.872 t/h, respectively, at forward speed of 1.0-1.4 km/h.

3) The fuel consumption (l/h) of harvester registered was significantly lowest at 1.0-1.4 km forward speed (1.224 l/h) and 550 stroke/min cutter bar speed (1.208 l/h), collected through rope method (1.534 l/h).

4) Significantly highest field capacity (ha/h) at 1.5-1.9 km/h forward speed (0.085 ha/h) and 1020 stroke/min cutter bar speed (0.090 ha/h) with guide bar method of collection (0.078 ha/h).

5) Material capacity of sugarcane harvester was highest at 1.5-1.9 km/h forward (17.40 t/ha) and 1020 stroke/min cutter bar (18.750 t/ha) speeds collected through guide bar method (16.001 t/ha).

6) Guide bar method of collection proved to consume more fuel than rope method, but the labour requirement (5 man-h/ha for rope method and 3 man-h/ha in guide bar method) was reduced up to 66%. This system has simple bar mechanism for guiding of cut stalks to one side so as to avoid the canes being crushed under the tyres. Time required to

insert the rope inside the crop was more which resulted in higher labour requirement in case of the rope method.

7) This harvester can only do cutting work and labour is required for detrashing operation.

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