Optimization cane traction output from hopper in full-automatic sugarcane planters by using response surface modeling and analytical hierarchy process

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Abstract: Agriculture mechanization plays a significant economic role by increasing agriculture production and reducing cost of cultivation. There is a dire need to develop more processing machinery for value addition of agricultural produce with a reduction in time and labour. The planting operation is one of the most important tasks that sugarcane growers undertake. It should result in a plant stand at the desired density that emerges quickly and uniformly. Austoft sugarcane planter was studied and the CAD model for metering device was simulated with Catia software. Main components of this machine are hopper, metering device, and basis. Multiple regression and Response Surface Methodology (RSM) were applied to data for investigating the effect of angle and speed of sugarcane billet metering device on discharging and precision indices. The speed of metering device had more effect than angle on both performance indices. Analytical hierarchy process (AHP) used to match the best operation condition for discharging billets from hopper. The angle of 80° and speed of 1 m s^{-1} was the best suited condition for sugarcane billet metering device with 98.64% for precision index and 4.2 billets in per second for discharging index. A consistency ratio evaluation value of 0.1 confirmed the results.

Keywords: sugarcane, planters, AHP, mechanization agriculture, RSM, computer aided design (CAD)

Citation: Taghinezhad, J., R. Alimardani, and A. Jafari. 2013. Optimization cane traction output from hopper in full-automatic sugarcane planters by using response surface modeling and analytical hierarchy process. Agric Eng Int: CIGR Journal, 15(2): 138−147.

1 Introduction

Sugarcane (Saccharum officinarm L.) is an important raw material for the sugar industries (Frank, 1984). Sugarcane is a perpetual agricultural crop grown primarily for the juice extracted from its stalks. Raw sugar produced from these juice is later refined into white sugar, also recently sugarcane has received special attention due to its potential as a renewable energy source (Santos et al., 2006). As a perennial crop, planting of sugarcane will generally allow for three to six or more annual harvests before replanting is necessary (Taghinezhad et al., 2012a). There are more than 70 sugar-producer countries around the world (Taghinezhad et al., 2012b). In Iran, sugarcane is widely cultivated on an area of about 68352 ha with an annual production of about 5,685,090 ton (FAO, 2010).

Received date: 2013-01-08 **Accepted date:** 2013-03-28

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The planting operation is one of the most important tasks that sugarcane growers undertake. It should result in a plant stand at the desired density that emerges quickly and uniformly (Staggenborg et al., 2004). Sugarcane is propagated from cuttings, rather than from seeds. Although certain types still produce seeds, modern methods of stem cuttings have become the most common method of reproduction. It is also reported that bud emergence is quicker when the sets are planted with the cutter planter. It also significantly increases the yield per unit area (Srivastava, 1978). Billet length affects the level of sugarcane deterioration and the invisible losses (Peloia et al., 2010). Stalks are cut into

30 to 40 cm long pieces, called setts. These setts are then placed or planted in an orderly manner in soil furrows (Srivastava, 2004) and each cutting must contain at least one bud (Mandal and Maji, 2008). There are not much scientific references because mechanized planting is a new activity. Some references are about experiment and tests with no scientific method (Ripoli and Ripoli, 2010).

Carlin et al. (2004) consider the most important factor for good yield is the quality of planting, which should provide a good stand of buds per meter. Ripoli (2006) says that the excessive variability in the agricultural productivity of sugarcane is not only due to genetic factors, but in practice did not provide adequate soil preparation for planting and that the mechanical planting should reduce this tendency. Stolf et al. (1984) studied the influence of mechanized planting on germination rate of sugarcane. The results showed that the germination rates were 38% and 37.2% for conventional and mechanized practices.

Sugarcane cutter planter has an effective field capacity of 0.15 hectare per hour. There was substantial reduction of labour requirement from 130-150 man-hours per hectare (by conventional method) to 35-40 man-hours per hectare by machine planting (Bhal and Sharma, 2001). Yadav and Choudhuri (2001) reported that overall requirement of labour for sugarcane cultivation was 33000 man-hours. Labour requirement for planting is 238.0. He emphasized the need to develop and popularize sugarcane machinery system based on regional situation. Bachche et al. (2007) studied economic comparison between semi-mechanized sugarcane cutter planter and traditional method. He reported that the cost of operation for the mechanized planting was computed as 6.67 \$ h^{-1} and for the conventional planting cost of operation was found as 10.72 \$ h^{-1}.

Patil et al. (2004) evaluated the two semi-mechanized sugarcane planters; he found forward speed of 1.8 and 2.5 km hr^{-1} present an effective working and the seed requirement was observed above 9.0 tonnes per hectare. Salassi et al. (2004) estimated cost differences between whole-stalk and billet sugarcane planting, and found billet planting was better than whole stalk planting. Dafa'alla (1991) evaluated the performance of one sugarcane planter and studied the effect of forward speeds on machine planting. They found the forward speed of 4 km hr^{-1} would result in higher field machine capacity and save a seed material without considerable loose in yield.

Ripoli and Ripoli (2010) evaluated the five sugarcane planters and found a comparative result among them, based in a standard method under the same field conditions. They found that effective costs of mechanized system was significantly cheaper than the semi-mechanized practice and also reported that neither of the planters that seeded billets showed an adequate distribution mechanism for the prime matter. They are all throw-out mechanisms.

Thus sugarcane planter cutters are getting great response from farmers, because the reduction of drudgery involvement in unit operations, i.e. sett preparation, carrying of seed cane, opening of furrows, dropping of setts, pesticide application, fertilizer placement, and covering and pressing setts (Khedkar and Kamble, 2008; Mandal and Maji, 2008). It yielded a saving of about 32% in total cost as well as total energy required for raising sugarcane crop (Srivastava, 1978).

A reduction in the amount of billet used in mechanized planting of sugarcane from a cost reduction perspective is very important. This can be achieved by improving the metering device system on billet planters. The focus of this article was to investigate the effect of speed and angle of metering device in mechanized planter and finding the best operating set in these machines for reduction of billet use.

2 Materials and methods

2.1 Description of the apparatus

The AUSTOFT sugarcane planter (Figure 1) studied and metering device of this machine was simulated and developed for tests (Figure 2) at the Department of Agricultural Machinery Engineering, Faculty of Agricultural Engineering and Technology, University of Tehran, Iran. Computer aided design of machine was done by using Catia V5 R21 (2011) software. This design helps to find out the typical dimensions of various components of machine with great accuracy in less time. This design also gives fine representation of sugarcane metering device system by using simulation.

Figure 1 Automatic sugarcane planter and its metering device

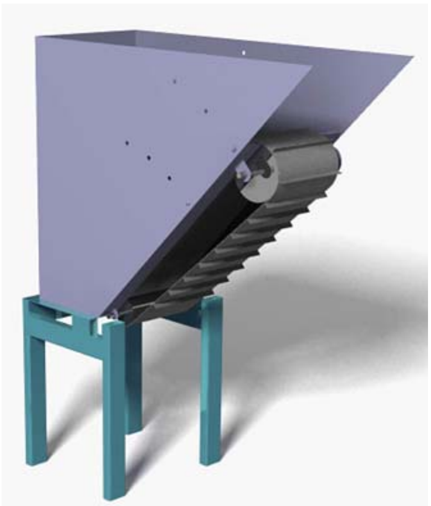

Figure 2 Simulated metering device

The metering device consists of the feed hoppers, metering device system, and basis. Feed hopper that fed the metering device. The maximum capacity of hopper designed is 0.425 m^3. The dimension of the hoppers is (0.35+1.35)/2 m × 0.5 m × 1 m. There are some holes on sides of hopper for setting angle of rubber belt and metering device can turn around lower cylinder axis.

The metering device consists of rubber belt with 2 m length and 40 cm width, two cylinders with 5 and 14 cm diameter and twenty aluminum cornerstone smashed on the rubber belt with 30 cm length and 3 cm sides for carrying sugarcane billets from hopper.

Basis: The assembly of hopper and metering device was clinched to the basis for fixing apparatus.

2.2 Experimental sugarcane for tests

Sugarcane stalks were harvested in October, 2011 from a field in Debel Khazaie, Ahvaz, Iran and were transferred to the Physical Properties of Materials Laboratory, Department of Agricultural Machinery Engineering, Faculty of Engineering and Technology, University of Tehran, Karaj, Iran. The stockpile sugarcane was stored (one month) indoors until the experiments were carried out in a laboratory having air temperature of about 25℃ and relative humidity of about 55%, where the canes naturally dried and balanced with the current ambient conditions. No degradation of the canes was observed after the field rise and the indoor storage, as the canes had maintained their structural integrity as was evident during material preparation cuts of the canes. The 100 samples of sugarcane stalks of approximate length of 30 cm were cut using a band saw with fine blade.

2.3 Experimental

The 100 samples of sugarcane stalks were selected for tests deposed in the hopper and three levels of linear speed (0.2, 0.32 and 0.4 m s^{-1}) were used in five angles (37°, 45°, 60°,70° and 80°) for billet metering device. For driving metering device, an electro motor with 1.75 hp power was coupled with upper cylinder of metering device. An LG iG5A variable frequency drives invertor used for control and changing of electro motor speed. Also a tachometer used for determining the real speed of billet metering device.

A professional digital camera (Excel 9 mega pixel) was installed at 0.5 m ahead and above of the metering device belt (Figure 3). A belt with 0.5 m width and two meters length for determining the results of tests were used and reposed on ground in the front of metering device belt.

The evaluation system included three main components: a digital camera for recording of passing canes, a motion analyzer for image analysis and a computer for data processing and monitoring. The capture of unpredictable events was readily accomplished using the electronic triggering features of the Motion Analyzer. The 720×576 pixel sensor produced sharp images with 256 levels of RGB. High light sensitivity of the system reduced the need for supplemental lighting. For image processing, ImageJ 1.44p software was used and Adobe Photoshop CS(6) Timeline software was used for analyzing frames.

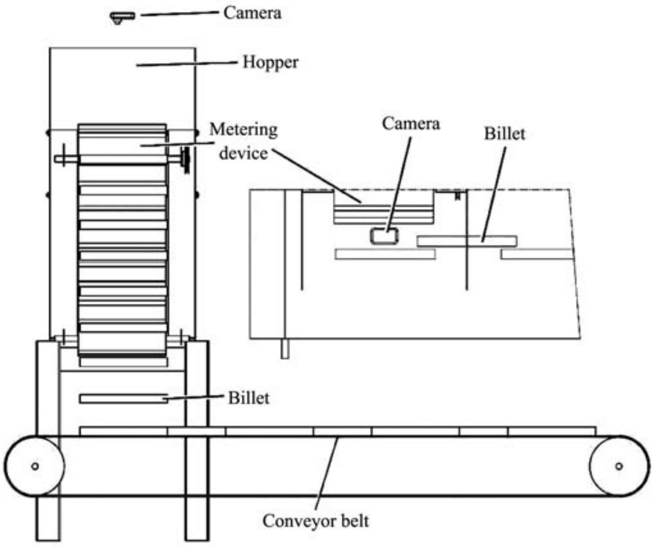

Figure 3 Schematic of testing apparatus

2.4 Analytical method

The multiple regression and Response Surface Methodology (RSM) technique were used for investigation the effect of speed and angle on the performance indices and for optimization of the factors affecting the performance of the metering device of sugarcane billet planter. Some researchers like Singh et al. (2005) and Yazgi and Degirmencioglu (2007) used this method for optimization cotton seeds planter and vacuum type precision seeder respectively. Finally, Analytical Hierarchy Process (AHP) method was applied to data for selecting the best operating condition in sugarcane billet metering device. Statistical software packages (Microsoft Excel 2010, IBM SPSS, Microsoft Mathematics and DPlot) were used to analyze data.

2.5 Analytical hierarchy process

For selecting the best operating condition for metering device analytical hierarchy process was applied according to follow. Table 1 indicates alternatives and the measured values for them in tests. From these fifteen positions, one must choose the best.

Analyses are performed via below stages:

1) Hierarchy decision tree making

2) Evaluate the priorities

3) System consistency ratio

The acceptable value for inconsistency of a matrix or a system dependent on decision maker but Saaty (1980) indicated 0.1 or below is considered acceptable and any higher value at any level indicate that the judgments warrant re-examination. Now, calculate the consistency ratio and check its value.

There are three steps to arrive at the consistency ratio:

1) Calculate the consistency measure.

2) Calculate the consistency index (CI).

3) Calculate the consistency ratio (CI/RI where RI is a random index).

Approximation of the consistency measure and the Consistency Index:

1) Multiply each row of the pairwise comparison matrix (Table 2 and Table 3) by the corresponding weight.

2) Divide of sum of the column entries by the corresponding weight.

3) Compute the average of the values from step 2, denote it by λ_{max}.

4) Then approximate (Equation 1)

Where: λ_{max} is the eigenvalues of the pairwise comparison matrix and n is the number of row or column of pairwise comparison matrix (Table 2 and Table 3).

3 Results and discussion

3.1 Effect of simulated forward speed and angle of belt on discharging and precision indices

Discharging index values increase as the speed was increased but decreased with increasing the angle (Figure 4); with lower speed and at higher angles, the metering device belt does not get enough time to pick up seeds, resulting in lower discharging indices.

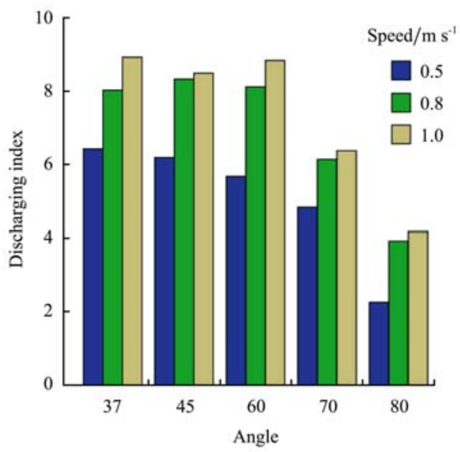

Figure 4 Effect of speed on discharging index at five different angle of metering device

For precision index the effect of speed is complicate at different angles, middle speed indicated high precision index at lower angles while high speed raised quickly with increasing angle of metering device and at angle of 80° high speed had higher precision index among three different speeds (Figure 5). The multiple regression equations for the discharging index I_{dis} and precision index I_p, incorporating the simulated forward speed v in m s^{-1}, and angle α in degree, are given as:

$$I_{dis} = -10.957 + 22.724v + 0.393\alpha - 10.344v^2 - 0.004\alpha^2 - 0.054v\alpha \quad (1)$$

$$I_p = 0.467 + 1.131v + 1.074\alpha\ 10^{-5} - 0.955v^2 - 3.857\alpha^2\ 10^{-5} + 0.007v\alpha \quad (2)$$

with values for the coefficient of determination R^2 of 0.93 and 0.95, respectively.

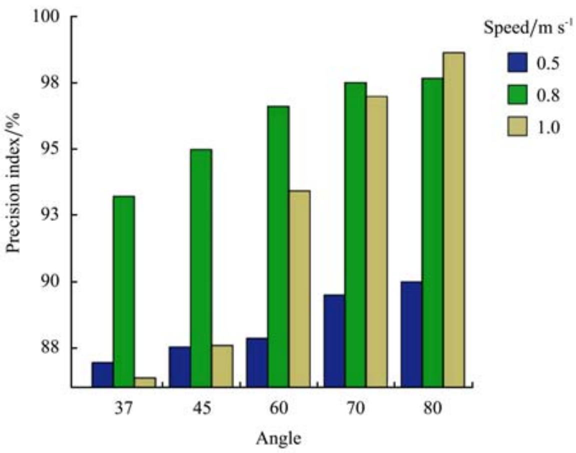

Figure 5 Effect of speed on precision index at five different angle of metering device

It may be noted from Equations (1) and (2) that the speed of the metering device belt has a more pronounced effect than the angle on both the discharging index and precision index. At speeds higher than 0.77 m s^{-1} and belt angle lower than 55°, the discharging index values obtained from Equation (1) are more than eight billets in one second also four billets in second is desired discharging index and occurred in angles more than 69° (Figure 6). At these speeds higher than 0.77 m s^{-1}, however, precision index values ranged higher than 95%. On the other hand, precision indices are computed to be less than 90% at speeds lower than 0.7 m s^{-1}. The lower effect of angles on the values of precision indices is shown in Figure 7 at lower speeds.

The mean discharging and precision in spacing define the pattern of seed distribution of metering device. The effects of speed and belt angle on these values are shown in Figures 6 and 7 with contour analysis of their response surface. It is observed that discharging and precision indices both are affected by the speed and angle of the metering device.

3.2 Hierarchy decision tree making

The first stage in Analytical Hierarchy Process is making a graphical view of tests. Such a hierarchy can be visualized as a diagram (Figure 8), with the goal at the top to determine the best operating condition for sugarcane billet metering device. The 15 alternatives at the bottom indicated the way in reaching the goal, and the two criteria in between against which the alternatives need to be measured. There are useful terms for describing the parts of such diagrams: each box is called a node. A node that is connected to one or more nodes in a level below it is called a parent node. The nodes to which it is so connected are called its children.

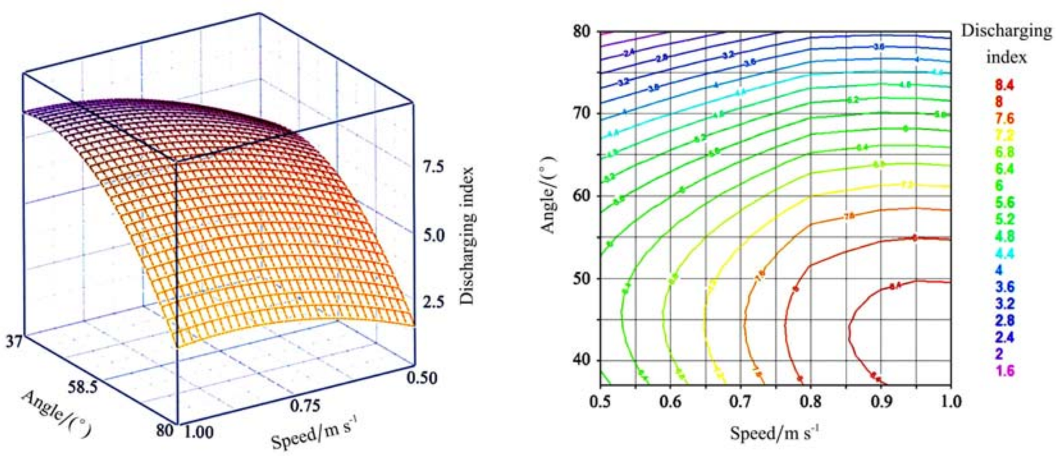

Figure 6 Effect of simulated forward speed and angle on discharging index with its contour analysis

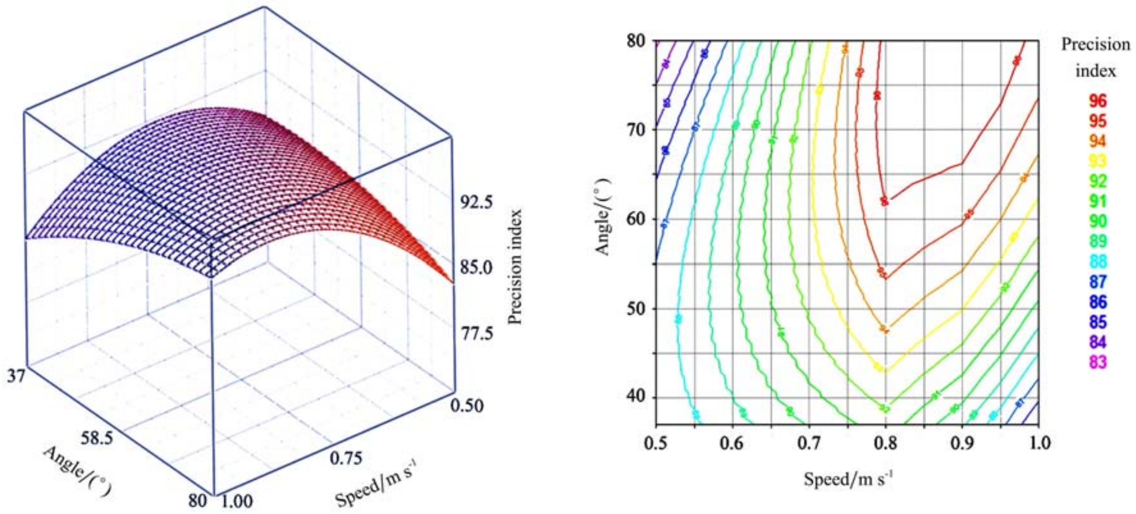

Figure 7 Effect of simulated forward speed and angle on precision index with its contour analysis

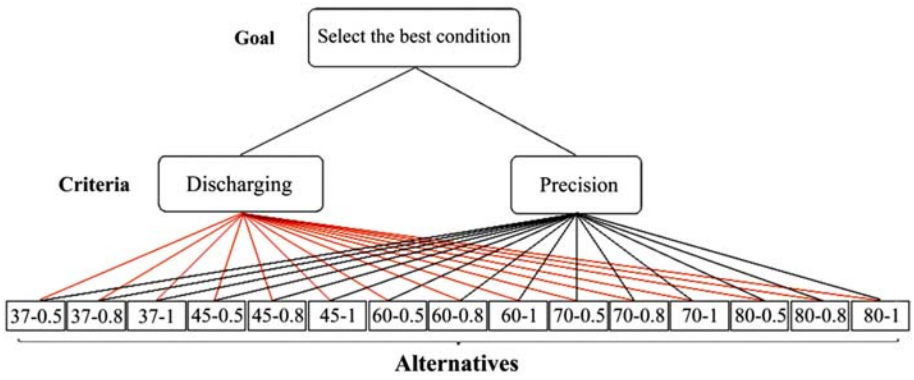

Figure 8 AHP hierarchy for choosing the best

3.3 Evaluation of priorities

Analytical hierarchy process evaluated priority of each node in each level in relation with its parent by pairwise comparison that named local priority. Then with incorporation of local priorities, overall priority of each alternative specified. First alternatives compared with respect to criteria separately and priority of each alternative in relation with these criteria evaluated. Afterwards priority of criteria in relation with goal specified and overall priority of alternatives determined via incorporating them.

All comparison in analytical hierarchy process performed in pairwise. For example if we compare alternatives with respect to discharging index, first alternative 1 (37° angle and 0.5 m s^{-1} speed of metering device) compared with alternative 2 (37° angle and 0.8 m s^{-1} speed of metering device), then this comparison performed with alternatives 1 and 3 (37° angle and 1 m s^{-1} speed of metering device) and also with 2 and 3.

Because of importance of reduction in amount of used billets in metering device, the number of billets discharged in one second (discharging index) preferred to the percent of billets that discharged correctly (precision index) with 3 to 1 ratio and priority of each alternative

Table 1 Validated values for discharging and precision indices

Alternative	Position	Precision	Discharging
1	37-0.5	86.96	6 (6.43)
2	37-0.8	93.21	5 (8.03)
3	37-1	86.37	4 (8.93)
4	45-0.5	87.54	7 (6.19)
5	45-0.8	94.98	6 (8.33)
6	45-1	87.60	5 (8.49)
7	60-0.5	93.41	4 (8.84)
8	60-0.8	97.61	6 (8.12)
9	60-1	88.54	7 (5.68)
10	70-0.5	84.86	7 (4.84)
11	70-0.8	97.67	7 (6.14)
12	70-1	96.99	8 (5.05)
13	80-0.5	84.64	7 (2.26)
14	80-0.8	96	9 (3.93)
15	80-1	98.64	9 (4.18)

spotted its gained ratio in tests for the precision index but since we prefer four numbers of billets discharged in one second, we used 1-9 scale to validate these numbers (Table 1).

We must respect that in pairwise comparison, the priority of each alternative in relation with own is 1 thus all numbers on diameter of pairwise comparison matrix equaled to 1. Also that is obvious if priority of A to B was 2, the priority of B to A would be 0.5. The pairwise comparison matrixes indicated in Table 2 and Table 3.

Table 2 Pairwise comparison matrix for precision index

Alternatives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1	0.933	1.007	0.993	0.916	0.993	0.931	0.891	0.982	1.025	0.890	0.897	1.027	0.906	0.882
2	1.072	1	1.079	1.065	0.981	1.064	0.998	0.955	1.053	1.098	0.954	0.961	1.101	0.971	0.945
3	0.993	0.927	1	0.987	0.909	0.986	0.925	0.885	0.975	1.018	0.884	0.891	1.020	0.900	0.876
4	1.007	0.939	1.014	1	0.922	0.999	0.937	0.897	0.989	1.032	0.896	0.903	1.034	0.912	0.887
5	1.092	1.019	1.100	1.085	1	1.084	1.017	0.973	1.073	1.119	0.972	0.979	1.122	0.989	0.963
6	1.007	0.940	1.014	1.001	0.922	1	0.938	0.897	0.989	1.032	0.897	0.903	1.035	0.913	0.888
7	1.074	1.002	1.082	1.067	0.983	1.066	1	0.957	1.055	1.101	0.956	0.963	1.104	0.973	0.947
8	1.122	1.047	1.130	1.115	1.028	1.114	1.045	1	1.102	1.150	0.999	1.006	1.153	1.017	0.990
9	1.018	0.950	1.025	1.011	0.932	1.011	0.948	0.907	1	1.043	0.907	0.913	1.046	0.922	0.898
10	0.976	0.910	0.983	0.969	0.893	0.969	0.908	0.869	0.958	1	0.869	0.875	1.003	0.884	0.860
11	1.123	1.048	1.131	1.116	1.028	1.115	1.046	1.001	1.103	1.151	1	1.007	1.154	1.017	0.990
12	1.115	1.041	1.123	1.108	1.021	1.107	1.038	0.994	1.095	1.143	0.993	1	1.146	1.010	0.983
13	0.973	0.908	0.980	0.967	0.891	0.966	0.906	0.867	0.956	0.997	0.867	0.873	1	0.882	0.858
14	1.104	1.030	1.111	1.097	1.011	1.096	1.028	0.984	1.084	1.131	0.983	0.990	1.134	1	0.973
15	1.134	1.058	1.142	1.127	1.039	1.126	1.056	1.011	1.114	1.162	1.010	1.017	1.165	1.028	1

Table 3 Pairwise comparison matrix for discharging index

Alternatives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1	1.2	1.5	0.857	1	1.2	1.5	1	0.857	0.857	0.857	0.750	0.857	0.667	0.667
2	0.833	1	1.25	0.714	0.833	1	1.25	0.833	0.714	0.714	0.714	0.625	0.714	0.556	0.556
3	0.667	0.8	1	0.571	0.667	0.8	1	0.667	0.571	0.571	0.571	0.5	0.571	0.444	0.444
4	1.167	1.4	1.75	1	1.167	1.4	1.75	1.167	1	1	1	0.875	1	0.778	0.778
5	1	1.2	1.5	0.857	1	1.2	1.5	1	0.857	0.857	0.857	0.75	0.857	0.667	0.667
6	0.833	1	1.25	0.714	0.833	1	1.25	0.833	0.714	0.714	0.714	0.625	0.714	0.556	0.556
7	0.667	0.8	1	0.571	0.667	0.8	1	0.667	0.571	0.571	0.571	0.5	0.571	0.444	0.444
8	1	1.2	1.5	0.857	1	1.2	1.5	1	0.857	0.857	0.857	0.75	0.857	0.667	0.667
9	1.167	1.4	1.75	1	1.167	1.4	1.75	1.167	1	1	1	0.875	1	0.778	0.778
10	1.167	1.4	1.75	1	1.167	1.4	1.75	1.167	1	1	1	0.875	1	0.778	0.778
11	1.167	1.4	1.75	1	1.167	1.4	1.750	1.167	1	1	1	0.875	1	0.778	0.778
12	1.333	1.6	2	1.143	1.333	1.6	2	1.333	1.143	1.143	1.143	1	1.143	0.889	0.889
13	1.167	1.4	1.75	1	1.167	1.4	1.75	1.167	1	1	1	0.875	1	0.778	0.778
14	1.5	1.8	2.25	1.286	1.5	1.8	2.25	1.5	1.286	1.286	1.286	1.125	1.286	1	1
15	1.5	1.8	2.25	1.286	1.5	1.8	2.25	1.5	1.286	1.286	1.286	1.125	1.286	1	1

Simple mean used to the weight of each cell in pairwise comparison matrix (local priority). This step is to normalize the matrix by totaling the numbers in each column. This method includes three stages:

1) Sum of each column computed.

2) Each entry in the column is then divided by the column sum to yield its normalized score. In normalized matrix the sum of each column is 1.

3) The next stage is to compute the average values of each row and use these as the weights in the Objective Hierarchy.

Table 4 indicated final weights of each alternative in its criteria. These weights would be used in summing the measures as required in the evaluation of the Objective Hierarchy.

Then the weight of each criterion in relation with goal was determined and a pairwise comparison of criteria was done. The pairwise comparison matrix of criteria is indicated in Table 5 and Table 6.

Table 4 Weight of alternatives in each criterion

Alternative	Weights in Precision	Weights in Discharging
1	0.063	0.062
2	0.068	0.052
3	0.063	0.041
4	0.064	0.072
5	0.069	0.062
6	0.064	0.052
7	0.068	0.041
8	0.071	0.062
9	0.064	0.072
10	0.062	0.072
11	0.071	0.072
12	0.071	0.082
13	0.062	0.072
14	0.070	0.093
15	0.072	0.093

Table 5 Criteria pairwise comparison matrix

	Precision	Discharging
Precision	1	3
Discharging	0.33	1
Total	1.33	4

Table 6 Criteria normalized pairwise comparison and local priority computing

	Precision	Discharging	Row average
Precision	0.75	0.75	0.75
Discharging	0.25	0.25	0.25
Total	1	1	1

3.4 Evaluating overall priorities of alternatives

After computing the weight of criteria in relation with goal (Table 6) and the weight of alternatives in relation with criteria (Table 4), we can determine the priorities of alternatives in relation with goal (overall priorities). Whereas weight of criteria indicated their importance in goal and weight of each alternative in relation with criteria indicated importance of alternative in criteria that is obvious the overall priority of each alternative computed via total of weight of criteria multiple the weight of alternative in criteria. Finally, overall priority of each alternative computed with respect to local priorities (Table 7).

According to Table alternative 15 with simulated forward speed of 1 m s^{-1} and 80° angle of metering device is the best condition for sugarcane billet metering device with 98.64% for precision index and 4.18 billets per second for discharging index, alternative 14 with 0.8 m s^{-1} simulated forward speed and 80° angle of metering device with 96 % for precision index and 3.93 for discharging index is the next and are followed with 12 alternative with 1 m s^{-1} simulated forward speed and angle of 70° for metering device with 96.99% for precision index and 5.05 for discharging index.

Table 7 Overall priorities of each alternative

Alternatives	Overall priorities
1	(0.75 × 0.062) + (0.25 × 0.063) = 0.062
2	(0.75 × 0.052) + (0.25 × 0.068) = 0.056
3	(0.75 × 0.041) + (0.25 × 0.063) = 0.047
4	(0.75 × 0.072) + (0.25 × 0.064) = 0.070
5	(0.75 × 0.062) + (0.25 × 0.069) = 0.064
6	(0.75 × 0.052) + (0.25 × 0.064) = 0.055
7	(0.75 × 0.041) + (0.25 × 0.068) = 0.048
8	(0.75 × 0.062) + (0.25 × 0.071) = 0.064
9	(0.75 × 0.072) + (0.25 × 0.064) = 0.070
10	(0.75 × 0.072) + (0.25 × 0.062) = 0.070
11	(0.75 × 0.072) + (0.25 × 0.071) = 0.072
12	(0.75 × 0.082) + (0.25 × 0.071) = 0.079
13	(0.75 × 0.072) + (0.25 × 0.062) = 0.070
14	(0.75 × 0.093) + (0.25 × 0.070) = 0.087
15	(0.75 × 0.093) + (0.25 × 0.072) = 0.088

3.5 Consistency analysis

Table 8 represented the weight of each alternative in precision index and discharging index pairwise comparison matrixes (Table 2 and Table 3) and total weight, where W_1 and W_2 are the weight of each alternative in precision index and discharging index criteria, respectively.

Table 8 Weight of each alternative in criteria and total weight

Alternatives	W_1		W_2		$W_1 + W_2$
1	0.016	+	0.047	=	0.063
2	0.017	+	0.039	=	0.056
3	0.016	+	0.031	=	0.047
4	0.016	+	0.054	=	0.070
5	0.017	+	0.047	=	0.064
6	0.016	+	0.039	=	0.055
7	0.017	+	0.031	=	0.048
8	0.018	+	0.047	=	0.065
9	0.016	+	0.054	=	0.070
10	0.016	+	0.054	=	0.070
11	0.018	+	0.054	=	0.072
12	0.018	+	0.062	=	0.080
13	0.016	+	0.054	=	0.070
14	0.018	+	0.070	=	0.088
15	0.018	+	0.070	=	0.088

Table 9 indicated computing λ for each alternative, average of λ resulted λ_{max} that was used to calculating consistency index.

Table 9 Computing λ and λ_{max} for consistency index

Alternatives	$(A_1 \times W_1$	+	$A_2 \times W_2)$	/	(W_1+W_2)	=	Λ
1	(0.240	+	0.699)	/	0.063	=	14.904
2	(0.257	+	0.582)	/	0.056	=	14.993
3	(0.238	+	0.466)	/	0.047	=	14.984
4	(0.242	+	0.815)	/	0.070	=	15.101
5	(0.262	+	0.699)	/	0.064	=	15.016
6	(0.242	+	0.582)	/	0.055	=	14.984
7	(0.258	+	0.466)	/	0.048	=	15.076
8	(0.269	+	0.699)	/	0.065	=	14.897
9	(0.244	+	0.815)	/	0.070	=	15.141
10	(0.234	+	0.815)	/	0.070	=	14.995
11	(0.270	+	0.815)	/	0.072	=	15.070
12	(0.268	+	0.932)	/	0.080	=	14.994
13	(0.234	+	0.815)	/	0.070	=	14.987
14	(0.265	+	1.048)	/	0.088	=	14.925
15	(0.272	+	1.048)	/	0.088	=	15.008
					λ_{max}	=	15.005

Via λ_{max} and Equation (1), it is possible to determine consistency index:

Calculating consistency ratio calculated via:

$$CR = \frac{CI}{IR} \quad (2)$$

where, *IR* is random index, this index is determined by Harker and Vargas (1987) (Table 10).

Table 10 Random consistency index

n	1	2	3	4	5	6	7	8
R.I.	0	0	0.58	0.9	1.12	1.24	1.32	1.41
n	9	10	11	12	13	14	15	-
R.I.	1.45	1.49	1.51	1.48	1.56	1.57	1.59	-

Because n=15 then *R.I* = 1.59 and finally:

According to *CI* = 0.00023 and is lower than 0.1; results in Table 7 are acceptable and there is no need to revising them.

4 Conclusion

Austoft sugarcane planter was studied and Computer Aided Design (CAD) of sugarcane billet metering device was simulated by using Catia V5.R21 (2011). The sugarcane billet metering device fabricated by using CAD model for scientific and laboratory tests. Tests were done to find out the best condition for sugarcane metering device. Regression models for discharging and precision indices presented with 0.95 and 0.93 R^2 respectively. Analysis indicated that the speed of the metering device belt had a more pronounced effect than the angle on both the discharging index and precision index. Desired discharging index values occurred in angles more than 69° for four billets in a second. At speeds higher than 0.77 m s^{-1}, precision index values ranged higher than 95%. From analytical hierarchy process, it was observed that angle 80° and speed of 1 m s^{-1} was best suited for sugarcane billet metering device working condition with 98.64 % for precision index and 4.18 billets in per second for discharging index. Also angle of 80° with speed of 0.8 m s^{-1} and angle of 70° with speed of one m s^{-1} are the next suited conditions. The value of consistency ratio was 0.00023 and was lower than 0.1, which indicated there was no need to revise results. The result of this article can be used for improving the sugarcane planters yielding by providing the best traction condition for metering device of billets in full automatic sugarcane planters.

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