Experimental study on lodged corn harvest loss of small harvesters

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Abstract: The harvesting difficulty caused by corn lodging aggravated the loss of grain, especially in the regions where small harvesters were used as the main force for corn harvesting. An experimental study and analysis of harvest loss of small harvesters on the root lodged corn were made to get the laws of lodged corn harvest loss. The experiment was conducted in different harvesting directions and at a range of harvesting speeds. A 4-row self-propelled corn harvester (JM-4Y), a 2-row crawler type self-propelled corn harvester (JM-2C), and a 2-row crawler-type corn harvester equipped with a spiral auxiliary feeding device for lodged stalks (JM-2CAF) were taken as the research objects and the grain loss per square meter and the ear loss quantity per 30 square meters were taken as the experiment indices. The results showed that the average grain loss masses of the JM-4Y harvester, the JM-2C harvester and the JM-2CAF harvester in different harvesting directions were 101.88g, 285.72 g and 110.20 g, while the average corn ear losses were 10.08, 33.54 and 9.28 pieces. The lowest harvest loss of the JM-4Y harvester appeared when the harvesting was the same as the lodging direction, while the JM-2CAF harvester caused the lowest harvest loss when the harvesting direction was opposite to the lodging direction. The different feeding demands of the ordinary harvester head and the auxiliary feeding devices made the harvesters have different feeding conditions. At different harvesting speeds, the average grain loss mass of the JM-4Y harvester, the JM-2C harvester and the JM-2CAF harvester were 139.06 g, 453.42 g and 236.64 g while the average corn ear loss quantities were 15.12, 52.52 and 34.80 pieces. The JM-4Y harvester had the lowest harvest loss at almost every harvesting speed, and the JM-2CAF harvester only had lower harvest loss when the harvesting speed was lower than 0.8 m/s. The insufficient time to lift and deliver the lodged stalk and the impact between the spiral blades and the stalks were the causes of harvest loss when harvesting speed got higher. This study provides practical and theoretical references for the loss reduction of lodged corn harvesting.

Keywords: corn, combine harvester, harvest loss, lodging, small harvester, experimental study
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1 Introduction

At present, researches on corn lodging focus mainly on the cultivation of lodging resistance[1-5]. Generally, the stem structure strength is taken as the optimization index for variety cultivation[6-8]. This will lead to a higher structural strength of corn stalk in recent decades[9]. More and more researches focus on the measurement and prediction of root and stalk lodging resistance in engineering practice[10]. For example, Wen et al.[11] and Robertson et al.[12] proposed that the bending strength could reflect the ability of stalk lodging resistance. Cook et al.[13] designed a measuring device with a phenotyping method for stalk strength, and measured the bending strength of corn stalks at different heights. Guo et al.[14,15] developed a non-destructive method to classify corn stalk lodging resistance by exerting the maximum equivalent force on corn stalks. Allcroft et al.[16] and Brune et al.[17] built analysis models to quantify root lodging and lodging resistance of corn stalks. As one of the main factors that can cause large areas of lodging, the wind force was studied to determine its relationship with lodging quantitatively. The characteristics of stalk lodging under different wind forces were simulated in the wind field[18-20]. Also, the estimation of dimensions and severity of lodging is taken as a research hotspot[21,22]. Han et al.[23] and Wilke et al.[24] used UAVs to collect information on the lodging situation based on image recognition, and accurately measured the lodging area. Li et al.[25] and Chauhan et al.[26] used satellite images to collect and analyze lodging information.

However, the above studies just evaluated the potential probability of lodging or the possibility of yield reduction. The difficulties in mechanized harvesting of lodged corn and the caused grain loss had not been paid enough attention to, especially when the task was fulfilled with small harvesters[27]. In the regions where agricultural technology is relatively developed, the harvest loss of lodged corn can be effectively reduced by adopting harvesters with wider heads[28]. But in China and other areas with smaller farm sizes, harvesters with narrow heads of less than 4 rows are taking the dominant position in the harvest of lodged corn. As the narrow heads cannot deal with the whole plant lateral feeding of the lodged corn, the loss is usually extremely high in the

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harvest[29].

Therefore, it is of help to corn production to clarify the operation characteristics of small harvesters with the lodged corn. By employing different harvesting modes on the lodged corn, the operation rolls will be generalized to guide the work of harvesters. This paper presents the harvest loss of 3 types of small corn harvesters equipped with a 4-row head, a 2-row head, and a modified model based on a 2-row head, respectively. The difference of loss caused by harvester structure and dynamic parameters is compared and analyzed. The impact of working factors including the harvesting speed and the relationship between harvesting direction and lodging direction on the harvest loss is discussed. The aim of this research is to obtain the best operation mode of small harvesters in harvesting lodged corn, and provide references for the improved design of small harvesters.

2 Materials and methods

2.1 Corn used in the experiment

Corn used in this experiment was planted in Changpaozi Village, Xiwei Town, Yitong Manchu Autonomous County, Jilin Province (43.139 °N, 125.336 °E). The corn variety was Xianyu-335. The sowing time of the corn was from April 20 to 30, 2020. The farmland was attacked by three typhoons in a row, namely, “Bavi” on Aug. 27, “Maysak” on Sept. 3, and “Haishen” on Sept. 7. The typhoons resulted in large areas of corn lodging. The measurement showed that the lodging rate of corn in the experiment was 92.4%, the main lodging form was root lodging, and the stalk breaking was less than 5%. The lodging of all the corn stalks was basically in the same direction, as shown in Figure 1.

Figure 1 The lodged corn used in the experiment

Before the experiment, the moisture contents of the grains and the corn stalks were measured with the oven-dry method. The result showed the grain moisture content was 31.7% while the corn stalk moisture content was 81.6%.

2.2 Harvesters used in the experiment

There were three corn harvesters used in the experiment, as shown in Figure 2. They were the 4YZP-4Y wheeled self-propelled corn ear harvester (JM-4Y harvester) and the 4YZLP-2C crawler style self-propelled corn ear harvester (JM-2C harvester) manufactured by Shandong Juming Machinery Co., Ltd., and the 4YZLP-2C crawler self-propelled harvester that equipped with a self-designed spiral auxiliary feeding device for lodged corn (JM-2CAF harvester).

Among the three harvesters, the JM-4Y harvester was equipped with an engine of 147 kW output power and a 4-row head with a width of 2600 mm, as shown in Figure 2a. The adopted snapping units were equipped with six-rowed stalk rolls and straight snapping plates with big fillets. The rotating speed of the stalk rolls was 950 r/min. The length of the picking section on the snapping plates was 800 mm. The inclination angle of the corn head was 30° at work. The minimum corn picking height of the head was 450 mm. The rated forward speed of the harvester was 0.56-1.11 m/s.

a. Juming 4YZP-4Y wheeled self-propelled corn ear harvester (JM-4Y harvester)

b. Juming 4YZLP-2C crawler style self-propelled corn ear harvester (JM-2C harvester)

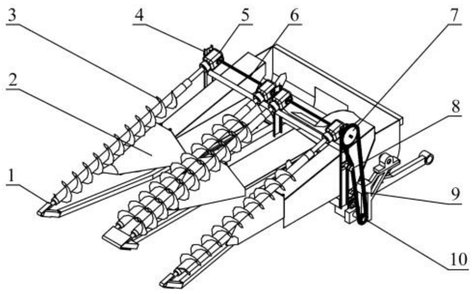
c. Juming 4YZLP-2C crawler harvester equipped with spiral auxiliary feeding device for lodged corn (JM-2CAF)

Figure 2 Three corn harvesters used in the experiments

The JM-2C harvester (Figure 2b) head had a width of 1 500 mm. The output power of its engine was 48 kW. The JM-2C harvester relied on two 500 mm wide rubber tracks to travel. Its rated forward speed was 0.56-1.11 m/s. The snapping units of this harvester were the same as those of the JM-4Y harvester. The rotating speed of its stalk rolls was also 950 r/min. The heads of the JM-2C harvester and the JM-4Y harvester had the same working parameters except for the number of working rows. When the JM-2C harvester was working, the head inclination angle was also 30° and the minimum harvesting height was 450 mm. The same parameters of the heads on the JM-2C harvester and the JM-4Y harvester ensured the complete comparability of working parameters and working quality of the harvesters.

The JM-2CAF corn harvester was refitted from the JM-2C harvester. A spiral auxiliary feeding device for lodged stalks was installed on the head of the JM-2CAF harvester, as shown in Figure 3. The structure of the spiral auxiliary feeding device for lodged stalks included stalk dividers, spiral stalk lifters, support frame, horizontal shaft, gearboxes and the chain transmission system. The chain transmission system included a power output sprocket, power input sprocket, tension wheel and the transmission chain. The stalk dividers were installed on the bottom of the corn head and extended forward. The front part of the stalk divider was tilted upward to reduce soil resistance. There was a cover plate at the end of the divider to prevent grass entanglement and blockage. The spiral stalk lifters were connected with the output shaft of the gearboxes through couplings. The gearboxes were installed on the horizontal shaft that was driven by the power input sprocket of the chain transmission system. The power of the spiral auxiliary feeding device was transmitted from the power output sprocket to the power input sprocket through the transmission chain. The specific parameters of the spiral stalk lifters were as follows: the outer diameter of the spiral stalk lifter was 150 mm; the inner diameter was 50 mm; the pitch of the spiral blades was 150 mm; the length of the spiral was 1500 mm; the inclination angle was 30° that consistent with the corn head; the rotating speed was 300 r/min.

When the JM-2CAF harvester was working, the stalk dividers extended forward into the bottom of the lodged corn stalks, bringing the spiral blades into contact with the stalks. With the forward of the harvester and the rotating of the spiral lifter, the lodged stalks were lifted and delivered to the snapping position of the head. Then the ear picking was completed.



1. Stalk divider 2. Corn head 3. Spiral stalk lifter 4. Support frame 5. Gearbox 6. Horizontal shaft 7. Power input sprocket 8. Tension wheel 9. Transmission chain 10. Power output sprocket

Figure 3 Structure diagram of the JM-2CAF corn harvester head

2.3 Experimental indices

In the experiment, grain loss and corn ear loss were taken as the quantitative indices of the harvesting. Thereinto, the weight of grain dropped to the ground in one square meter was used as the measurement index of grain loss. After each implementation, 5 measurement units were randomly selected with an area of 1 m^2. The stalks were removed from the ground surface to collect the grains, as shown in Figure 4a. The grains connected to the corn cobs were threshed off to weigh with the ones scattered on the ground.

As lodging disturbed the row distribution of corn stalks, it was difficult to measure the corn ear loss by rows and harvesting distance. The losses of corn ears in this experiment were counted within randomly selected areas of 30 m^2. After each trial, an oblong plot was selected randomly to count the corn ears dropped on the ground. The length and width of each plot were 10 m and 3 m. The length of the plot was in the same direction as the forward direction of the corn harvester. The dropped corn ears in the defined area were collected, and the crushed corn ears were pieced together to get the precise number, as shown in Figure 4b. The measurement of ear loss was repeated 3 times, and the average values of ear loss in each experiment were calculated.

a. Grain loss statistics

b. Corn ear loss statistics

Figure 4 Statistics of grain loss and ear loss in the harvest

2.4 Experimental factors

2.4.1 Harvesting direction and lodging direction

In the process of corn ear picking, the stalks were pulled downward by the stalk rolls. When the corn ears got contact with the snapping plates and stopped to move down, the ear peduncle was forced to break. The interaction between stalks and the stalk rolls, as well as the way corn stalks fed into the snapping position had important influences on the process of ear picking. Therefore, the relationship between the forward direction of the harvesters and the stalk lodging direction had great impacts on the harvest loss. In this study, experiments were conducted on the lodged corn at different harvester forward directions to determine how the feeding mode affects the harvest loss.

The harvesters were employed to pick the corn ears on the lodged stalks along with the following travel directions: a. the forward direction of the harvesters was the same as the stalk lodging direction (the intersection angle was 0°), as shown in Figure 5a; b. the forward direction of the harvesters had a 45° intersection angle with the stalk lodging direction, as shown in Figure 5b; c. the forward direction of the harvesters was perpendicular to the stalk lodging direction, as shown in Figure 5c; d. the forward direction of the harvesters had a 135° intersection angle with the stalk lodging direction, as shown in Figures 5d and 5e. the forward direction of the harvesters was opposite to the lodging direction of the stalks, as shown in Figure 5e. In order to ensure comparability of the obtained data, the forward speeds of the three corn harvesters were set to 0.5 m/s uniformly. After harvesting, the grain loss and ear loss were recorded and analyzed.

a. 0° b. 45° c. 90° d. 135° e. 180°

Figure 5 Harvesting of lodged corn with different intersection angles

2.4.2 Harvester forward speed

The feeding quantity of corn plants on the corn head was controlled through the harvester's forward speed. So the forward speed of the harvesters had an important impact on the harvest efficiency and harvest loss of the lodged corn. By controlling the forward speed of the harvesters, the best operating speed of the harvesters for lodged corn could be obtained, and the influence of feeding quantity on harvest loss could be compared and analyzed.

In order to eliminate the systematic statistical error caused by the harvesting direction, the three repetitions of each harvester were carried out as follows: the harvestings were conducted in the same direction with the stalk lodging direction, perpendicular to the stalk lodging direction, and opposite to the stalk lodging direction, respectively. The rated harvesting speeds of the harvesters applied in this experiment were set in the range of 0.56-1.11 m/s. The harvesting speed range in this experiment was a little larger than the rated harvesting speed. The experiments were conducted at speeds of 0.4, 0.6, 0.8, 1.0 and 1.2 m/s, respectively. The grain loss and ear loss of the above were measured, and the average values were calculated for the comparative analysis.

3 Results and discussion

3.1 Effect of harvesting direction

The harvest loss of the three harvesters on lodged corn in different harvesting directions is listed in Table 1. For the JM-4Y harvester, when the forward direction was the same as the lodging direction or at an intersection angle of 45°, the feeding of corn plants started from the roots to the tops, and the grain loss and ear loss were maintained comparatively low. In these situations, the grain loss and ear loss showed no significant change with the increase of the intersection angle between the forward direction and the corn lodging direction. When the intersection angle increased to 90°, the feeding direction was perpendicular to the lodging plant, the grain loss and ear loss increased significantly. Compared to the situations when the intersection angles were smaller than 45°, the grain loss mass and corn ear loss quantity increased 2.05 and 5.22 times respectively; when the intersection angle increased to 135° and 180°, the feeding of corn stalks started from the top of the plants, the grain loss and ear loss increased sharply. The grain loss mass and corn ear loss quantity increased 5.47 and 11.57 times compared to the situations when the intersection angles were smaller than 45°.

Table 1 Grain loss and ear loss of the 3 harvesters at different harvesting directions

Harvester	The intersection Angle/(°)	Grain loss /g m^{-2}	Ear loss quantity in 30 m^2 (pieces)
JM-4Y	0	26.7	1.7
	45	31.5	1.3
	90	89.0	9.7
	135	168.8	20.7
	180	193.4	17.0
JM-2C	0	223.5	24.3
	45	208.8	28.0
	90	361.4	36.7
	135	311.2	40.7
	180	323.7	38.0
JM-2CAF	0	196.0	16.7
	45	177.2	19.0
	90	97.3	3.7
	135	43.2	4.3
	180	37.3	2.7

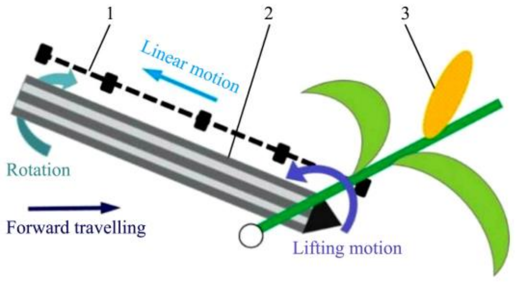
For the JM-2C harvester, the grain loss and ear loss stayed at high values when the harvester moved forward at different intersection angles with the stalk lodging direction. With the increase of the intersection angle, the grain loss and ear loss showed a trend of increasing. When the intersection angle was 90°, its grain loss mass and corn ear loss quantity increased by 67% and 47% respectively compared to the situations when the intersection angles were smaller than 45°. When the intersection angle increased to 135° and 180°, the average grain loss mass and corn ear loss quantity increased by 40% and 50% compared to the situations when the intersection angles were smaller than 45°.

For the JM-2CAF harvester, the harvest loss was obviously lower than that of the JM-2C harvester. Moreover, with the increase of the intersection angle between the forward direction and the stalk lodging direction, the harvest loss decreased continually. In other words, the grain loss reached the minimum when the lodged corn stalks were fed to the harvester from the top of the plants. This was contrary to the JM-4Y harvester and the JM-2C harvester. It meant the spiral stalk lifters had changed the movement law of stalks in the feeding on the ordinary corn heads. It avoided the factors that caused severe loss when the stalks were fed from the top of plant and caused greater loss when the corns were harvested from the direction of corn roots.

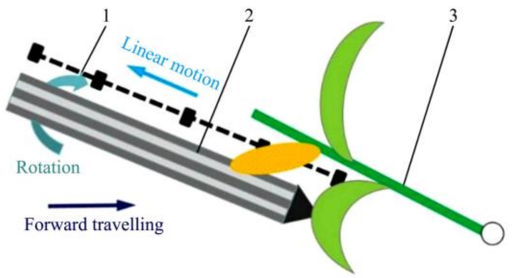
Comprehensively comparing the harvest loss of the three corn harvesters in all harvesting directions, the average grain loss of the JM-4Y harvester, the JM-2C harvester and the JM-2CAF harvester were 101.88 g/m^2, 285.72 g/m^2 and 110.20 g/m^2 respectively, while the corn ear loss quantity per 30 m^2 of these harvesters 10.08, 33.54 and 9.28 pieces. It showed that the JM-4Y harvester and the JM-2CAF harvester had similar high harvesting adaptability to the lodged corn under the tested speed. Yet, the JM-2C harvester was not capable of harvesting lodged corn because of the high harvest loss.

According to the above information, some conclusions could be drawn. Firstly, the harvest loss of the 4-row harvester and the 2-row harvester without an auxiliary feeding device showed an uptrend with the increase of the intersection angle between the forward direction and the lodging direction. It indicated that the harvest loss of the corn heads without auxiliary feeding devices could be reduced by feeding the lodged corn stalks from the roots. In this way, the gathering chains would touch the root stalks first and lift them with the help of the resistance force from corn root. So that the stalk rolls could touch the stalks and pull them down in an easier way, and the corn ears would be picked like on the upright corn stalks, as shown in Figure 6a. Otherwise, the gathering chains would touch corn ears first, as shown in Figure 6b. The corn ears had chance to be picked and gathered by the gathering chain. If the pins on the gathering chains could not break the corn peduncles, the corn ears would be rolled down to the ground and could never be picked. It made the harvest loss stay at high levels when the harvesting was opposite to the lodging direction.

Secondly, the harvest loss of the 4-row harvester was much lower than that of the 2-row harvester. By comparing the structural parameters and working parameters of the two harvesters, it can be speculated that the difference between the harvest loss of the harvesters was resulted from two aspects. On one hand, the wider corn head had a better picking effect on the ears of the lodged corn. As the wider head could involve almost the whole plant of lodged corn into the working space, most stalks would be transported to the snapping positions of the head, so the harvest loss could be reduced, just as shown in Figure 7. It also explained why the harvest loss of the JM-2C harvester reached its maximum value when its forward direction was perpendicular to the stalk lodging direction. On the other hand, the great disparity of engine output power between the harvesters might have made a difference in the harvest loss. As the engine output power of the 4-row harvester was about 3 times of the 2-row harvester in this experiment, the insufficient power of the 2-row harvester might affect the stalk acquisition ability of the gathering chains and stalk rolls. That was why more corn ears were left on the ground and greater loss was caused.



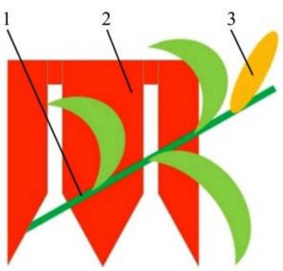
a. Harvester moved in the same direction with corn lodging



b. Harvester moved in the opposite direction with corn lodging

1. Gathering chain 2. Stalk roll 3. Corn stalk

Figure 6 Effects of different harvesting directions on the movement of corn stalks and corn ears



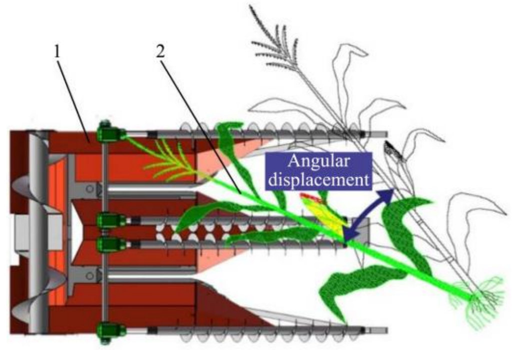
a. Lodged corn harvesting of the 2-row harvester head

b. Lodged corn harvesting of the 4-row harvester head

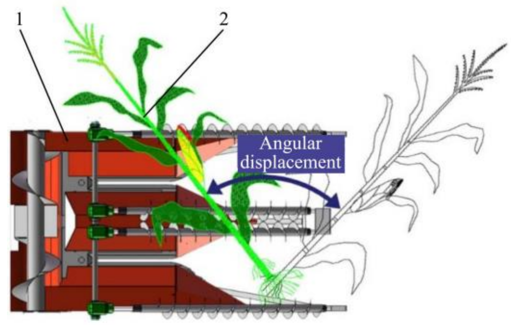
1. Corn stalk 2.Corn harvester head 3. Corn ear

Figure 7 Effect of different harvester head widths on the movement of corn stalks and corn ears

Thirdly, the 2-row harvester head fixed with the spiral auxiliary feeding device could reduce grain loss and corn ear loss dramatically. Furthermore, the lowest harvest loss of the 2-row harvester fixed with the spiral auxiliary feeding device occurred when the harvesting direction was opposite to the stalk lodging direction. It indicated that harvesting from the top of the lodged stalk was more suitable for the spiral auxiliary feeding device on the corn head. It could be inferred that lifting the lodged corn stalk starting from the top of the plant was easier for the spiral auxiliary feeding device. When the harvester equipped with the spiral auxiliary feeding device moved in the same direction as the corn lodging, the angular displacement of the lodged corn stalks was much larger than that when the harvesting direction was opposite to the corn lodging direction, as shown in Figure 8. Because the stalks were lifted with the travel of the harvesters, the stalk lifting was limited in a short moment. The short of time made it difficult to lift the corn ears to their needed snapping height. That led to greater harvest loss. Also, the stalks would impact the rotating spiral blades during the lifting, which could break the corn stalks and cause corn ear loss. What's more, the spiral auxiliary feeding device was more vulnerable to the influence of stalk gravity and the impact of the adjacent stalks. By lifting the stalks from their top, the effect of the stalk's self-gravity and the impact of the adjacent stalks could be minimized.



a. Harvester moved in the opposite direction with corn lodging



b. Harvester moved in the same direction with corn lodging

1. Corn harvester head 2. Corn stalk

Figure 8 Effects of different harvesting directions on the movement of corn stalks on the JM-2CAF harvester

3.2 Effect of harvester forward speed

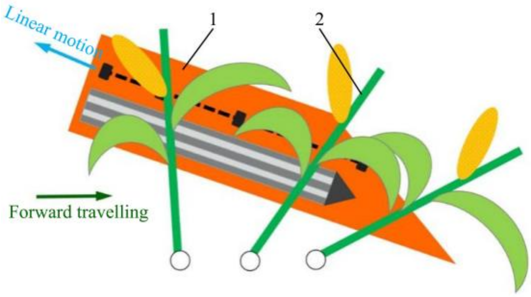
The grain loss and ear loss of the three corn harvesters for lodged corn plants at different harvesting speeds are listed in Table 2. The variation tendency of harvest loss among the three corn harvesters shows strong homogeneity. With the increase of corn harvester forward speed, the grain loss and ear loss of all the harvesters increased obviously. The grain loss of the JM-4Y harvester increased from 59 g/m^2 to around 200 g/m^2, and the quantity of ear loss per 30 m^2 increased from 8.3 to 32.3 pieces; For the JM-2C harvester, the grain loss increased from 279.6 g/m^2 to more than 600 g/m^2, the ear loss increased from 30.7 to 82.3 pieces; The grain loss of the JM-2CAF harvester increased from around 100 g/m^2 to 533.2 g/m^2, and the ears loss increased from 10.3 to 76.7 pieces.

By calculation, the all-speed average grain loss of the JM-4Y harvester, the JM-2C harvester and the JM-2CAF harvester were 139.06 g/m^2, 453.42 g/m^2 and 236.64 g/m^2. The average corn ear loss quantity in 30 m^2 of the JM-4Y harvester, the JM-2C harvester and the JM-2CAF harvester were 15.12, 52.52 and 34.80 pieces. The JM-4Y harvester had the best harvesting adaptability to the lodged corn. The JM-2CAF that equipped with the auxiliary feeding device showed high adaptability to the lodged corn when the harvesting speed was lower than 0.8 m/s.

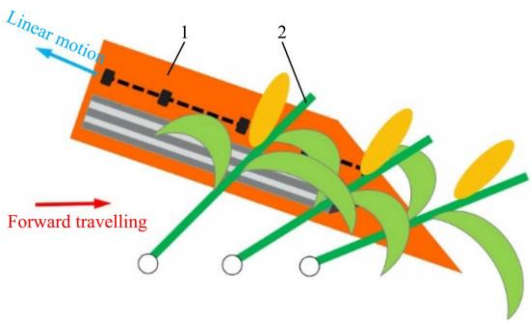
Table 2 Grain loss and ear loss of 3 harvesters at different harvester forward speed

Harvester	Forward speed of the harvester/m s^{-1}	Grain loss /g m^{-2}	Ear loss quantity in 30 m^2 (pieces)
JM-4Y	0.4	59.0	8.3
	0.6	57.1	5.7
	0.8	163.4	15.0
	1.0	222.5	14.3
	1.2	193.3	32.3
JM-2C	0.4	279.6	30.7
	0.6	315.9	43.3
	0.8	444.7	38.3
	1.0	622.5	68.0
	1.2	604.4	82.3
JM-2CAF	0.4	103.1	10.3
	0.6	89.7	18.0
	0.8	136.6	13.3
	1.0	320.6	55.7
	1.2	533.2	76.7

As can be seen, the JM-2C harvester had the highest grain loss and ear loss at different forward speeds. It indicated that harvesters with narrow head width were not suitable for the harvesting of lodged corn without the auxiliary feeding device. The grain loss and ear loss of the JM-4Y harvester were relatively low at every forward speeds. It means the wider head of the JM-4Y harvester was more suitable for the harvest of lodged corn. As the working parameters of corn harvester heads were determined based on the ear picking of upright corn, the speed combination of the gathering chains and the stalk rolls was usually a fixed parameter. But the harvesting of lodged corn needed more time to lift the stalks before corn ear picking. When the harvester moved forward at high speeds, the gathering chains did not have adequate time to lift and feed the corn stalks. The corn stalks would stack in front of the corn harvester head and the corn ears on these stalks could not be picked, as shown in Figure 9. What's more, the stacking of corn stalks in front of the corn harvester heads would also cause severe blockage, as shown in Figure 10a.



a. Corn harvester moved at low speed



b. Corn harvester moved at high speed

1. Corn harvetser head 2. Corn stalk

Figure 9 Effects of harvester forward speeds on the movement of corn stalks

For the JM-2CAF harvester, when the forward speed was low, the harvest loss of the JM-2CAF harvester was close to that of the JM-4Y harvester. With the increase of forward speed, the grain loss and ear loss increased sharply. When the forward speed reached 1.2 m/s, the grain loss and ear loss of the JM-2CAF harvester increased approximately to that of the JM-2C harvester. Therefore, the auxiliary feeding device fixed on the JM-2CAF harvester could reduce the harvest loss of on narrow harvester heads significantly at low speeds. But when the harvester was driven at higher speed, the feeding ability of the spiral auxiliary feeding device would decrease notably. As the stalk lifting and feeding of the JM-2CAF harvester relied on the rotating of the spiral lifters, the spiral blades would lift and deliver the stalks when the rotating speed matched well with the amount of the stalks. Otherwise, the spiral blades would impact the stalks and fracture them. The corn ears on the fractured stalks would fall to the ground and could not be picked, as shown in Figure 10b. Therefore, the JM-2CAF harvester could not have the equivalent adaptability to the lodged corn as the JM-4Y harvester.

a. Head blockage of the JM-2C harvester

b. Stalks fracture on the JM-2CAF harvester

Figure 10 Severe harvest loss caused by over high harvesting speed

4 Conclusions

1) In this study, the factors affecting the lodged corn harvest loss of small corn harvesters were experimented and analyzed on the 4-row JM-4Y harvester, the 2-row JM-2C harvester and the 2-row JM-2CAF harvester equipped with the spiral stalk lifters. The results showed that appropriate harvesting direction, larger head width, lower harvesting speed, and equipping of the auxiliary feeding device could help to reduce harvest loss of lodged corn.

2) In different harvesting directions, the average grain loss of the JM-4Y harvester, the JM-2C harvester and the JM-2CAF harvester were 101.88 g/m^2, 285.72 g/m^2 and 110.20 g/m^2. The average corn ear loss quantities per 30 square meters of these harvesters were 10.08, 33.54 and 9.28 pieces respectively. The JM-4Y harvester and the JM-2CAF harvester had a similar lower harvest loss. The harvest loss of the JM-4Y harvester increased as the intersection angle between the harvesting direction and corn lodging direction got larger, while the JM-2CAF harvester had the

lowest harvest loss when the harvesting direction was opposite to the lodging direction. It was the different feeding demands between the ordinary harvester head and the auxiliary feeding devices that made the harvesters have different feeding conditions.

3) At different harvesting speeds, the average grain loss of the JM-4Y harvester, the JM-2C harvester and the JM-2CAF harvester were 139.06 g/m^2, 453.42 g/m^2 and 236.64 g/m^2. The average corn ear loss quantities per 30 square meters of these harvesters were 15.12, 52.52 and 34.80 pieces respectively. The JM-4Y harvester had the lowest harvest loss at almost every harvesting speed, while the JM-2CAF harvester only had lower harvest loss when the harvesting speed was lower than 0.8 m/s. The insufficient time to lift and deliver the lodged stalk was the main cause of harvest loss when the harvesting speed got higher. For the JM-2CAF harvester, the impact between the spiral blades and the stalks was another reason that caused corn stalk breaking and ear picking failure.

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