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Research Article

Research of the Fracture Morphology and Mechanical Connection Properties of Plot Breeding Wheat Ear

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Abstract: Combining with the plot breeding wheat ear to analysis of its fracture morphology, by changing the stretching velocity (3 and 5 mm/min) and the stretching angle (60° and 90°), the mechanical connection forces of plot breeding wheat ear was tested under 7 kinds of moisture content, the regression model between moisture content and connecting force was established based on the test results using EXCEL. The experimental results showed that, the tensile speed had little impact on tensile ability for breeding wheat ear within the range test, but the clamping angle had significant effects. The research results could provide the reference basis for selection and optimization design parameters of the threshing device.

Keywords: Fracture morphology, mechanical connection properties, plant mechanics, plot breeding wheat

INTRODUCTION

Plot breeding harvesting machine is the key equipment to realize the plot breeding wheat fully mechanized (Stafford *et al*., 1996; Dai *et al*., 2012; Shang *et al*., 2010; Zhao *et al*., 2010). The fracture morphology of plot breeding wheat ear was the important cause of yield loss and seed retention into the threshing device and plot breeding harvesting machine with comb cut off stage (Gao *et al*., 2011; Miu and Kutzbach, 2007). The scholars at home and abroad, which researched the yield loss and seed retention about the wheat ear from the kinematics and dynamics with the harvesting equipment, while ignoring the research of the fracture morphology and mechanical connection properties of plot breeding wheat ear (Reitz, 1996; Miu, 2008; Dai *et al*., 2011).

In this study, by combining with the plot breeding wheat ear to analysis of its fracture morphology, the mechanical connection forces of plot breeding wheat ear was tested and found out the factors that affect the connection forces significantly with the plot breeding wheat harvesting. Which could provide the reference basis for selection and optimization design parameters of the threshing device.

MATERIALS AND METHODS

Structure of the breeding wheat ear: As shown in Fig. 1, the test crop was the Longchun-23 breeding wheat, which wheat ear was compound spike, consists of two parts, the cob and the spikelet. The cob was made up of zigzag permutation proglottid and the

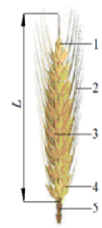

Fig. 1: Structure diagram of breeding wheat ear
1: Cob proglottid; 2: Spikelet; 3: Awn of wheat; 4: Wheat bran; 5: Top spikelet

length of the proglottid owing to the different crop varieties (Lei *et al*., 2011; Brett and Alex, 2002). A wheat ear is usually about more than 10 to over 20 spikelet and forms a double line and its width and arranging tightness owing to the different varieties, which is the foundation of constitute different type spike. The top of the cob have a small spikelet, which stretched and became also by the cob. The bottom of wheat ear often had 1 or 2 small degeneration spikelet, the size were much smaller than stronger spikelet.

Analysis of fracture morphology about the plot breeding wheat ear: The plot breeding wheat ear had 3 different type of fracture morphology. As shown in Fig. 2, the wheat stalks and wheat ear got fracture with the stress concentration and another fracture appeared on the breeding wheat ear cob shaft section.

As shown in Fig. 3, when the half feeding type combine harvester working in the field, which applied of comb cut off stage to harvest the wheat and caused the lots of tear-petiolate breeding wheat affecting

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Fig. 2: Different fracture mode in breeding wheat ear

Fig. 3: Breeding wheat ear with tear-petiolate

performance in threshing device. So that to produce congestion easily in threshing device and increase work loads with the cleaning system.

In the threshing process of breeding wheat, the wheat ear got fracture and tear-petiolate not only was associated with the structure and motion parameters selection of threshing device, but also had a close relationship between each component connection forces of breeding wheat ear. With the mechanical connection forces of plot breeding wheat ear was tested and found out the factors influencing the connection forces. The test results would provide the reference basis for selection and optimization design parameters of the threshing device.

Tensile mechanical properties tests of breeding wheat ear: Test materials were the breeding wheat ear, which collected from Gansu province academy of agricultural sciences. During the tests, the full and no damage of the breeding wheat ear were selected. The material properties parameters of Longchun-23 breeding wheat as shown in Table 1.

Equipment and method of test: As shown in Fig. 4, the tensile mechanical properties tests of breeding

Fig. 4: CMT2502 electronic omnipotent test machine

Fig. 5: Tensile trial process of the breeding wheat ear

wheat ear in Gansu agricultural university-New SANS company joint mechanics laboratory and applied the CMT 2502 electronic omnipotent test machine to measure the tensile force of breeding wheat ear (Zhang *et al*., 2010).

The tensile force size of wheat cob reflected the degree of difficulty or ease about the threshing; this index was the main factor affecting wheat threshing performance. When the connection force was small and applied of threshing device to work, which caused larger threshing material loss of fall grain and easily threw the grain. But when the connection force was too large, which caused threshing difficulty and threshing rate was low. To select the different moisture content and different clamping angle, by using the CMT 2502 electronic omnipotent test machine to measure the tensile force of breeding wheat ear.

Trial operation process: As shown in Fig. 5, in different moisture content (17.4, 18.6, 19.5, 20.7, 21.5, 22.6 and 23.3%, respectively) of breeding wheat ear was rigidly clamped with tester jig. In order to prevent the breeding of wheat ear on both ends of the tester jig slipped, the wheat ear ends was bound up with soft paper of about 18 mm wide and fixed with 502, quick-drying glue. When the both ends of wheat ear were dry,

Table 1: Material properties parameters of longchun-23 breeding wheat

Variety	Length of wheat ear (mm)	Number of grain per panicle	Thousand seed mass (g)	Moisture content (%)
Longchun-23 breeding wheat	116.4-143.5	41.6	43.2	17.4-23.3%

the breeding wheat ear was rigidly clamped with tester jig in different clamping angle (60° and 90°).

After setting the tensile testing program and testing parameters, under setting the different tensile speed (3 and 5 mm/min) of omnipotent test machine to measure the tensile force of breeding wheat ear.

RESULTS AND DISCUSSION

Test results: Under different tensile speed and different clamping angle test, the wheat ear mechanical properties parameter values as shown in Table 2 to 5.

By the test results could be seen that, in the same clamping angles (60° and 90°), the mechanical connection properties parameters values of breeding wheat ear had a little change with the increase of tensile load speed. When the breeding wheat ear was rigidly clamped with tester jig in the clamping angle of 60° and the tensile speed by 3 mm/min increased to 5 mm/min, with the moisture content was raised, the connection force changed from 13.61~20.97 to 13.97~21.40 N, which increased by 2.0~2.65%. When the breeding wheat ear was rigidly clamped with tester jig in the clamping angle of 90° and the tensile speed by 3 mm/min increased to 5 mm/min, with the moisture content was raised, the connection force changed from 7.24~10.86 to 7.31~10.91 N, which increased by 0.46~0.97%. Therefore, the tensile speed within the range test for breeding wheat ear had no effect on the tensile ability.

When the tensile speed by 3 mm/min increased to 5 mm/min and the breeding wheat ear was rigidly clamped by tester jig with the clamping angle reduced constantly and the moisture content was raised, the connection force changed from 7.24~10.91 to 13.61~21.40 N, which increased by 87.9~96.2%. Therefore, the different clamping angle within the range test for breeding wheat ear had a significantly effect on the tensile ability.

The connection force regression model was established about breeding wheat ear: From the analysis of experimental results showed that, within the range test through the EXCEL software fitted out respectively in different clamping angle.

When the breeding wheat ear was rigidly clamped with tester jig in clamping angle of 90° and the tensile speed was 3 mm/min, the regression model between the breeding wheat ear connection force and the different moisture content, which could be given as (1):

$$y = 0.0454x^2 - 1.2801x + 15.847 \tag{1}$$

where,
y = The connection force of breeding wheat ear, N
x = The moisture content, %

When the breeding wheat ear was rigidly clamped with tester jig in clamping angle of 90° and the tensile speed was 5 mm/min, the regression model between the breeding wheat ear connection force and the different moisture content, which could be given as (2):

$$y = 0.0543x^2 - 1.6468x + 19.638 \tag{2}$$

where,
y = The connection force of breeding wheat ear, N
x = The moisture content, %

When the breeding wheat ear was rigidly clamped with tester jig in clamping angle of 60° and the tensile speed was 3 mm/min, the regression model between the breeding wheat ear connection force and the different moisture content, which could be given as (3):

$$y = 0.1578x^2 - 5.2376x + 57.044 \tag{3}$$

where,
y = The connection force of breeding wheat ear, N
x = The moisture content, %

When the breeding wheat ear was rigidly clamped with tester jig in clamping angle of 60° and the tensile speed was 5 mm/min, the regression model between the

Table 2: Mechanical connection properties parameters of breeding wheat ear (3 mm/min, 90° clamping angle)

Moisture content (%)	17.40%	18.60%	19.50%	20.70%	21.50%	22.60%	23.30%
Connection force (N)	7.24	7.86	8.23	8.94	9.12	9.98	10.86

Table 3: Mechanical connection properties parameters of breeding wheat ear (5 mm/min, 90° clamping angle)

Moisture content (%)	17.40%	18.60%	19.50%	20.70%	21.50%	22.60%	23.30%
Connection force (N)	7.31	7.82	8.19	8.96	9.07	9.88	10.91

Table 4: Mechanical connection properties parameters of breeding wheat ear (3 mm/min, 60° clamping angle)

Moisture content (%)	17.40%	18.60%	19.50%	20.70%	21.50%	22.60%	23.30%
Connection force (N)	13.61	14.15	15.21	16.22	17.30	18.87	20.97

Table 5: Mechanical connection properties parameters of breeding wheat ear (5 mm/min, 60° clamping angle)

Moisture content (%)	17.40%	18.60%	19.50%	20.70%	21.50%	22.60%	23.30%
Connection force (N)	13.97	14.31	15.19	16.28	17.12	18.95	21.40

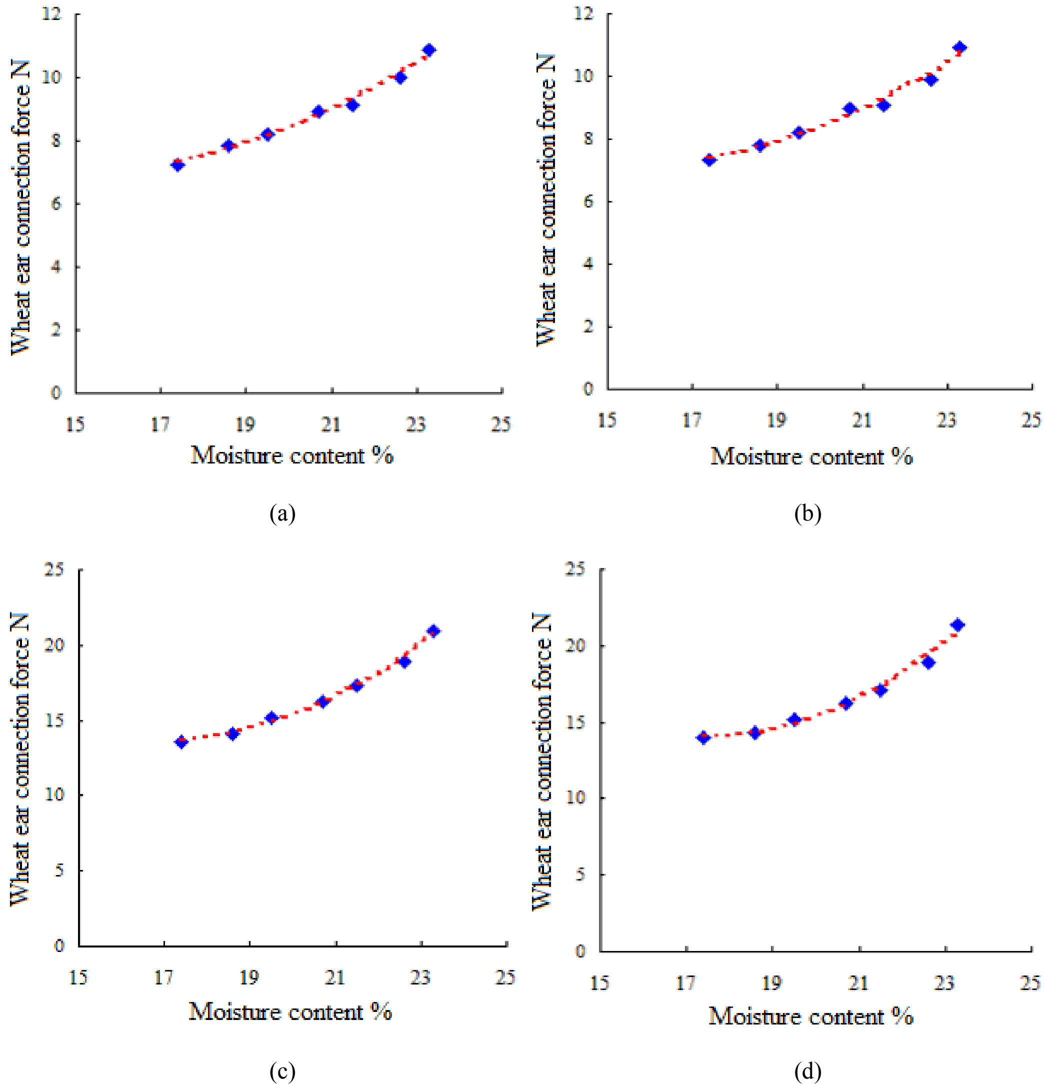

Fig. 6: Curve fitting of connection force regression model

breeding wheat ear connection force and the different moisture content, which could be given as (4):

$$y = 0.2086x^2 - 7.3189x + 78.278 \tag{4}$$

where,
y = The connection force of breeding wheat ear, N
x = The moisture content, %

The curve fitting of regression model: The curve fitting of connection force regression model (1)~(4) about breeding wheat ear in Fig. 6a to d.

By the equation (1)~(4) to be seen that the regression model between the breeding wheat ear connection force and the different moisture content was approximate quadratic function, which was the opening up of the parabola.

When the breeding wheat ear was rigidly clamped with tester jig in clamping angle of 90° and the tensile speed was 3 mm/min, the regression coefficient: R^2 = 0.9859. When the breeding wheat ear was rigidly clamped with tester jig in clamping angle of 90° and the tensile speed was 5 mm/min, the regression coefficient: R^2 = 0.9791. When the breeding wheat ear was rigidly clamped with tester jig in clamping angle of 60° and the tensile speed was 3 mm/min, the regression coefficient: R^2 = 0.9918. When the breeding wheat ear was rigidly clamped with tester jig in clamping angle of 60° and the tensile speed was 5 mm/min, the regression coefficient: R^2 = 0.9870.

CONCLUSION

The plot breeding wheat ear had 3 different type of fracture morphology. For respectively the wheat stalks and wheat ear got fracture with the stress concentration and another fracture appeared on the breeding wheat ear cob shaft section, as well as the breeding wheat ear with tear-petiolate.

With the different tensile speed (3 and 5 mm/min) and different clamping angle (60° and 90°), the connection force of breeding wheat ear was 7.24~21.40 N, as well as the connection force regression model was established about breeding wheat ear. The result indicates that the tensile speed for breeding wheat ear had no effect on the tensile ability, but the different clamping angle had a significantly effect on it.

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