MECHANICAL HARVEST AFFECTS WINTER RAPE (*BRASSICA NAPUS* L.) PROFITABILITY

Ni Ma[1]*, Yugui Cheng[2], Shihai Gao[3] Jun Li[1], Shujie Zhang[1], Guangming Li[1], Minghai Zhang[2], Chunlei Zhang[1]
(*[1]Oil Crops Research Institute Chinese Academy of Agricultural Science, Key Laboratory of Oil Crop Biology of the Ministry of Agriculture, Key Laboratory of Crop Cultivation and Physiology, Ministry of Agriculture, Wuhan 430062, China; [2]Research Academy of Agricultural Science of Yichang, Hubei Province, 443004,China; [3] Agricultural Bureau of Zhongxiang City*, *Hubei Province*, *431900*, *PR China)*
**Corresponding author. Tel: +86 27 86739796; fax: +86 27 86739796.*
E-mail addresses: clzhang@vip.sina.com

Background

China has the largest acreage of rapeseed in the world. Of the country's total rapeseed acreage, 87% can be found in the reaches of the Yangtze River, producing 89% of the country's total seed yield. The harvest of winter rapeseed was usually delayed by the spring rainfall and manual operations. Moreover, deterioration of seed often occurred after the rapeseed plants were cut down and left in the fields under very humid conditions. Most importantly, with the transferring of labor from rural to towns and cities, rapeseed production was adversely affected by inadequate and costly labor. Hence, the development of mechanical harvest was looked as one of the solutions that could increase the yield of rapeseed oil production and maximize the profit. Although researches on the mechanical harvest of rapeseed have been conducted for many years, high harvest loss continues to limit mechanical practices of winter rapeseed. Determining the appropriate harvest time was very important.

Objective

In winter rape growing areas, coordinating the cultivars, choice of harvest time was significant issues. In this paper, two elite rapeseed cultivars (Zhongshuang No.11 and Zhongyouza 11, *Brassica napus* L.) was used in two experiments from 2008–2010. Optimal harvest period was determined, morphological and physiological parameters of rapeseed plant were compared with respect to combine harvest properties, which would provide information for winter rape production. Planting profits could be optimized.

Materials and methods

The field experiments were conducted from 2008 to 2010 at Zhongxiang and Yichang experimental stations, Hubei Province, China, within the reaches of the Yangtze River. The seeds were sown on 20 September 2008 and 24 September 2009 with sowing machine (2BFQ-6, made in Wuhan, China), the planting density was 300,000 plants ha^{-1}. Three replications were designed with 9 units plots in the adjacent unit plot (200 m^2) for each cultivar. Three harvest times were conducted for both cultivars.

At the maturity stage, the morphology, pod color, seed color of main stems and primary branches were investigated before every harvest time and method. 100 pods on main stems and 100 pods on first branches of 10 plants were selected randomly to detect the pod color and seed color. Seed loss that occurred before harvest (pre-harvest) was measured. Five areas of each plot were considered with the use of a wire frame (2.0m × 0.5m). All seeds and soil for 5cm depth within the frame were collected and the soil was washed, seeds were weighted and mean weight was calculated. Machine walked forward with the speed of 2.5 km h^{-1} and losses from shattering and uncut losses were determined in five areas of each plot with the use of the same wire frame, all seeds fell in the frame were collected and weighed. The means of the five measured values were obtained. Pods in the area of each frame were also collected, threshed and weighed. Harvest seeds were weighed instantly, 0.20kg–0.25 kg of seeds were collected and sealed in plastic bags for determining moisture content in every plot. After seeds were dried in sunshine for 3–5 days, 1,000-seed weight was measured. At 9% moisture content, seed weight was calculated and compared. Total loss was calculated using the following equation:

$$W_{tl} = W_{sl} + W_{ul} \qquad (1)$$

where
W_{tl} = Total loss (kg ha^{-1})
W_{sl} = Shattering loss (kg ha^{-1})
W_{ul} = Uncut loss (kg ha^{-1})

After measuring the amount of different loss, loss rates (%) were determined using the following equation:

$HL_r = (W_{tl} - W_{pl})/(Y_h + W_{tl}) \times 100$ (2)

where

HL_r = Harvest loss rate (%)

W_{tl} = Total losses (kg ha^{-1})

W_{pl} = Pre-harvest loss (kg ha^{-1})

Y_h = Harvest yield (kg ha^{-1})

In 2008-2010, technological instruction on cultivation techniques was prepared, and recording tables and detailed statements of accounts were distributed to farmers. Inputs and outputs from sowing to harvest were recorded, including the cost of seed treatment, fertilizers, mechanical and fuel investments, and the output of commercial seeds. More than 50 farmers participated.

All data from the two field experiments were analyzed using ANOVA (GLM, SPSS v9.0). Means were compared using Duncan's multiple range tests at 5% level of significance.

Results

Average plant height for mechanical harvest was 165 cm, and the height of first branching from the ground was approximately 70 cm. The plants were of small stature, and each plant had fewer than seven primary branches. Angles between first branches and main stems were 35° and the thickness of the layer of pods was 60 cm (data not shown). At the first harvest time, the color of the pods on the main stems and 80% of those on the branches were yellow, the seeds from the main stems were black, whereas 80% of those from the branches were brown and black. During the period of ripening, the pod color and seed color changed quickly in the following two later harvest times. At the third harvest time, pod color of main stem was yellow and brown, pod color of branches was yellow. The seeds on the plant were all black. When all of the seeds on main stem and 80% seeds on the branches were black, and the moisture content of seeds was 15-20%, it was suitable for mechanical harvest. The moderate harvest period of Zhongshuang No. 11 was about 12-day, the harvest losses were lower than 8%. The yield from the second harvest time was significantly higher in comparison with those of the other two harvest times and manual harvest. Yield loss, including pre-harvest loss, shattering and uncut loss, were significantly increased during the harvest period, the shattering losses were significantly increased too. On the contrary, the uncut loss showed significantly decrease. In terms of production profits, mechanical production was profitable with an input/output ratio of 1:1.5. Labor cost accounted for more than 50% of the total cost, which contributed to low economic profit of conventional manual rapeseed production.

Discussion

Currently, harvest is a key problem to be solved by mechanization. In this paper, it was instructive that the morphological and physiological parameters related to different harvest times were analyzed. Assessing the most suitable moisture content for harvest to reduce losses and impact damage is important. There existed a certain optimum level of moisture content at which, under the effect of impact forces, the seeds are minimally damaged. In the case of rapeseed kernel, the optimum level of moisture content is approximately 11%–15%. Our results propose that, the amount of combine harvesting loss is significantly reduced when the moisture is approximately 70% for stems and 18.0% for seeds.

With our results, if plants were harvested too earlier or too late, the loss would be equal to the manual harvest. In three harvest times, high total loss and uncut loss in earlier harvest time appeared because too many immature seeds were lost. However, if the seeds were harvested too late, seed loss would reach more than 10%, and high shattering loss was due to over-ripening and the collision between the plants and the machine in the course of harvesting.

Mechanical harvest was correlated with production profits. The economic analysis of input/output played an important role in agricultural production. The input/output evaluations show that high labor cost was the main factor behind high total costs and low comparative benefits. Our results also revealed that mechanical harvest could increase income. If rapeseed cultivation depends excessively on manual operations with low mechanical levels and the situation of high production costs remains unimproved, the development of rapeseed industry will be hampered. Hence, the mechanization of winter rape production should be globally popularized in the suitable growing areas.