Gerd Joachim Sauter, Hans Kirchmeier and Horst Neuhauser, Freising

Using a windrow inverter for lucerne hay

Lucerne is a protein-rich forage plant which causes problems when harvested as hay. During normal hay harvesting procedure (tedding/turning and windrowing) the fine nutritious leaves are knocked off the stalks as shatter loss, resulting in feeding value and quality reductions. This has led in the USA to the application of a windrow inverter in preparing lucerne hay. The Bavarian State Institute for Agricultural Engineering is currently testing the application possibilities of the windrow inverter method under Bavarian climate and field size conditions using the New Holland system as an example.

Dr. agr. Gerd Joachim Sauter und Dipl.-Ing. agr. (EH) Hans KIrchmeier are staff members, Dr-Ing. Horst Neuhauser is department manager, Procedural Technology in Plant Production, Bavarian State Institute for Agricultural Engineering Weihenstephan, Am Staudengarten 3, 85354 Freising.

Keywords

Shatter losses, lucerne, windrow inverter, hay making

Using a windrow inverter means that the two system steps tedding/turning and windrowing are replaced by the single machine. The system is based on the harvest material being laid in a windrow by the mower. Following the drying of its surface the windrow is then turned onto the free neighbouring ground so that the underside can be dried. This step is repeated once or twice a day depending on the size of windrow and the weather until after three days the moisture content has normally reached hay level. For better exploitation of the lifting machinery the final inversion can be used to put two or even three windrows together.

Design

Windrow inverters comprise three function parts:
- a pick-up system,
- a system for transporting the harvested material laterally to the direction of travel and
- a unit for inverting and then replacing the windrow onto the ground.

Usually, conventional pick-up mechanisms are used for lifting the material. Instead of this one manufacturer uses a rubber belt with tines attached. The windrow can be transported laterally to direction of travel actively visa side-delivery conveyor belts or by a rotating disc (d = ~ 2m). A further manufacturer favours passive transport. This is carried out by a plough-form guiding system of rubber which also ensures the inversion step. With another maker, the actual inversion of the windrow is achieved through special drop steps and with the help of the forward motion of the machine. Currently on the North American market there are four different constructions (ProFab, Dion, Tippen and New Holland). All inverters are pulled machines either driven by hydraulic motors or ground wheels.

System New Holland

This system (*fig. 1*) is the most used oversees. It comprises a ground wheel driven pick-up and a rubber lateral conveyor belt. A drop step positioned to the side of the conveyor belt acts together with the forward momentum of the machine to invert the windrow. The list price (in Canada) is around 5700 €. The advantage of this system can be seen in the positioning of the lateral conveying belt. For laying several windrows together the manufacturer offers as extra equipment (list price ~ 2400 €) an additional hydraulically driven conveyor belt which forms an extension to the lateral conveyor belt.

Matching the windrow inverter to local conditions

First trials with this windrow inverter indicated that it cannot be applied directly for use under Bavarian conditions. Because of the small field structures and the associated frequent turning manoeuvres the manual lifting of the pick-up did not meet the practical

Fig.1: Windrow inverter: system New Holland

Dates	Conventional	Windrow inverter
23. 7. 2001	16: 00 - 19: 00 h mowing	
24. 7. 2001	11: 00 h tedding	13: 00 h windrow inverting
25. 7. 2001	13: 00 h turning	11: 00 and 16: 00 h windrow inverting
26. 7. 2001	13: 00 h turning	11: 00 and 16: 00 h windrow inverting
27. 7. 2001		11: 00 h windrow inverting
28. 7. 2001	13: 00 h windrowing	13: 00 h windrow inverting

Table 1: Process steps in making lucerne hay

standards required. This problem was solved by the fitting of a lifting cylinder at the pick-up. The ground drive of the inverter represented a further problem. Where the crop is heavy this is overworked which can lead to the machine being unable to cope with the material flow. For this reason an hydraulic drive is planned. Through a flow distributor the working speed of the machine can then be matched to its travelling speed. As with tedding the mower must work in harmony with the following machine (pick-up). Mowers with working widths of 2.7 and 3 m produce a windrow which exceeds the breadth of the pick-up working width (165 cm) by from 10 to 15 cm. This leads to high pick-up losses at lifting which are due not to the system but instead to the unsuitable matching of the different working implements. Through the side fitting of windrowing wheels on the pick-up, it is to be attempted in the next trail series to find out the extent of working width increase this measure would allow.

For fully exploiting the following lifting technology (baler or self-loading wagon) the windrow resulting from a single mower width is too narrow and it therefore makes sense to aim for a bundling of at least two or even three swaths just before lifting. With the inverter this can be catered for through the fitting of a second lateral conveyor belt.

Materials and method

A first-year lucerne crop on Hirschau Experimental Farm, TU Munich-Weihenstephan was made available for testing the windrow inverter system. In the first cut a harvested amount of 42.5 dt dm/ha was determined. After mowing, the test crop was divided into two trial parts. One half was conventionally worked as shown in *table 1* with rotor tedder-turner and rotor windrower. On the second, the windrower-inverter was used. Immediately before the crop was removed from the field every two windrows were laid together for better exploitation of the final lifting machinery.

With the conventional system four working operations were required before crop removal from the field, with the windrow inverter system, seven. At removal (baling) samples were taken from both variants (n = 10) which were then analysed for moisture content and nutritional composition. Shatter losses were collected with leaf vacuum on swaths 20 m long and with a width of 0.75 m by a simple pass of the tractor. The vacuum collected samples were weighed, ground and then crude ash content determined. Finally the organic matter content was calculated.

Results

Even during the field drying it became clear that the conventionally treated plots were drying faster. In practice the conventional plot could have been baled as early as the afternoon of 27. 7. 2001. However, because the weather conditions were very good and because the alternative variant was still too moist both plots were not baled until a day later on 28. 7. 2001. At time of baling the harvest material had a dm content of 87.5% in the conventional variant and 85.8% in the alternative. The sample analyses showed a protein content of 13.8% for the windrow inverter material while that in the conventionally-handled hay was 5.7% lower. No significant difference was determined between the two variants for crude fibre. The alternative variant had 40.5% and the conventional material 39.9%. The crude ash content correlated with the protein content with only very small differences: 9.5% for the windrow inversion method and 8.3% for the conventionally treated lucerne.

The qualitative differences were above all due to the shatter losses. Thus with the conventional variant an average (n= 10) 5.6 dt/ha of pure organic material was vacuumed whereas only 2.9 dt/ha was secured after the alternative methods.

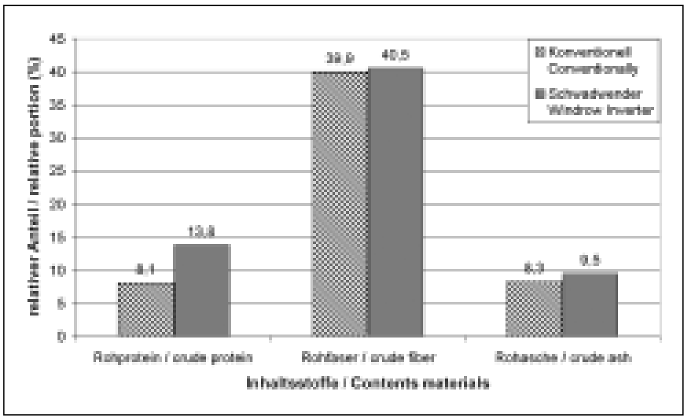

Fig. 2: Contents in lucerne with different hay making processes

Summary

The first trial for examining the application of a windrow inverter for lucerne hay preparation was carried out. Contrary to conventional techniques, using the inverter resulted in higher quality hay in terms of protein content. Unsatisfactory was, however, the long drying time of five days for which an extremely stable weather situation would be required. Hay making using the conventional procedure led to double the amount of shatter losses compared with the windrow inverter system, despite the material having to be handled more often for the latter. In the light of the shatter losses the alternative method gave a calculated crude protein yield of 5.4 dt/ha (42.5 dt dm/ha minus 3.2 dt dm/ha shatter losses with a crude protein content of 13.8%). With the conventional method the crude protein yield was 2.9 dt/ha. Cutting was by mower without conditioner. Applying a mower with roller conditioner could result in accelerated drying but at the same time the risk of higher shatter losses increases. As the trials so far indicates, this might not have such a negative effect with the windrow inverter. Further trials should follow to look into this. Also unclear is the number of passes required for optimum drying. The application of the windrow inverter system for silage preparation would also be possible but here there is no great difference in shatter losses between both systems to be expected because the danger of causing shatter loss first increases with higher dry matter contents.