Thomas Hoffmann and Christian Fürll, Potsdam-Bornim

# Weather influence on combine harvesting operations

*Economic cereal production depends on modern production methods. But the investments required for modernisation are all the more difficult to justify the lower the yield and price of grain. The investments apply over a long term and must be calculated with this in mind. Often when technical equipment is chosen not enough attention is paid to the fact that the combining, preservation and use of grain are all relevant areas within the total calculation. The weather too, has a stochastical influence over all of these areas. For every individual farm, this complex association necessitates acknowledgement of the harvest and preservation processes as a whole concept, with the technical equipment involved in the foreground.*

Dr. Thomas Hoffmann is a member of the scientific staff and Prof. Dr.-Ing. habil. Christian Fürll is Director of the department Technology in Preparation, Storage and Conserving in ATB, Max-Eyth-Allee 100, 14469 Potsdam (Scientific Director: Prof. Dr.-Ing. J. Zaske); e-mail: thoffmann@atb-potsdam.de.
The research work ran from 1992 to 1998 at the special department Technology in Plant Production, Humboldt University, Berlin, Philippstr. 13, 10115 Berlin under the Directorship of Prof. (ret.) Dr. agr. habil. Manfred Müller.

## Keywords

Weather, grain moisture, combine harvesting, preservation

In grain production, necessary technical decisions concern the type and extent of the harvesting and preservation technology required. Such decisions have a long term effect and have a substantial influence on the costs involved. Stochastical disturbance factors in harvesting have to be counteracted by precautionary measures planned by the farmer. When planning this technology, however, overcapacity must, as far as possible, be avoided. When deciding on the required technology, a comprehensive overview of weather records, grain harvesting and subsequent operations is necessary. The following paper reports on completed research work on this subject.

### Methodology

For necessary decisions on technology required, the probable accuracy of weather-influenced grain moisture content must be known. Because this sort of information is usually not available, it was deduced through the evaluation of weather records. The association between weather and grain moisture was determined via regression equations. Used as fundamental data was the pairing of grain moisture and weather parameters. With the regression equations and with long term meteorological data, the weather-caused length of specific grain moistures in individual years was calculated in a simulation model and a representative grain moisture distribution produced.

The length of weather-caused grain moistures was the basis for the assessment of combining times and harvested quantities with certain grain moistures. For calculation of effort and costs for combine harvesting, ventilation drying, active cooling, warm air drying and preservation-storing of ground grain, procedural models were established. Through the connecting of the combine harvesting and the preservation models, the sum of their effects could be investigated.

### Grain moisture hours

From 1977 to 1995, 258 daily records of grain moisture and weather were made, out of which 92 daily records were made after combining. Weather parameters chosen from this data were used for regression analysis. Using investigations carried out at the Humboldt University in Berlin [1, 2] the weather parameters were applied within the regression equations, not with their fixed values, but instead according to the length of time of their existence, or the length of time where values were over a certain threshold. The target parameter was the grain moisture up to predetermined levels measured in hours throughout the particular day (*table 1*). Winter wheat (WW) and winter rye (WR) as well as spring barley (SB) and winter barley (WB) could, without influencing the result, each be summarised within a particular model. The comparison of measured grain moisture value during a harvesting period with the results of the model "WW+WR combining harvesting" showed a satisfactory agreement (*fig. 1*) [3].

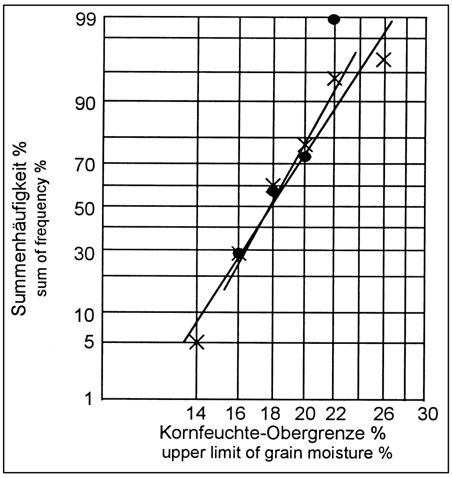


*Fig. 1: Measured and computed values for length of defined grain moisture after combining; (x) winter rye measured 29. of July till 11. of August 1988 [1], (•) computed with the model "WW+WR Mähdrusch" [5]*

The model with reference to grain moisture in the crop and the crop values of the

*Table 1: Influence and target parameters of regression equations*

| Parameter | Information | Unit |
|---|---|---|
| ***Influence parameters*** | | |
| Relative air moisture content | Number of hours on the harvesting day and on the two previous days with rel. air moisture content up to a maximum of 60, 70 and 80% | h/d |
| Precipitation level | on harvesting day and the two previous days | mm/d |
| Length of sun shine periods | on harvesting day and the two previous days | h/d |
| Grain moisture hours | already identified grain moisture hours for the harvesting day | h/d |
| Grain moisture hours | Grain moisture hours on the previous day | h/d |
| ***Target parameters*** | | |
| Grain moisture hours | Number of hours on harvesting day in grain moisture classes | h/d |

*Table 2: Number of hours in grain moisture classes; example winter rye*

| | | Grain moisture upper limit % 14 | 16 | 18 | 20 | 22 | 24 |
|---|---|---|---|---|---|---|---|
| Winter rye, 23.7. to 5.8. | | | | | | | |
| KTBL[1] | Σ % | 11 | 34 | 56 | 73 | - | 91 |
| WW+WR crop[2] | Σ % | 15 | 41 | 59 | 71 | 79 | 81 |
| WW+WR combining[2] | | | | | | | |
| - all harvesting periods | Σ % | 0 | 25 | 39 | 54 | 78 | 81 |
| - dry harvesting periods (27 % of all harvesting periods) | Σ % | 27 | 66 | 82 | 90 | 98 | 99 |
| - wet harvesting periods (31 % of all harvesting periods) | Σ % | 0 | 12 | 22 | 38 | 64 | 70 |

[1] Climate area 8 according to KTBL [4], 10 am to 8 pm MEST
[2] Simulation model "'Weather and grain moisture" [5] Station Potsdam 1951 – 1995, 10 am to 8 pm MEST, 100% = 140 h/HP; HP harvest period 80% accuracy possibility

*Table 3: Relative values grain quantities (%) after threshing in wet and dry harvesting periods (EP) with increasing combine utilisation [6]*

| Operation period [h/EP] | Rel. value of grain quantity with grain moisture content [%] up to 16 | 17 to 19 | 20 to 22 | over 22 |
|---|---|---|---|---|
| Dry harvesting seasons (such as, e.g., 1971,1982, 1992, 1994, 1995) | | | | |
| 100 | 100 | | | |
| 150 | 100 | | | |
| 200 | 86 | 14 | | |
| Wet harvesting seasons (such as, e.g.1954, 1965, 1977, 1987, 1993) | | | | |
| 100 | 39 | 48 | 13 | |
| 150 | 28 | 39 | 33 | |
| 200 | 22 | 30 | 37 | 11 |

[1] Threshing performance affected by grain moisture, 180 kW engine power
[2] Station Potsdam, 1951 to 1995; harvests of winter barley, winter rye, spring barley, oats and winter wheat; harvesting period 27 calendar days, 10 am to 8 pm MEST, 100%= 270 h/HP

KTBL [4] gave, for the harvesting period of winter rye, nearly the same times with particular grain moisture (*table 2*). The length of time of the grain moisture after the harvesting, within the classes with less grain moisture, lay substantially under the values from KTBL and the crop model. The model on grain moisture after harvesting illustrated the effect which can be seen in practice that, during the actual harvesting operation, moisture from straw and from green material is transferred to the grain. After the harvesting, the grain moisture content was higher than it was before combining took place. Information on grain moisture in the standing crop gave potential threshing hours of which only a portion were usable in practice. For the measuring of combine capacity, the main applicable model is that pertaining to grain moisture after harvesting. The evaluation of dry and wet harvest periods indicated the span in moisture conditions which must be covered by harvesting and preservation technology.

### Combine harvesting and preservation

The material resulting from combining has a grain moisture distribution and grain moisture upper limit (*table 3*). Should, on economical grounds, 200 h cereal harvesting with a large combine have be completed on the example farm, this means that in the dry harvesting periods (HP) the grain moisture upper limit is 19%, and 22% in the wet harvesting periods. The maximum grain moisture content is set by the capacity of grain drying technology on the farm.

The 22% upper grain moisture content cannot be avoided during the wet harvesting periods when an economical exploitation of the combine harvester is to be attained (*fig. 2*) [6]. In the example of feed grain conservation (fig. 2) the digression of costs with the combine harvesting is stronger than the cost increases for the drying of the grain batches.

An alternative to drying is the storage of ground moist grain [7]. Advantages here are the smaller preservation costs and the usage of the combine during periods of higher grain moisture.

### Conclusions

A necessary amount of available technology is one of the concrete requirements on a farm, especially during the weather-caused harvesting periods linked to grain moisture content after the harvesting. To be considered is the amount harvested, the grain moisture distribution and grain moisture upper limit. In the interest of less total costs, a high period of use for the combine must be aimed at, even when this means that grain preservation costs are thus increased.

## Literature


Books are signified with •

[1] • *Leberecht, M.*: Witterungsbedingte Dauer der Kornfeuchten als Grundlage für die Verfahrensgestaltung in der Ernte, Konservierung und Lagerung von Getreide. Dissertation, Humboldt-Universität, Berlin, 1990

[2] • *Hill, L.*: Witterungsbedingte Zeitdauer der Strohfeuchte im Schwad als Grundlage für die Verfahrensgestaltung . Dissertation, Berlin, 1984

[3] *Hoffmann, T.* und *M. Müller*: Erntemanagement für leistungsfähige Mähdrescher und die Folgen für die Konservierung. VDI/MEG Kolloquium „Mähdrescher", Hohenheim, 1997

[4] • Taschenbuch Landwirtschaft. Landwirtschaftsverlag GmbH, Hiltrup, 18. Auflage, 1996

[5] *Hoffmann, T.* und *M. Müller*: Simulationsmodell „Witterung und Kornfeuchte des Getreide im Bestand und nach dem Drusch." Fachgebiet Technik in der Pflanzenproduktion. Humboldt-Universität, Berlin, 1996, (unveröff.)

[6] • *Hoffmann, T*: Gestaltung von Technik und Verfahren für die Ernte und Konservierung von Getreide auf der Grundlage witterungsbedingter Kornfeuchten. Dissertation, HUB, Berlin,1998

[7] *Hoffmann, T., M. Müller* und *C. Fürll*: Feuchtes Getreide kostengünstig lagern. Neue Landwirtschaft 9 (1999), H. 7, S. 74 – 77


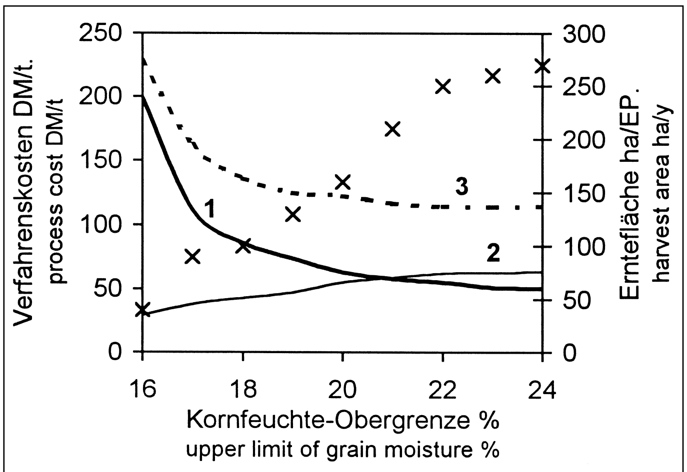


*Fig. 2: Operational costs for processing grain coarse meal in wet harvesting periods (HP); harvested area (x) of a combine with 180 kW rated engine power. 1 costs of combine and losses; 2 costs for maintaining-ventilation, warm-air drying with transport, grinding before feeding; 3 sum of 1 and 2*