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Calculation of available field working days for harvesting of roughage in Austria

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Summary

The objective of this project was to determine the amount of available field working days for harvesting different kinds of roughage in Austria by using the saturation deficit sum method. The model used by Luder (1982) in Switzerland was modified and adapted to the climatic conditions in Austria. For 188 weather stations all over Austria available field working days were calculated for silage making and field and barn drying of hay. For each of the harvesting processes results are available for the first and second cut, 2 – 3 different levels of yield and for all half-months from May to October. Finally, the results from all individual stations have been transferred into an area using a geographical information system (GIS). The resulting maps show the distribution of the available field working days over the whole area of Austria.

Keywords: available field working days, harvesting of silage and hay, applied climatology

Introduction

The success of many outdoor farm operations highly depends on weather conditions. Especially the harvest of roughage demands adequate periods of fair weather conditions. The knowledge of the amount of available field working days is therefore important for different farm management planning, e.g. work planning, or planning of machine capacity. Important investigations about the calculation of available field working days have been made in Switzerland (Luder, 1982) and Germany (Augter, 1991). Rehrl (1975) calculated the available field working days in Austria, but these data are not accurate enough to meet modern requirements. They also neglect the saturation deficit (sd) of the air as an important factor for drying silage and hay. Therefore the objective of this work was to calculate the available field working days for harvesting of silage and hay in Austria, using the saturation-deficit method by Luder (1982). This method has proven to be well suited for the description of drying processes and to enable sufficient accurate computations based on meteorological standard data.

Material and methods

In several field drying experiments Luder (1982) investigated the relation between the sd of the air and the drying of hay. He computed the saturation deficit sum (sds), which was necessary for the harvesting of silage, barn and field drying of hay. He compensated the rewetting by dewfall during the night by neglecting all sd from 6 pm to 9 am. The experiments also show that there was a difference in the drying-behaviour of hay in mountain and valley-areas. Therefore he introduced an empirical linear correction term for his threshold values, which depends on the elevation above sea level.

For the calculation of the daily sds it is necesarry that temperature and relative humidity are recorded hourly. In fact, hourly recordings over a period of about 30 years were only available at three weather stations in Austria. Most of the weather stations recorded only three times a day. We were able to show, that it is possible to estimate the daily sds at weather stations that record only three measurements per day (9 am, 2 pm, 7 pm) using a linear regression equation. All weather stations, which have hourly recordings over a period of at least three years, can provide sufficient data for the computation of a stable regression equation with R^2 lying between 0.942 and 0.966. As an example for this figure 1 shows the regression equation for July in Gumpenstein (Styria).

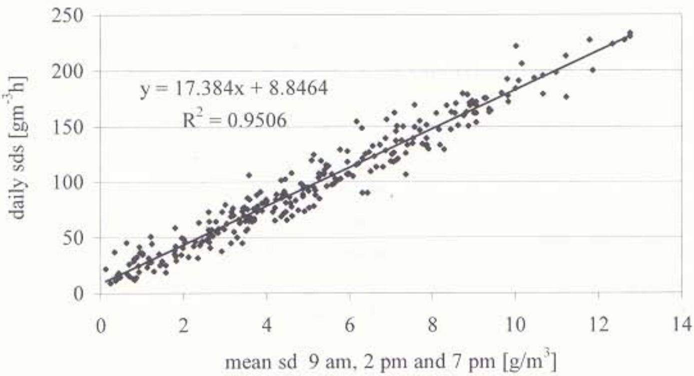

Figure 1. Relation between mean sd calculated from records at 9 am, 2 pm, 7pm and daily sds in Gumpenstein (July). Regression equation and R^2 based on 10 years of data.

The analysis of weather data in Austria also revealed, that there are fundamental differences in the diurnal variation of the sd between valley or flat land areas and hilltop or mountain areas. In weather stations situated in valleys or flat land 70 % of the daily sds are reached within the time from 9 am to 7 pm whereas in weather stations situated on hilltops or mountains this percentage is only 50 %. Figure 2 shows the mean diurnal cycle of relative sd during the growing period at two weather stations from the same region. Mariapfarr is situated in a valley and St. Kolomann on a hilltop. If the regression equation of Mariapfarr were used to compute the daily sds in St. Kolomann, the daily sds in St. Kolomann would be systematically underestimated. Therefore we decided to calculate own regression equations for each weather station. We were also able to show that the differences in diurnal variation are not related to absolute elevation above sea level, but depend on topology. For example Mariapfarr which behaves like a valley station is situated 1153 masl and St. Kolomann which behaves like a mountain station is situated 1000 masl (figure 2). These topological effects cause a difference in the frequency of nightly dewfall in valleys and on mountains or hilltops. This was also confirmed by Cehak (1977), who found a significantly higher frequency of dewfall in valley areas than in mountain or hilltop areas in Austria. The absence of dewfall is a reason, why hay in mountain areas dries more rapidly, than in valleys, where rewetting of hay during the night happens more frequently.

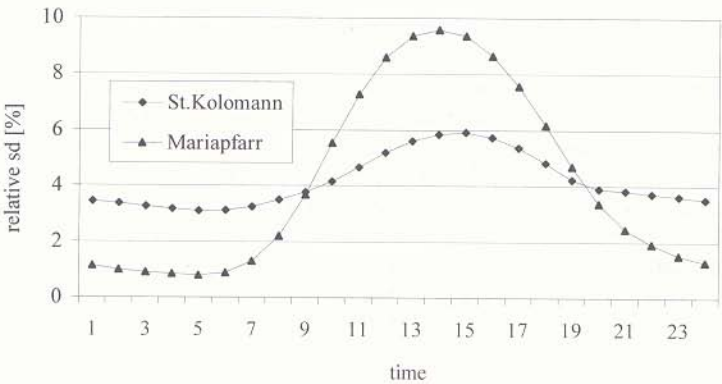

Figure 2. Mean diurnal cycle of relative saturation deficit in the growing period (April – May) in Mariapfarr (valley, 1153 masl) and St. Kolomann (hilltop, 1000 masl).

To compensate these different conditions caused by the topological location, we used the meterological data of all 24 hours for the computation of the daily sds and introduced a parameter for the rewetting by dewfall during the night. Only if dewfall is actually registered, the estimated daily sds is reduced. The reduction amounts to 12 and 18 g/m^3*h for slight and heavy dewfall respectively. We also had to adapt the threshold values for silage, barn and field drying of hay (table 1) as well as for the definition of "fair-weather-days" by Luder (1982), because he compensated for nightly dewfall by neglecting all sd from 6 pm to 9 am.

Table 1. Adapted threshold values (sds in g/m^3*h) used for the calculation of harvesting opportunities for silage, barn and field drying of hay in Austria.

	silage			hay barn drying			hay field drying		
	yield [dt dm/ha]								
	30	40	50	30	45	60	30	45	60
first cut	90	110	133	174	210	245	250	280	292
second cut	72	84	-	129	163	-	181	229	-

Based on our newly adapted model a computer programme was developed. It calculates the amount of harvesting opportunities in every half month from May to October by comparing actually calculated sds with the threshold values. If the sds of a single day or a period of several days (at maximum 4 days) exceeds a threshold value, this period of days is classified as „harvesting opportunity“. Only such periods of days can be classified as harvesting opportunities, where harvesting of silage and hay is possible without rewetting by rain. Therefore the computer-programme makes an additional classification of all days into fair weather days, neutral days, days with thunderstorms occuring in the late afternoon or evening and bad weather days. The classification scheme includes the factors daily sds, precipitation and cloudiness. The amount of harvesting opportunities is calculated for all half months from May to October and for a period of 39 years per weather station on average.

From these results we could calculate the amount of harvesting opportunities which occur with a security of 80 % in every year. Therefore the relative frequencies for the occurence of 0, 1, 2 etc. harvesting opportunities per half month were calculated. These relative frequencies were added until a cumulative frequency of 0.2 was reached.

Results

Available field working days for harvesting of silage, barn and field drying of hay were calculated for all half months from May to October. The results from 188 weather stations in Austria show a high variation in the amount of harvesting opportunities between individual locations.

As an example figure 3 shows the amount of harvesting opportunities from May to October in Gumpenstein. Gumpenstein is situated in the alpine region of Austria and is an example for an alpine valley with mean precipitation of 1000 mm per year. In this region only 0.5 – 1 harvesting opportunities for field drying and about 0.9 – 2.2 for barn drying can be expected in spring with a security of 80 %. For most of the farmers this will probably not be enough to bring in their whole harvest of hay, even with high machine and work capacity. From July to August conditions are better. Approximately 1.0 – 2.8 and 1.7 – 3.3 harvesting opportunities can be expected for field and barn drying hay respectively with a security of 80%. Silage making seems a good alternative especially in spring with 2.1 – 4.4 opportunities from May to June and up to 5.2 opportunities in the second half of July. From the second half of September less than 1.7 harvesting opportunities can be expected even for silage making.

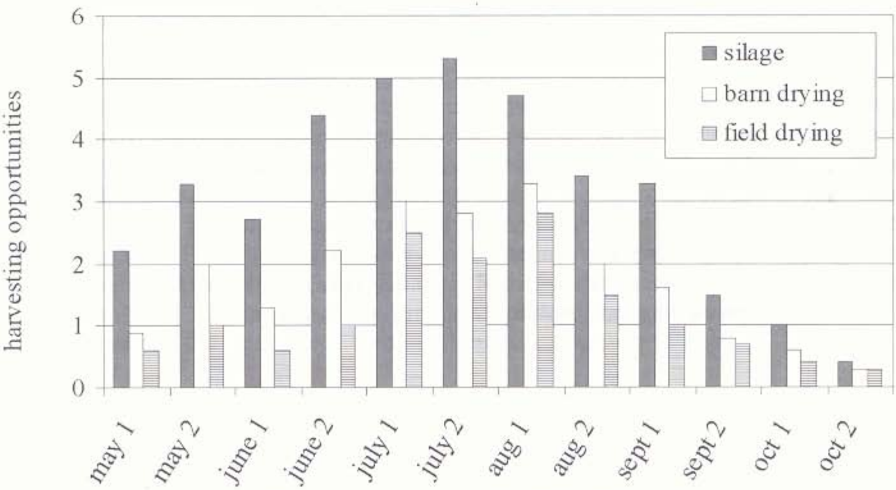

Figure 3. Amount of available harvesting opportunities (80 %) for silage, barn and field drying of hay from May to October in Gumpenstein.

Figure 4 shows the the amount of harvesting opportunities for Gross-Enzersdorf, which is situated in a completely different climatic area, the so called pannonian region in the north-east of Austria. The characteristics of this climate are very hot and dry summers with mean precipitation of maximum 600 mm per year. For field and barn drying of hay 2.1 – 4.1 and 3.3 - 5.5 harvesting opportunities respectively can be expected in spring. In summer harvesting opportunities range from 4.2 – 8.4 for field drying and from 5.1 – 9.6 for barn drying of hay. For silage making 4.8 - 7.7 harvesting opportunities can be expected with 80 % security in spring and 5.9 – 11.4 in summer.

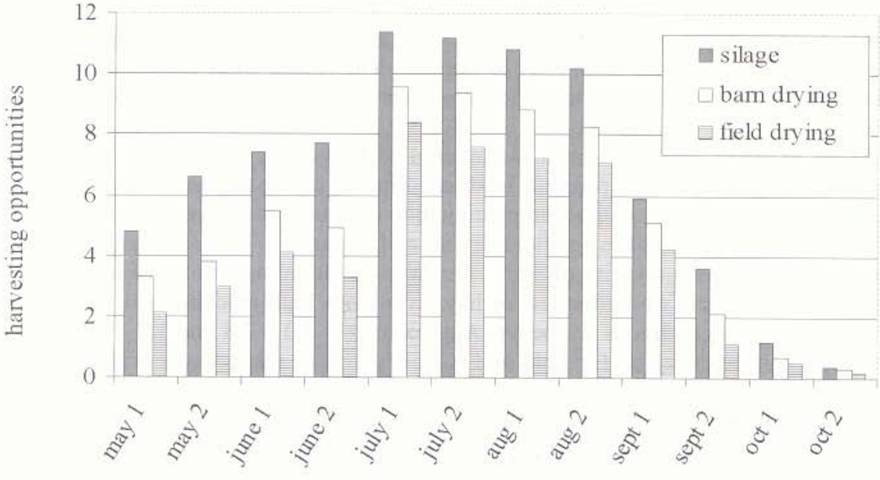

Figure 4. Amount of available harvesting opportunities (80 %) for silage, barn and field drying of hay from May to October in Gross-Enzersdorf.

Altogether, available field working days were calculated for 188 locations in Austria. This enables to resolve regional differences concerning climatic conditions very accurately. Generally it turned out that the amount of harvesting opportunities declines with the absolute elevation above sea level. Figure 5 shows the harvesting opportunities calculated for 188 weather stations in Austria for field drying of hay in the second half of July. The decline of harvesting opportunity dependent on elevation above sea level can be described by an exponential regression equation in which R^2 is 0.61. This means that roughly 60 % of the variation can be explained by the absolute elevation above sea level.

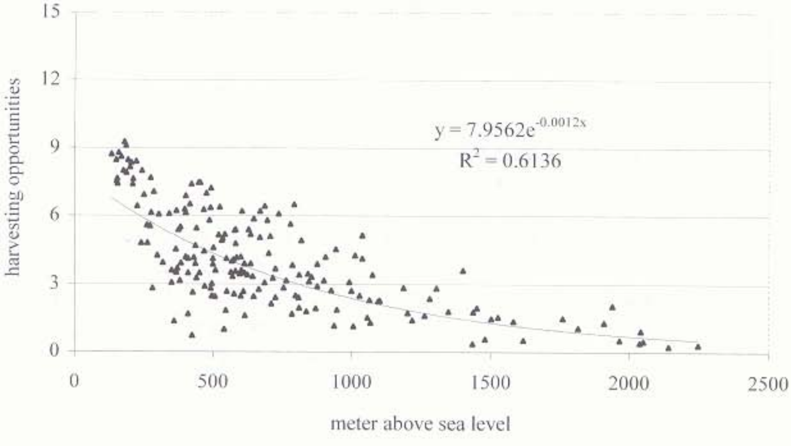

Figure 5. Harvesting opportunities for field drying of hay in the second half of July (results of 188 weather stations in Austria) and their decline with absolute elevation above sea level.

We found the same elevation dependency with regression coefficients between 0.60 and 0.71 for all harvesting processes and for all half-months from May to August. This effect can be explained by the increase of precipitation with absolute elevation above sea level (Auer, 1991). Additionally, temperature declines with absolute elevation above sea level, which causes also a decline in the saturation deficit.

Finally the data from all individual stations have been transferred into the area through interpolation using the geographical information system (GIS) "Arc-View". The interpolation was done in two steps. First the amount of harvesting opportunities for each grid point was estimated from the elevation of this grid point using exponential regression equations (see figure 5). Then the differences between the actual values at the weather stations and the expected values from the regression equation were calculated. These residues were interpolated using a kriging model (Wakernagl 1995). Finally, the residue-field and the elevation field are added. It is possible to find out the amount of harvesting opportunities for each grid point in Austria with a resolution of about 10 ha. Maps are available for each half month from May to October and each harvesting process at 2-3 different levels of yield.

Conclusions

Many grassland areas in Austria are situated in the alpine regions where climatic conditions for field drying of hay are difficult especially in spring. In many alpine areas for the first hay cut there are only 0 – 1 harvesting opportunities available for field drying. The maximum amount of harvesting opportunities is reached between the second half of July and the first half of August in most areas of Austria. Generally, about one harvesting opportunity can be expected more for barn drying than for field drying. Silage seems to be a good alternative in risky areas especially for first cut. It provides about 3 harvesting opportunities more than field drying. Another possibility to increase the amount of harvesting opportunities is to accept a higher weather risk. This would be interesting for farms with low mechanisation. An increase of the weather risk from 20% to 30% results in about one harvesting opportunity more for silage, barn and field drying of hay. An excel-file with the data of 188 individual weather stations together with the maps provide useful information about harvesting opportunities for roughage in Austria and can be used by extensionists and farmers as well.

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