

RAPSEED CROP DAMAGE BY WILDLIFE ASSESSED FROM LANDSAT IMAGES

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ABSTRACT

Rapeseed is the fourth most important crop in Hungary regarding its cultivation area. Crop damage by deer and boar has been becoming strongly debated issue in the last few years. More exact clarification of damage was aimed at in this study with help of Landsat images. Six rapeseed fields were investigated both in 2012 and 2013 in the administrative area of Várfölde, Bánokszentgyörgy, Bázakerettye and Borsfa (Zala County, Hungary). The total area in 2013 was 43 hectares. 100 % wildlife damage affected 3.9 hectares and 10 hectares were free from any damage. The total area in 2012 was 40 hectares in which 3.3 hectares were free from damage but neither fields suffered total damage. Yield map from 2017 of a 26 hectares field near to Gutorfölde and Szentkozmadombja was used to validate the space image based assessment method with real yield data. Landsat 7 images with acquisition dates of 2013.04.16., 2013.05.18. and 2013.06.03. were downloaded from the website of US Geological Service. All bands and NDVI index were investigated for all dates to establish best estimator for differences between damaged and not damaged fields. Band 5 (SWIR: 1.55-1.75 μm) in 16th of April proved to be the best. It was concluded with help of the reflectance data (zero damage: 96.4, complete damage: 164.5, partial damage: 124.7 on the average) that yield reduction was 41.5 % on areas with partial damage. There was no complete damage in 2012. However, reflectance data of not damaged fields were very close to each other in the two years (96.4 in 2013 and 89.9 in 2012 on the average) thus, it could be assumed that the same is true for reflectance data of completely damaged fields, so data from 2013 can be used for the comparison. Based on the data (zero damage: 89.9/2012, complete damage: 164.5/2013, partial damage: 118.4/2012 on the average) it was calculated, that one field suffered 38 % yield reduction, one hectare portion of another field suffered 23 % yield reduction, and other fields were not damaged significantly. Yield map from 2017 and Landsat 8 SWIR reflectance (Band 6: 1.566 – 1.651 μm) in 3rd of April have shown strong correlation ($R^2=0,634$), which was a direct evidence that both yield and wildlife damage of rapeseed can be reliably assessed from Landsat SWIR reflectance data acquired in April.

Keywords: rapeseed, damage by wildlife, Landsat 7, SWIR

INTRODUCTION

Rapeseed has been becoming more importance in the Hungarian agriculture for the last decades. Compared to the early 1990's when its production area was around 50 thousand hectares and the average yield varied between 1-2 tons per hectare, to-date it occupies more than 300 thousand hectares and the national average harvest has grown over 3 tons per hectare in the last few years with a record 3.6 tons per hectares in 2016 (KSH 2019a). The best farmers harvest well above 4 tons per hectare. Rapeseed advanced to the fourth place among arable crops regarding the cultivation area (KSH 2019b) and being a high investment-high return commodity, it contributes significantly to the profitability of farms. Evidently any damage to this crop is a painful loss for the growers.

In the same period, large herbivore wildlife stocks soared too. Deer and boar combined bag increased from 81 thousand to 217 thousand between 1990 and 2018 (KSH 2019c). In the late 2000's and early 2010's the compensation for wildlife damage exceeded 2 billion Hungarian forint per year (CSÁNYI ET AL, 2011, 2012). Most of the damage was attributed to deer and boar (MÁTRAI AND JÁRÁSI 1986; BUZGÓ, 2006). Although systematic research on this relationship is scarce but there is a few spectacular anecdotal evidence for the

damage (e.g. VAOL, 2019; VADKARINFO, 2019) and scientific analysis (BLEIER, 2014) has also confirmed the exponential relationship between deer and boar abundance and compensation. Most damage in Hungary affects maize but rapeseed damages by deer and boar are becoming more and more important especially in Zala county where wildlife abundance is high (BLEIER, 2014).

Our study aimed at investigating Landsat images as tools to more precisely determine rapeseed crop damage by wildlife.

MATERIAL AND METHOD

Six rapeseed fields were investigated both in 2012 and 2013 in the administrative area of Várfölde, Bánokszentgyörgy, Bázakerettye and Borsfa (Zala County, Hungary). The total area in 2013 was 43 hectares. 100 % wildlife damage affected 3.9 hectares and 10 hectares (two fields) were free from any damage. That was confirmed by an official wildlife damage inspector in an official assessment. The total area in 2012 was 40 hectares in which 3.3 hectares were free from damage but neither fields suffered total damage. Again, this was confirmed in an official assessment. Yield map from 2017 of a 26 hectares field near to Gutorfölde and Szentkozmadombja was used to validate the space image based assessment method with real yield data. Data were recorded by a Green Star 3 Monitor. Study areas are shown on *Figure 1*. Landsat 7 images with acquisition dates of 2013.04.16., 2013.05.18. and 2013.06.03. were downloaded from the website of US Geological Service (USGS, 2019). All bands and NDVI indices were investigated for all dates to establish best estimator for differences between damaged and not damaged fields.

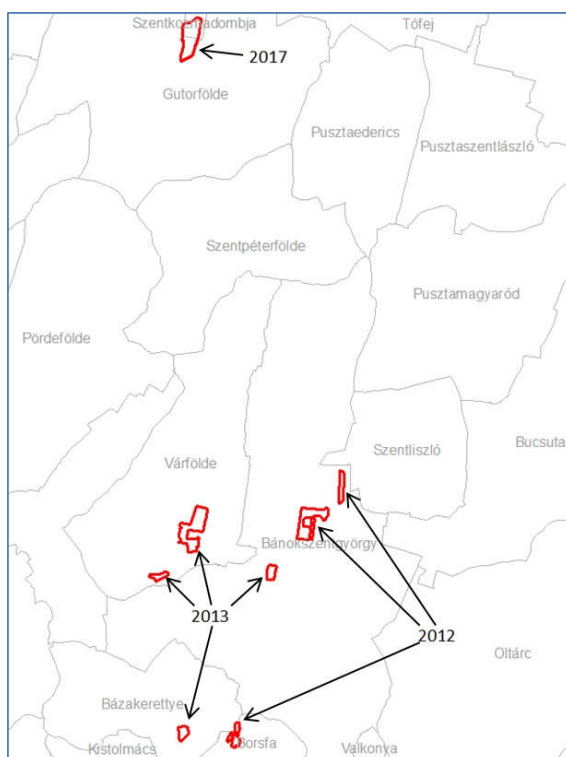


Figure 1. Study areas in Zala county

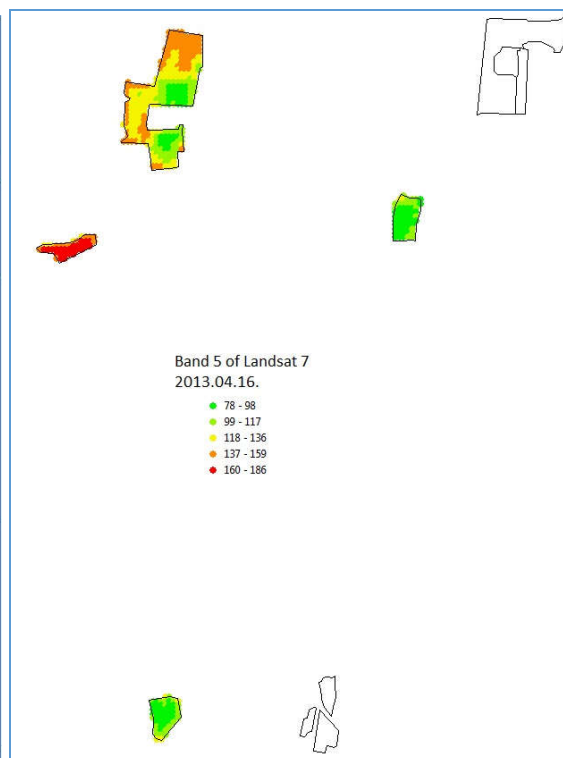


Figure 2. SWIR wavelength values in 2013

Landsat 7 images with acquisition date of 2012.04.29. and Landsat 8 images with acquisition date of 2017.04.03. were also downloaded from the same source and only the

best estimator wavelength bands (selected in the previous step) were used to assess crop damage or to validate reflectance values with yield map data.

RESULTS

Landsat 7 band data from 2013 were grouped in three categories: total crop damage, partial crop damage and no crop damage by wildlife. NDVI indices were calculated for all the three dates from Band 4 and Band 3 data. One way analysis of variance was applied to distinguish between the categories. The differences were significant for all NDVI indices and all wavelengths (bands). F test value of the ANOVA were used to select the best predictors for differences (*Table 1*). Band 5 of April 16th proved to be the best among all. Interestingly, NDVI indices performed rather poorly. This time the damaged crop was still in place. Band 5 and 7 of May 18th were better but by that time the damaged field was disk tilled already so the sharper difference was consequence of the tillage not of wildlife damage.

Table 1. F test values for the different variables

variable	F-value	remark	variable	F-value	remark
May18_B7	402,72	*	April16_ndvi	146,13	
May18_B5	325,37	*	May18_B4	115,99	*
April16_B5	250,64	best	June3_B3	95,34	*
April16_B7	237,16		June3_ndvi	94,39	*
June3_B5	224,64	*	May18_B8	72,90	*
May18_B3	216,29	*	June3_B4	70,13	*
June3_B7	204,02	*	June3_B1	65,34	*
May18_ndvi	189,92	*	June3_B62	63,34	*
April16_B3	185,89		June3_B61	61,82	*
May18_B2	182,69	*	April16_B4	51,48	
May19_B1	179,26	*	May18_B62	51,08	*
April16_B1	177,11		May18_B61	43,92	*
April16_B2	174,24		June3_B8	27,86	*
April16_B61	155,97		April16_B8	15,67	
April16_B62	154,68		June3_B2	4,23	*

*after disc cultivation on the field which were totally damaged by wildlife

Band 5 is the short wave infrared reflectance (SWIR: 1.55-1.75 μm). Its spatial distribution is shown on *Figure 2*. Considering the endpoints of the scale (no damage = 96.4 vs. total damage = 164.5) as detailed on *Figure 3*, the partial damage can be calculated: 41.5 %. Considering the area (28.6 ha) and the yield on not damaged area (4 t/ha) the total yield loss is 47 tons.

There was no complete damage in 2012. However, reflectance data of not damaged fields were very close to each other in the two years (96.4 in 2013 and 89.9 in 2012 on the average) thus, it could be assumed that the same is true for reflectance data of completely damaged fields, so data from 2013 can be used for the comparison. Based on the data (zero damage: 89.9/2012, complete damage:164.5/2013, partial damage:118.4/2012 on the average) it was calculated, that one field suffered 38 % yield reduction and a one hectare portion of another field suffered 23 % yield reduction. Three other fields were not

damaged significantly. Based on the areas and average yield (4.3 t/ha) the total yield loss was 15 tons.

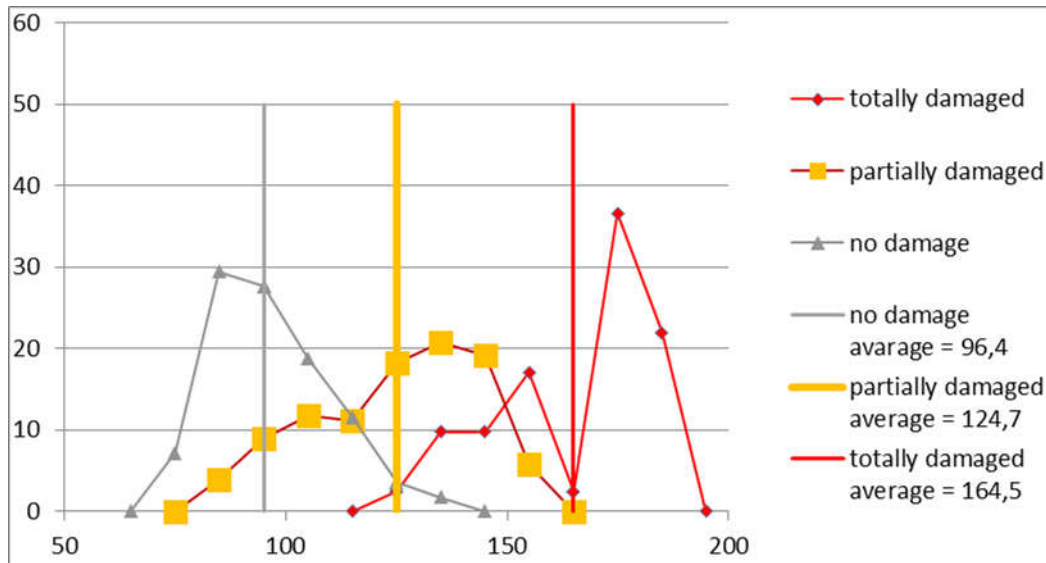


Figure 3. Distribution and averages of SWIR reflectance values for 2013

Landsat 8 SWIR reflectance (Band 6: 1.566 – 1.651 μm) in 3rd of April 2017 were validated with yield map from 2017. Landsat 8 images have pixel values between 0-65535 (2^{16}) while Landsat 7 images between 0-255 (2^8). Pixel values were recalculated to the range of Landsat 7 images, yield data were averaged for the 30x30 metre pixels of the images, and yield values with same reflectance value were averaged too. The relationship between pixel reflectance values and yield was acceptably strong ($R^2=0.634$ Figure 4).

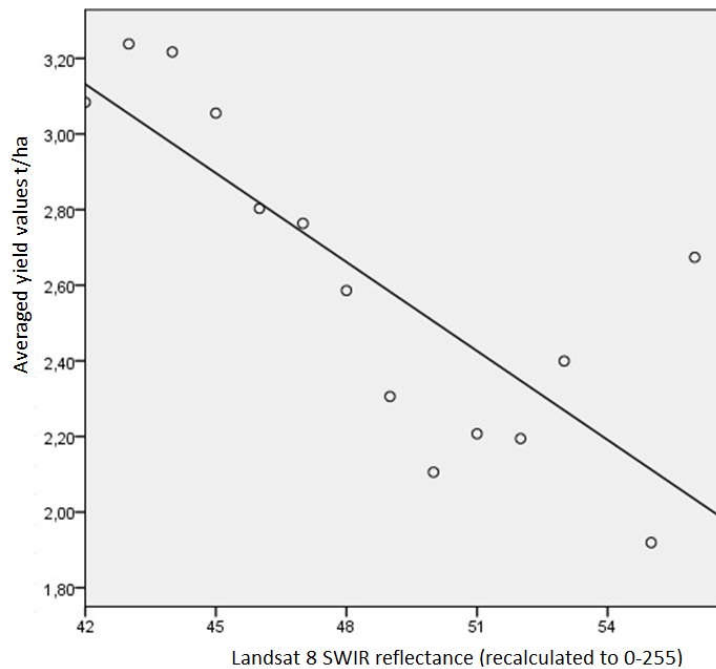


Figure 4. Regression between SWIR reflectance and averaged yield map data

CONCLUSIONS

Remarkable conclusion from our study that NDVI indices performed worse than SWIR reflectance. April is the flowering time of rapeseed when very intensive biochemical processes are going on parallel with a rapid growing. The SWIR reflectance value in April correlated very well with the yield harvested in early July as evidenced by the investigation for 2017. The distributions of the pixel values for 2013 (*Figure 3*) show some skewness for the not damaged area indicating weaker spots even in a field with high average yield. The pixel values for partly damaged field have overlapping bimodal distribution indicating relatively undamaged spots within the field. The pixel values for completely damaged field show two distinct distribution. Higher values might indicate bare ground with total destruction of the crop and lower values might represent still existing, highly damaged crop. The divide between the two groups is exactly at the point where the distribution of partial damage cases which also confirms that conclusion.

Finally the conclusion can be drawn that SWIR reflectance values in April are good indicators for rapeseed yield and the proposed method is an appropriate tool for wildlife damage assessment in case reference values for zero and total damage are available.

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