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Cropmarks 2011 in Poland – is there a need for further discussion?

Włodek Rączkowski[1]

Introduction – what do we know about the origin of cropmarks?

From the beginning of aerial archaeology, cropmarks have been a subject of great interest to archaeologists therefore, by now, we should have identified the factors influencing their appearance. From experience to date we all know that dry periods in particular affect the emergence of cropmarks. However, our knowledge of the complex processes which take place in the soil, buried archaeological features, vegetation etc., is based more on a common-sense approach than in-depth investigation. A more detailed analysis was undertaken in the 1970s when the connection between differential crop growth and moisture levels was identified by Jones and Evans (1975) who referred to pedology and crop cultivation. Evans and Jones (1977) analysed a series of aerial photographs of two archaeological sites (Glenlochar, Kirkcudbrightshire and Fisherwick, Staffordshire) taken over a number of years. The aim of that study was to explain the mechanisms causing the differential crop growth. Cropmarks in cereal fields usually appeared under dry conditions when there was less moisture in the top soil and a potential soil moisture deficit (PSMD) of approximately 50 mm arose (Evans, Jones 1977: 63). Information on PSMD can now be found online and may be used when planning aerial survey.

The in-depth analysis of soil types, sorption properties, the observation of PSMD levels and the resulting differential crop growth led the authors to define a number of regularities (Evans, Jones 1977: 75). First, if the soil moisture deficit increases in relation to the potential capacity of the soil then such conditions encourage cropmarks to emerge. Second, the depth of the soil affects how much water is held within the profile and cropmarks may appear (when the deficit of moisture is high) more in areas where the soil is deeper as compared to where it is shallow. Third, if the bedrock is compact and drainage is poor then weak cropmarks may emerge even during very wet years. Fourth, if a soil moisture deficit leads to the appearance of cropmarks then they will remain visible even if later rainfall provides a better water supply that levels out this deficit. Fifth, cropmarks on grass (pasture, meadow) compared to cereal crops cultivated on the same soil, appear when the soil moisture deficit is higher. Sixth, soil maps are useful for the prognosis of the probability of cropmarks appearing.

Similar studies were carried out by Riley (1979: 31) around Doncaster and Nottingham. He pointed out that apart from PSMD, the type of crop cultivated and if whether it was a winter or spring crop was also important. Riley showed the process of cropmarks appearing and changing using photographs of Standlake, Oxfordshire, where from 4 June to 16 July 1943, he regularly took photographs of barley fields. In his comments on the role of PSMD he pointed out the significance of which crop is being cultivated as the rate of water evaporation is affected not only by the soil type (heavier soils hold moisture for longer – also Riley 1983: 72), but likewise by the crops growing there. The speed with which water evaporates from the leaves is fundamental and so, therefore, their surface area may have a significant impact on the occurrence of PSMD.

[1] wlodekra@amu.edu.pl

Considering the importance of the relationship between how much water is available for crops and the appearance of differential crop growth, further investigation in this direction was deemed necessary. Water plays a decisive role in the nourishment of plants as it contains the chemical compounds which are essential for their growth. Nitrogen and calcium are of particular importance. Their presence in the soil significantly influences how other elements are absorbed. Nitrogen accounts for how plants look, their height, greenness and the duration of vegetation. Calcium is responsible for how the sources of nourishment to be found in the soil are exploited by the plants themselves. Acidity levels can affect the absorption of phosphorus, magnesium, copper and even nitrogen and as a result, plant size and colour (Wilson 1982: 55).

For Martin (1971), the analysis of how often cropmarks and soilmarks emerge under certain soil and climate conditions became the basis for the formulation of the theory that it is possible to predict their appearance. The properties of the soil and the amount and frequency of rainfall determine when cropmarks and soilmarks appear and how long they may be visible for. Depending on the year, this period may vary by even up to six weeks.

Having such knowledge at our disposal we can then plan aerial survey and expect positive results. Furthermore, it is relatively easy to find information on PSMD, rainfall levels and the soil types in the regions which are of interest to us. It seems that we are properly prepared for what we may see from the air.

Aerial survey 2011

Prospects for aerial survey in Poland in 2011 looked promising. On one hand this was due to financial support, and on the other, to the spring drought which had lasted for quite some time. This year's aerial survey was financed by ArcLand, the National Heritage Board of Poland together with the University of Szczecin (as part of the project recording megalithic graves in NW Poland) and the Institute of Prehistory at the Adam Mickiewicz University in Poznań (the Kujawy Region) (Figure1). When planning aerial reconnaissance in this part of Poland, knowledge of the soil types is not a major issue for me. This is due to the fact the the soil in this region is patchy and ‘multi-component’ as a result of the last glaciation. Generalised soil maps do not show the local conditions, small areas of specific soils (Kiarszys, Rączkowski, Żuk 2007: 56-57). Our expectations and the aerial survey plans were based on the identification of the moisture conditions in 2011 and had to fit around various other commitments. As a result, aerial survey focusing on photographing cropmarks took place in two phases: 21-28 June and 14-19 July.

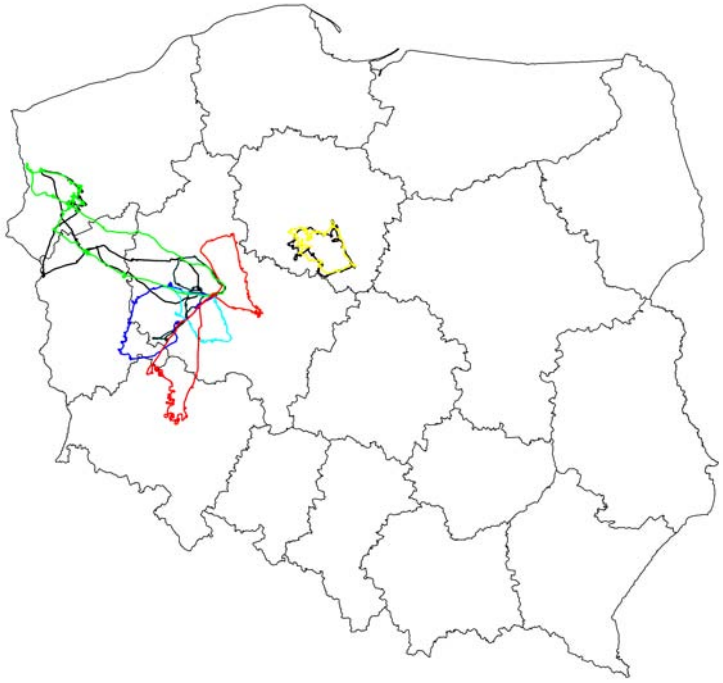

Figure 1. Aerial survey in Poland – June-July 2011. Source: author.

My experience so far has shown that in a "normal" year the end of June is still a little early for the observation of clear cropmarks in this region of Poland. However, as spring 2011 had been very dry we were expecting cropmarks to be visible already in June. The area affected by drought covered the whole of the north-west of Poland (Figure 2), including the area of the planned reconnaissance. It was reminiscent of the situation in 2000, and so expectations were running high. The clarity of the cropmarks was not so bad but not quite up to expectations. What is more, the fact that the crops were in a quite advanced state indicated that the harvest would be very early and may well be in progress by mid-July. This would have a negative affect on the results of the second phase of the aerial survey.

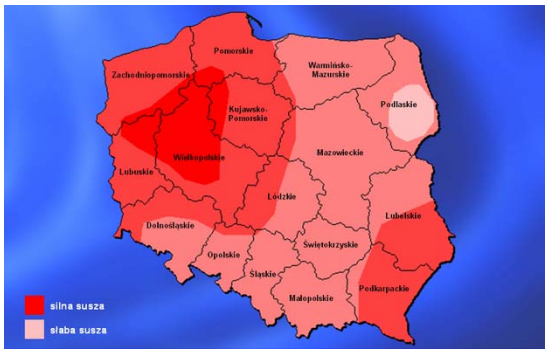

Figure 2. A map showing drought areas of Poland in 2011. Source: http://www.twojapogoda.pl/wiadomosci/108933,gdzie-jest-sucho-gdzie-zas-mokro

The weather deteriorated at the start of July and the rainfall meant that the harvest began in mid-July, only a little earlier than usual. This rescued the flying season in the last two weeks of July. This time, the cropmarks were extremely clear and readable (Figure 3).

Figure 3. Mutowo, Wielkopolska Region. Comparison of the appearance of cropmarks photographed on June 23rd (left) and July 16th (right). Source: author.

Questions (and answers?)

The fact that the clarity of cropmarks varies during the growing season is nothing surprising. But after thinking about this year's results a few doubts emerged. I had always considered, to put it rather simply, that drought provided good conditions for the appearance and visibility of cropmarks. This time however, this mindset let me down (at least to a certain extent). Paradoxically the situation had arisen where after (or during) a drought the cropmarks were relatively well defined, but were much better after rain. Therefore I asked myself two basic questions:

- why were the cropmarks less defined in June than I had expected, despite the long drought?
- why, despite the rain at the start of July, did the cropmarks become more visible (Figure 4)?

Figure 4. Krzan, Wielkopolska Region. Clearly-visible cropmarks on July 14th (beginning of the second phase of flying season). Source: author.

Intuition and the information I had gathered loosely led me to arrive at answers which I consider to be justifiable. This does not mean however that I am right and I am open to other suggestions. In trying to find the answer to question 1, I decided to look at the problem from a wider time perspective than just the two-month drought. Wielkopolska is a region which for some time has been recorded as having a low level of precipitation (rain, snow). Average rainfall is about 500-550mm annually which is less than other regions across Poland (Woś 1994). Winter 2010/11 brought quite a lot of snow which lay on the ground for a relatively long time. The snow melt significantly affected the moisture levels in the soil. The spring drought of course did have a negative effect on crop growth (Figure 5), but this was tempered by the level moisture in the soil (particularly in the subsoil). As a result the main factor affecting the appearance of cropmarks – the deficiency of moisture – may not have been sufficiently intense, especially as far as winter crops were concerned.

In so far as such an explanation may be acceptable in regards to question 1, then what happened in the first two weeks of July causing the cropmarks to suddenly become so clearly visible? My attempt to find an explanation here moves in a slightly different direction. A long drought (Figure 5) clearly weakens the plants due to disturbed nutrient sources, even if this does not immediately result in visible cropmarks. Any irregularities in growth connected to drought also affect areas where the plants are less resistant to various diseases. The rainfall at the beginning of July (Figure 5 – final map) created good conditions for an increase in some diseases and molds. It is in such conditions (damp and warm) that the saprotrophic black mold, mainly from the *Cladosporium genus*, occurs. This colours the stalks and leaves a characteristic dark brown-black. The crops which are even just a little stronger (ie., positive cropmarks) are able to "defend" themselves longer and remain lighter in colour. This in fact provides a good contrast and makes differentiation in field conditions clearly visible. If this response to question 2 is acceptable then it seems that PMSD is not the only factor that affects the visibility and clarity of cropmarks. This indirectly affects other processes – eg., biological

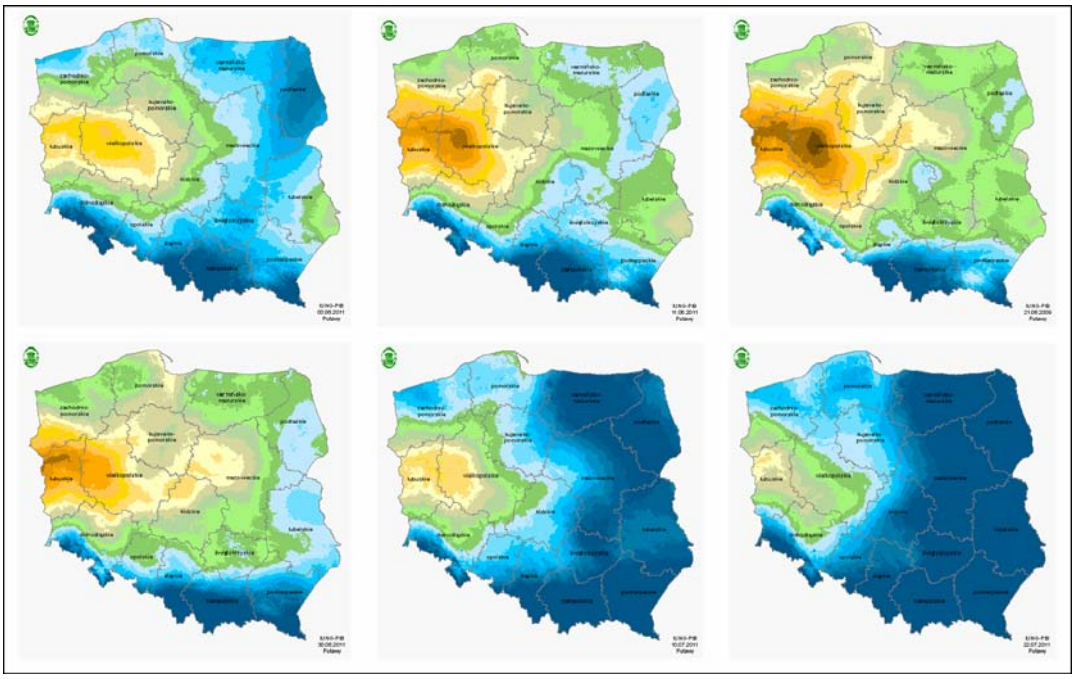

Figure 5. Changing of Climatic Water Balance in the period from April 1st to July 20th. Each map represents situation in 10 days sequence successively. Source: www.susza.iung.pulawy.pl

– which can strengthen or weaken the cropmarks. The situation in other parts of Europe (eg., in Hungary – Czajlik 2009; Czech Republic – Gojda 2004; Germany – Christlein, Braasch 1982; Schwartz 2003) is similar. This is unlikely to be a fundamental aspect and local conditions affect biological processes in various ways. So each time we have to face a complicated knot of many factors which affect strength of action. Perhaps this is the reason why cropmarks so often "surprise" us, sometimes appearing, sometimes not.

Conclusions

A critical review of the cropmarks of the 2011 season points to the fact that more in-depth study on this topic is necessary. Research carried out in the 1970s focused mainly on one point – PMSD. Perhaps it would be worthwhile investigating the influence of other factors? I think that only by furthering our knowledge of this method will we be able to properly evaluate the effectiveness of aerial survey, understand the presence or lack of cropmarks. Not only is the aspect of archaeological features affecting crops important, but also the visual result. After all, this has a significant influence on whether or not we recognise the presence of archaeological features. My intuition does not necessarily have to be adequate, but it may inspire someone else to investigate deeper.

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Editor's comment

This issue of *AARGnews* was held until this contribution had been completed. Reading it – and subsequent email discussion with Wlodek – gave rise to a number of questions that have also been floating around in discussion by, and with, Bob Evans as a result of our involvement with DART and a lunchtime meeting with him in the past couple of weeks when he came to talk about Johanna Dreßler's research. If I remember things correctly, some points can be summarised as follows:

The papers of the 1970s that pointed out the relevance of SMD were crucial in helping aerial photographers to begin to understand why, when and how crop marks may develop. Bob Evans revised his work in 2007 (in Mills and Palmer (ed) above) and has also noted that cereal crops of the 1970s (let alone those that Derrick Riley photographed in 1943 and used in his 1979 analysis) are very different to modern varieties which are shorter and have different leaf arrangements. Is new research or analysis needed to account for those crop differences?

Farmers now have the technology to selectively squirt small areas of each field in an attempt to balance the effect of soil type and depth so that crops ripen equally and at the same time. Are we likely to 'lose' archaeological information because of this? And, if so, is there anything we can do about it?

How useful is this 'in depth' knowledge anyway? Do we need to progress beyond the basic concept that a dry year gives us good crop marks? Are crop marks in April, or a dry May or June, a reliable sign that we need to commission vertical surveys or satellite passes rather than messing around ourselves trying to notice, then photograph, features in many individual fields?

We think there may be the potential here for a session at a future AARG meeting.