Aerial Photography as a Crop Management Aid

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Minimizing crop growth problems is a major objective of any crop production management program. But when a farm increases in acreage, the operator may find that objective more difficult to maintain because there is now less time available to manage each acre.

One tool that can help maximize a farmer’s limited crop management time while improving his decision-making ability is aerial photography. Aerial photographs are point-in-time visual records of specific land areas. They are used to assess field conditions and detect crop or soil problems that might otherwise go unnoticed at ground level. Often, it’s the patterns of symptoms that can give clues to the cause and extent of various problems.

The purpose of this publication is to help you, the crop producer, evaluate the merits and feasibility of aerial photography as a crop monitoring and management aid. Presented are such matters as: what kinds of problems can aerial photos detect; who provides aerial photography service, what’s involved, and what does it cost; when should it be done; what equipment/techniques may be used and which are preferred; and how are aerial photos “read” and interpreted? Six aerial photos taken in central Indiana (courtesy of Swaim & Associates, Crawfordsville, IN) are reproduced on pages 2 and 3 to illustrate the various field problems and photo interpretive elements discussed.

Problems Detected by Aerial Photographs

Here are some field conditions that can be successfully detected and measured using aerial photography. (See the referenced figures for examples.)

Tillage and compaction problems. Aerial photographs provide an excellent “base map” for determining the effectiveness of a tillage system, which should be evaluated by soil type and existing field conditions at the time various operations were performed. Aerial photos can also show subtle patterns of soil compaction that are almost impossible to see from the ground. By comparing patterns of traffic and irregular crop growth (Figure 5-A), compaction problem areas are identifiable.

Stand uniformity problems. Aerial photos can locate and accurately measure areas of irregular or reduced plant stand resulting from weather, soil, or planter problems (Figures 1-A and 2-A).

Moisture problems. Aerial photos can also detect and measure areas of crop stress caused by too much or too little precipitation or by inadequate drainage (Figure 2-C).

Fertilizer problems. Although difficult to see from the ground, lime or fertilizer skips and overlaps caused by equipment malfunction or operator error are easily detected on aerial photos (Figure 6-A). Nitrogen excesses or deficiencies due to mechanical error, denitrification, or volatilization may affect crop performance to the extent it can be observed on aerial photos (Figure 5-A, B).

Insect and disease problems. Crop stress resulting from an insect or disease infestation can often be detected by aerial photography. Field scouting is then required to confirm the infestation and its extent, identify the pest, and determine the potential treatment options.

Weed and herbicide problems. Weed infestations, which are rather easy to spot on aerial photos, usually indicate insufficient herbicide control due to poor timing of application, adverse weather, misapplication, or an ineffective spectrum of the material selected. Sometimes the weed pattern itself helps identify the cause of the problem (Figures 3-B and 4-C, D).

Together with field verification, aerial photography is also used to evaluate perennial weed problems (Figure 4-C). With yearly monitoring, one can see if an infestation is being kept in check or if it’s growing, which herbicides are working best in the problem areas, etc. Crop injury from carryover of herbicides can also be observed on aerial photographs (Figure 2-D).
Determining the Feasibility of Aerial Photography

While aerial photography would benefit any size farm, generally the larger ones (640 acres and more) are best able to justify the expense. They use it to monitor not only crops but also equipment operation and custom services performed.

Although aerial photography can aid in short-term management decisions, Indiana farmers more commonly use it to evaluate cropping season performance. For this purpose, good pictures in late July or early August can probably reveal the greatest number of problems to be addressed in the future.

The reason aerial photography is rarely used for short-term management has to do with atmospheric conditions. The minimums for acceptable aerial photography are: cloud cover of less than 10% and low density of atmospheric haze. In Indiana, such conditions are likely to exist only 8 days in July and 6 in August, and usually only in the morning hours. This makes it very difficult to plan photography on a regular basis. (Haze can be overcome somewhat by filters, but less haze is preferable.)

There are a number of aerial survey companies and crop consultants in the Midwest that offer aerial photography service to farmers. Many also provide interpretation. Some farmers with a good 35mm camera and access to an airplane take their own pictures, and may be available for custom hire.

The cost for aerial photography varies depending on whether slides or prints are requested and if and how much interpretation is provided. Generally for commercial aerial photography without interpretation, slide costs are at least 25 cents per acre and prints at least 50 cents. And there may be an acreage minimum.

“Bracketing” experimentation may be necessary to get the proper camera settings for infrared film. Bracketing involves adjusting one of the three variables (film speed, lens aperture, shutter speed) and recording the frame number and the complete setting of the camera. After the film is developed, quality of the pictures is compared and the camera settings for the best ones noted.

A film auto-winder is recommended when several frames will be taken rapidly. Other types of cameras may be available depending on the equipment used by a particular company.

**Lens.** Lenses are critical for an optical system to record images. Select them carefully, because lens quality is very important in aerial photography.

**Filtering System.** Atmospheric haze can distort aerial photographs. Haze is the scattering of ultra-violet and short-wavelength blue light by moisture and microscopic particles of dust and pollution in the air. A bluish tint often appears on slides or prints under normal summer conditions without the use of a haze filter. This tint decreases an image’s visibility and resolution. The haze filter absorbs ultra-violet and blue light, giving the image better color balance and resolution.

Color infrared film requires a yellow lens filter to absorb all blue light entering the camera. Density of the filter and amount of light filtered affect the color balance of a slide.

**Film**

Two types of film may be used for aerial crop monitoring—true color and color infrared. Because each has some unique advantages, a number of producers elect to use both by mounting two cameras together and operating them simultaneously.

**True color film** shows crops in their familiar natural colors (i.e., normal leaves are green, chlorotic leaves yellow); but it cannot detect crop stress to the degree of color infrared film. True color film and its processing are inexpensive and readily available, and processing turn-around time is short.

**Color infrared (CIR) film,** which is sensitive to the near-infrared wavelength, can make what is invisible to the eye visible on film through tonal and color differences. It not only produces a high contrast between non-living objects and natural foliage, but can detect subtle changes that occur when plants become stressed or diseased.

Changes in the chlorophyll concentration, internal structure, and orientation of the leaves of stressed plants alter reflectance of the infrared wavelength of light. Stressed plants will generally reflect less infrared radiation than non-stressed plants—a difference the CIR film will pick up.

Disadvantages of CIR film, compared to true color, are its purchase and processing costs and, more importantly, its processing time. The costs of
film and processing are minor relative to the total cost of aerial photography; but the two or more weeks often required for commercial processing make its use impractical for short-term management decisions. (For those who do their own film processing, Kodak E-4 Hobby-Pac development chemical can be used for CIR film.)

Altitude and Camera Angle

Altitude at which the aircraft should fly depends on the area to be covered and the focal length of the lens. Usually the range is from 3000 to 6000 feet.

Camera angle for aerial photography can be either vertical or oblique. Verticals are taken with

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Figure 1. A's show changes in tone and shape that are related to soil differences. B is an area where weeds are present. C's are differences in tone denoting different crops; soybeans are in the center, with corn on either side.

Figure 2. A is a tone variation related to decreased stand based on soil differences that have affected crop growth. B is a pattern caused by different hybrids. C shows the shape of a drainage pattern. D is the typical appearance of herbicide carryover; it is less of a problem in lower areas than on higher areas.

Figure 3. A is a tone and texture variation in soil that is caused by different crop variation due to weed growth where wet conditions occur. B is a pattern caused by different soybean varieties. C is a pattern caused by nitrogen applied at an appropriate time.

Figure 4. A's are tone variations caused by different herbicides. B is a pattern caused by different herbicides. C shows the shape of a drainage pattern. D is a variation in texture caused by different soils.
the camera pointed straight down at the ground, often through a port hole in the bottom of the plane; while obliques are taken with the camera pointed other than straight down, usually out a window. High-oblique photographs are ones that include the horizon; low-obliques do not.

For crop monitoring, vertical photography has some important advantages over oblique. (1) Resolution is better because the entire image on each frame is equidistant from the ground (vs. oblique where the upper portion of the frame, being further away, whitens and fades); (2) patterns, particularly subtle ones, can be seen much easier; (3) each frame covers about the same amount of acreage, if

Figure 5. A is a pattern related to nitrogen loss because of inadequate incorporation along traffic patterns; lighter areas also indicate additional N loss due to wetness. B is a tone variation caused by double application of nitrogen.

Figure 6. A's are pattern variations caused by non-overlapping nitrogen application at an angle to crop rows. B is the typical texture of forests; variations in tree growth and other features can be observed.
the aircraft flies at the constant height; and (4) acreage estimates can be made much more accurately. The disadvantage of vertical photography is that it requires a higher degree of planning and preparation than oblique.

**Aerial Photograph Interpretation**

Interpretation starts with noting the visual differences in four photographic elements—tone, texture, pattern, and shape. These differences can be caused by soil, environmental, vegetative, cultural, and other factors. Accurate interpretation is what determines the ultimate value of aerial photography as a crop management aid.

**Elements of Interpretation**

The following paragraphs discuss briefly each interpretive element—its definition, the differences it reveals, and reasons for those differences. The referenced figures show examples of the four elements.

*Tone* is the color or relative brightness of an object. It is the characteristic most noticeable for distinguishing between crops and in identifying problem areas within a crop. Soybeans, for example, reflect more green and infrared light than corn. Thus, in true color photos, soybeans look dark green and corn more yellowish-green (Figure 1-C); while on infrared photos, beans are dark red and corn has an orangish tint.

Wilting, chlorosis, and necrosis, which are evidences of plant stress problems, produce tonal differences that color infrared can detect. A true red indicates healthy plants, whereas light red, pink, and bluish-pink indicate plants under stress.

*Texture* is the degree of roughness or smoothness—a visual impression usually related to crop density and plant height variation. For instance, solid-seed soybeans have a smooth, velvety texture; while widely spaced corn rows appear much rougher. Lodging problems in a corn field or pockets of tall weeds in a smooth-textured bean field produce a rough, cobbled texture that is rather easy to spot (Figure 3-B).

*Pattern* is the repetition of tonal or textural characteristics over a given area. Pattern arrangement is often a clue to its origin. For example, linear patterns may be caused by compaction that resulted from tillage or traffic, or by broadcast applications of lime or fertilizer (Figure 5-A).

*Shape* is the recognition of geometric configurations usually defined by tonal differences. The shapes most noticeable in a field are those caused by changes in soil type (Figure 1-A). Shape is seen, for instance, in the contrast between lighter and darker colored soils, more poorly drained vs. better drained soils, etc. A soil survey map of the photographed areas can then be used to identify the different soils present.

**The Interpretive Process**

Aerial photo interpretation is a two-step process of (1) gathering information from the photograph utilizing the interpretive elements and (2) developing possible relationships from previous experience. Interpretation is a skill that improves with training and practice. It also requires confirmation by field evaluation and use of all the information available on that given land area.

Aerial photography can be an effective way to evaluate performance of cropland acreage. Along with soil surveys, soil testing, field scouting, and good record keeping, it may prove a valuable addition to your crop production management program.

If you have further questions or would like to be put in contact with persons who provide aerial photography service, contact the authors at the Agronomy Department, Purdue University, West Lafayette, IN 47907.