RESEARCH ARTICLE

Unmanned Aerial Vehicle for fertilizer management and human health

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Abstract: Groundwater is a main source for supplying drinking water. High concentration of fertilizer originated in soils accumulated through irrigation water causes negative impacts on the agricultural environment, soil-grass quality, livestock and fishery production and on the food chain. Fertilizer plays an important role in increasing agricultural production. Over-fertilizing has a negative effect on water quality which in turn negatively affects the health of the people and animals who use it. The purpose of this paper is to develop a methodology that has the potential to reduce the amounts of fertilizer used and thus to have secondary environmental benefits. This is done by using Unmanned Aerial Vehicles (herein after UAVs). The authors conducted experiments in both Hokkaido and Miyakojima, however in this paper, forage crop management in Hokkaido is discussed. UAVs equipped with RGB and near infrared cameras that take Blue Normalized Difference Vegetation Index (BNDVI) images fly over the cropland. Orthorectifying Aerial Photographs are obtained from both of RGB and BNDVI images. Comparing several images, the resulting data can be used, the amounts of fertilizer needed can be optimized by analyzing the spatial growth patterns of the cropland. The authors offer this paper here to stimulate research interest and contacts in the cross disciplinary fields of agriculture management, environmental issues and human health.

Keywords: bndvi, uav, ortho rectifying, fertilizer

Introduction

Groundwater arsenic contamination is a serious problem in Bangladesh (Haque et al, 2007). Fertilizer runoff from farms is recognized as having serious environmental problems (Novotny, 1994). According to the authors' survey to the operator and fisherman, feeding overfertilized forage to cows results in health problems. A cow is not able to stand up. Exceeded fertilizer is absorbed by plants and with rain drainage to water route and contaminates the sea. In this paper, appropriate fertilizer management on forage cropland next to Lake Notoro, eastern Hokkaido, Japan is proposed by using UAVs. UAVs are becoming widely used in various fields such as film making, civil engineering and agriculture. They are expected to increase economic efficiency by reducing data collection costs, and making possible the automatic/computerized application of collected data into the production process. Precision agriculture aims at delivering results with minimum delays to enable management decisions based on current cropland and soil status. Pre-programmable flights improve output data quality by maintaining flight elevation and trajectory (Siebert and Teizer 2014). Conventional aerial imagery from UAVs is increasingly used in the acquisition of high spatial resolution imagery (Pajares 2015). In Canada, data collected by UAVs showed accurate forest inventories (Hilker et al, 2008). UAV systems can provide terrain information in the form of Digital Elevation Models (DEMs) that are invaluable as they offer detailed topographic information. Low acquisition costs attract stakeholders. In this paper, precision agriculture combined with UAV technology is used to research the spatial variability of forage crop growth into micro-areas with the aims of adjusting fertilizer use for each micro-area. The Iwamoto farm owns more than 90 ha of forage cropland and is situated facing Lake Notoro, in eastern Hokkaido (Okhotsk region).

Materials and methods

The Authors are familiar with a variety of UAV models and technologies. In this study, the platform, a model Phantom3 Professional, DJI is mainly used. To make shooting conditions almost identical, UAVs should fly on a fixed course. Auto pilot software lets a UAV to fly along a pre-calculated course as if it were an automated cleaning machine.

Figure 1. UAVs in operation (Left) and Way points on the observatory (Right)

Overlapping, geotagged RGB and GNDVI images of forage cropland are obtained and a stereo-photogrammetry method is applied (Matsumura 2017). Orthorectifying aerial photographs are obtained from both of RGB and BNDVI images. The green leaves of plant absorbs RGB light spectrums ranging from 0.4 to 0.7μm and reflect the infrared(NIR) band spectrum ranging from 0.7 to 1.3μm. Making use of reflected difference, a normalized difference vegetation index (NDVI) is used for analysis. NDVI indices show changes in growth stages and conditions (Lu et al, 2015). The infrared lens "NDVI7" is obtained from the USA (IR-Pro 2017). In this research, instead of using the NDVI index, the Blue Normalized Difference Vegetation Index (BNDVI) images are used for analysis. The formula is expressed below.

BNDVI= (NIR-Blue)/ (NIR+Blue)

BNDVI values ranges from 0 to 1. A rotary platform equipped with a near infrared camera shoots Blue Normalized Difference Vegetation Index (BNDVI) images. The image is applied to the NIR, Green, and Blue channels. Instead of the red channel, the blue channel is used because the ability of the lens. Figure 2 shows extracted red channel from RGB image (Upper) and blue channel of NDVI7 (Lower) provided by Shoot Tech Company and it shows that the red channel and blue channel have almost the same distribution. In this preliminary research, the authors checked the accuracy of the collected data between the uav-produced BNDVI images and surface measurements; by using a Green Seeker Handheld Crop Sensor which collects NDVI values. The compared results were accurate within a statistically significantly range (Matsumura et al, 2016).

BNDVI images were collected on Apr 7th, May 17th and 19th, June 14th, 21th and 28th, Jul 3rd, 13th, 19th, 25th and 28th. Aug 2nd, 17th, 25th and 28th. Sep 19th, Oct 11th, Nov 17th.

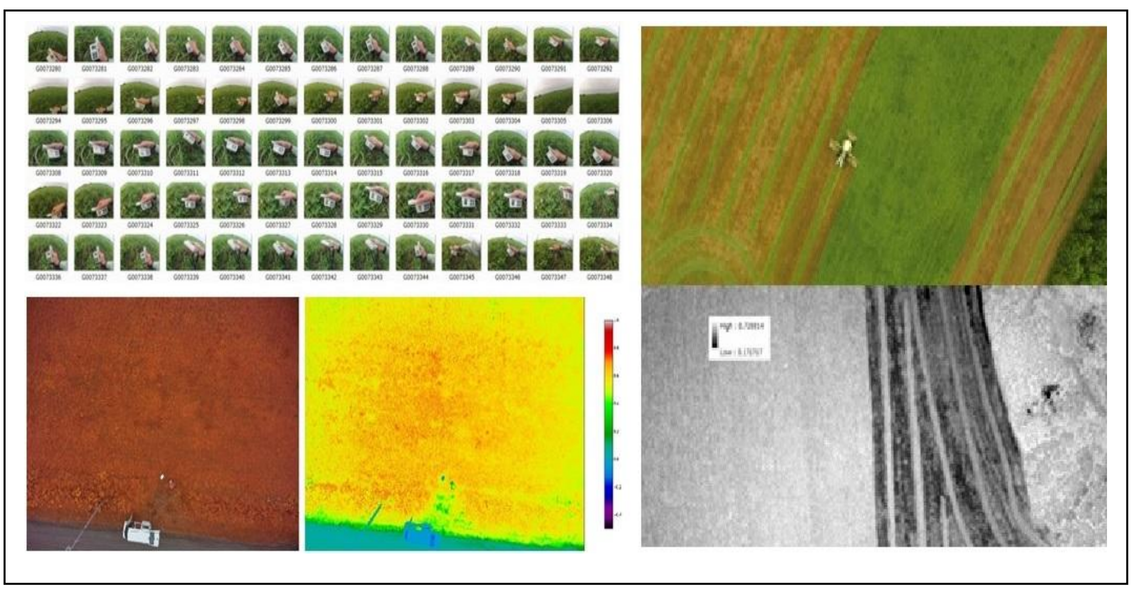

Figure 2. Observation by a chlorophyll meter (Upper Left) and corresponding observatory (Lower Left and Right)

A chlorophyll meter SPAD-502 was also used to check the relationships between BNDVI value and real values on Aug 28th. The average value obtained from a chlorophyll meter is around 38 and correspond to a BNDVI values ranging from 0 to 1. The forage crop was cut three times during this research period. Harvests were conducted on Jun 18th, Aug 4th, and Oct 16th. The harvested area shows lower levels of BDVI values. The average BNDVI value of the black colored area (before mowing) ranges from 0.3 to 0.4, while white area value (after harvesting) ranges from 0.5 to 0.6.

Table 1. Periods of shooting, fertilizing, cutting

	Mar	Apr		May		Jun							Jul				
	8	7	21	17	29	14	17	18	19	21	28	30	3	13	19	25	28
RGB	○	○								○	○	○		○	○	○	○
BNDVI		○		○	○	○				○	○		○	○	○	○	○
Cutting							1st										
Harvesting								1st									
Fertilizing			○						1st								

	Aug							Sep	Oct			Nov
	2	3	4	5	17	25	28	19	11	14	16	17
RGB	○				○	○	○	○	○			○
BNDVI	○				○	○	○	○	○			○
Cutting		2nd								3rd		
Harvesting			2nd								3rd	
Fertilizing				2nd								

The forage crop is cut 3 times a year and then fertilized. According to the owner, fertilizer is applied at a rate of N=117kg/ha, P=81kg/ha, K=105kg/ha.

Analysis and result

From the BNDVI images, May 17th, Jun 14th, Jul 13th, Aug 17th and Sep 19th are selected. Subtracting the previous image from the following image, BNDVI values were obtained. To highlight the difference, if the subtracted value showed over (less than) "0", it was colored in black (white). The May 17th image was subtracted from the June 14th image. During May 17th to June 14th, harvesting was not conducted. Most of the area is colored in black and it showed forage growth. June 14th image was subtracted from the July 13th image. On June 17th, first harvesting was conducted and the result showed more white area.

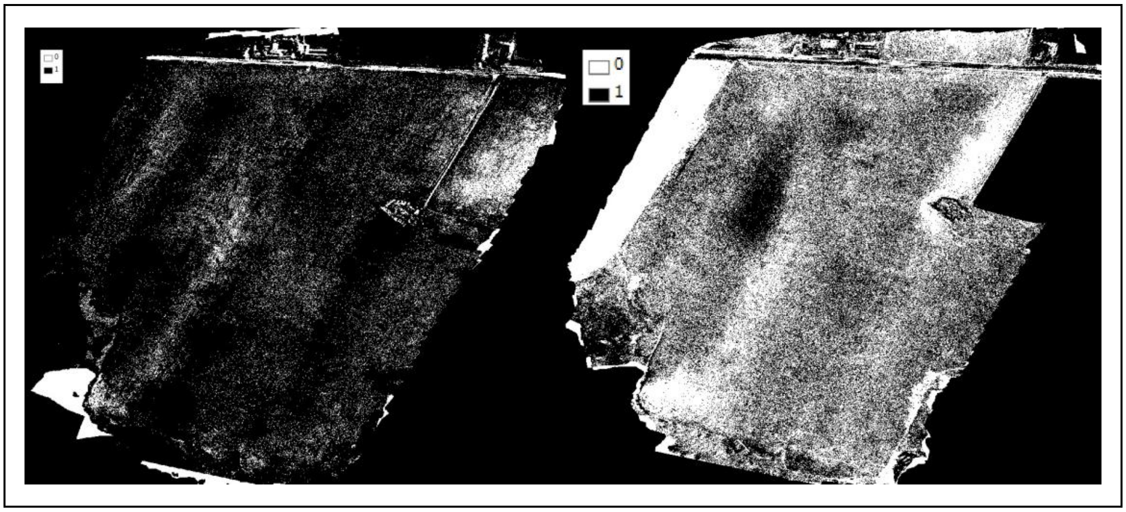

Figure 3. BNDVI difference subtracting May 17th from June 14th (Left) and BNDVI difference subtracting June 14th from July 13th (Right)

The July 13th image was subtracted from the Aug 17th image. On August 3rd, the second cut was conducted and showed more white area. The Aug 17th image was subtracted from the Sep 19th image. Cutting was not conducted during this period, most of area shows in black.

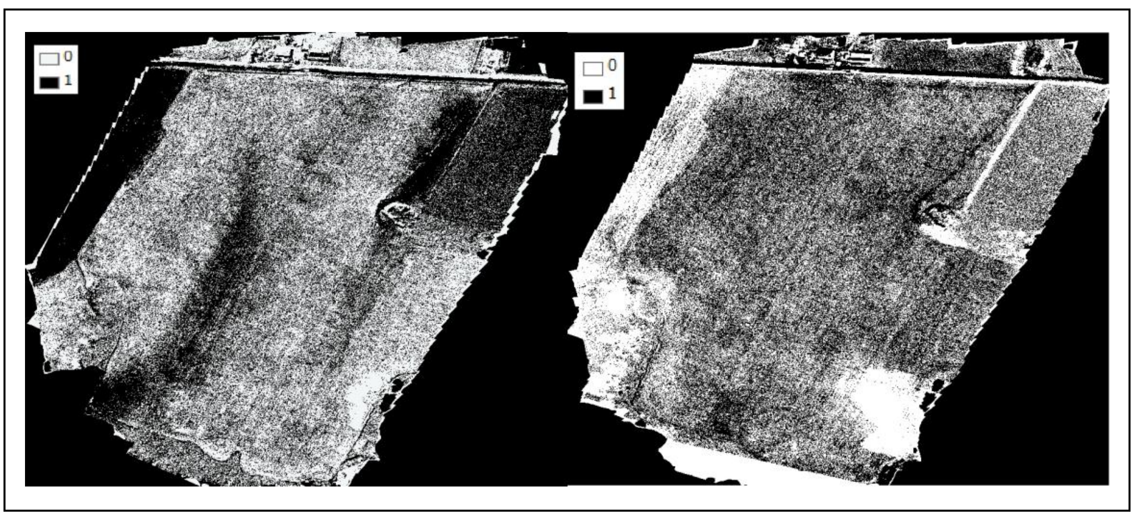

Figure 4. BNDVI difference subtracting July 13th from Aug 17th (Left) and BNDVI difference subtracting Aug 17th from Sep 19th (Right)

From the micro-areas, the operator can adjust the amounts of fertilizer applied, reducing costs. Multiplying Figure 7 by Figure 8, Figure 10 is obtained. There are spatially four combinations such as 1 by 1=1, 0 by 1=0, 1 by 0=0, and 0 by 0=0. First and second harvesting periods are included in Figure 3 and 4. After harvesting, BNDVI values decrease. However, there are some areas that show higher BNDVI values. Analysis of two images between harvest periods shows to the operator which micro-areas that might be over fertilized.

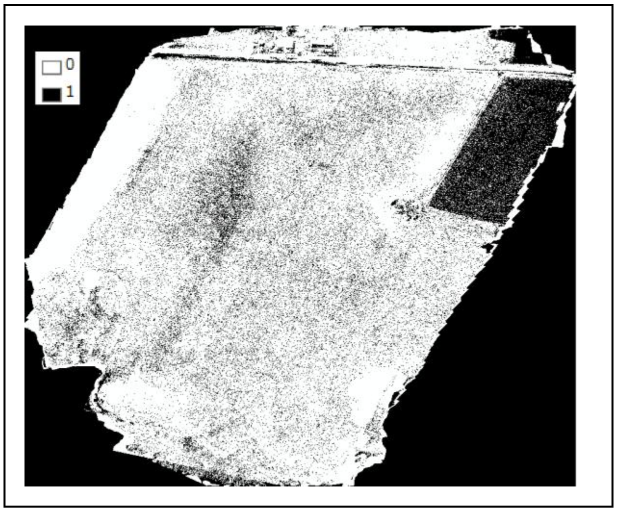

Figure 5. Portion that might be overfertilized (colored in Black)

Conclusions

Targeting forage cropland in eastern Hokkaido, RGB and BNDVI images are collected by using UAVs. First and second harvests were conducted Jun 17th and Aug 4th. Between harvesting periods, BNDVI images on Jun 14th, Jul 13th, and Aug 17th were used for analysis. After harvesting forage crop land, BNDVI values decrease. However, there are micro-areas that show increased BNDVI values. Multiplying BNDVI difference subtracting Jun 14th from Jul 13th by BNDVI difference subtracting Jul 13th from Aug 17th showed areas which might be over fertilized. According to the land operator, fertilizer costs for 90 ha approach up to 10 thousand US dollars multiplied 3 times. Reducing fertilizer leads to cost savings. Reduced fertilizer use impacts water runoff and ground water percolation. Water quality effects, the human health benefits and water treatment costs are topics for further research. Very precise Digital Elevation Models (DEMs) can be generated from series of pictures. Authors are trying to compare DEMs taken at different period to figure out height difference of forage plant. However, Global Positioning System on an UAV has height errors up to several meters. The authors are attempting to solve this problem. By multiplying precise pasture height and extent, the amount of biomass can be calculated. Amounts of fertilizer used for forage cropland and nutritional values of harvested forage are obtained from the operator. The relationships between biomass, fertilizer input and nutritional analysis can lead to more efficient management, healthier animal feed, palatable feed for cattle and environmentally friendly management systems.

Acknowledgement

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