ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 11, Issue, 04, pp.3189-3195, April, 2019

DOI: https://doi.org/10.24941/ijcr.34982.04.2019

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

ELECTROMAGNETIC RESPONSE IN STAGES OF PHENOLOGICAL GROWTH OF POTATO CULTURE *SOLANUM SPP* WITH VARIOUS METHODS TO ESTIMATE EVAPOTRANSPIRATION, USING RGB AND NIR IMAGES CAPTURED WITH A CAMERA CANON SX260HS

[1]Pamela Andrea Paula, [2]Juan León R. and [3]Paulina Paula A.

[1]Escuela Superior Politécnica de Chimborazo, Facultad de Recursos Naturales, CENSIG Riobamba – Ecuador, EC060155

[2]Escuela Superior Politécnica de Chimborazo, Facultad de Recursos Naturales, Centro Experimental del Riego Riobamba – Ecuador. EC060155

[3]Escuela Superior Politécnica de Chimborazo, Facultad de Informática y Electrónica, Diseño Gráfico Riobamba – Ecuador, EC060155

ARTICLE INFO

Article History:
Received 18th January, 2019
Received in revised form
15th February, 2019
Accepted 20th March, 2019
Published online 30th April, 2019

Key Words:
Infrared, NDVI,
Lysimeters,
Phenological

Corresponding author:

ABSTRACT

This article is focused on understanding how the potato crop behaves and captures the solar energy to be reflected, through the use of CANON SX260HS camera with sensor that capture the electromagnetic spectrum of the near infrared. This is captured during the phenological process of the potato crop Solanum spp. in its four stages of growth as: Vegetative Growth, Start of tuber production, Growth of Tubers and Maturation or Senescence, with a drip irrigationsystem. In each phenological stage we observe different behavior in the Reflectance of solar energy that is measured through the Normalized Vegetation Differential Index that ranges from 0.2 to 0.9. These results are obtained since irrigation sheets were applied according to the information on: three drainage lysimeters, evaporimeter tank and empirical formulas. In the field research, completely randomized blocks were designed with three treatments T1 = application of the irrigation sheet measured by lysimeter, T2 = application of the irrigation sheet measured with tank type A, T3 = application of the irrigation sheet calculated with formula with three repetitions of each.

Citation: Pamela Andrea Paula, Juan León R. and Paulina Paula A. **2019.** "Electromagnetic response in stages of phenological growth of potato culture solanum spp with various methods to estimate evapotranspiration, using RGB and NIR images captured with a camera canon sx260hs", *International Journal of Current Research*, 11, (04), 3189-3195.

INTRODUCTION

Food production in developing countries, according to the FAO (2008) is carried out 60% on lands that depend on rain and the remaining 40% depend on irrigation, making water an indispensable requirement to achieve and preserve sustainable development. According to the studies carried out by Watson et al. (1997) indicates that the main effects of climate change on crops are evidenced in the duration of growth cycles, physiological alterations due to exposure to temperatures outside the permitted threshold, water deficiencies and responses to new concentrations of atmospheric CO2. The plants, when subjected to a water imbalance. The non-reflected light penetrates inside the sheet and is successively refracted, reflected and diffracted. As a consequence, emergent radiation has a diffuse character. This dispersion depends on the structure of the leaf itself, the composition of its cells (such as the presence of starch crystals) and its degree of humidity, counteract it with the closing of the stomas, thus avoiding the loss of water from inside the mesophyll cell and with it the decrease of transport and translocation of nutrients, resulting in a reduction in photosynthesis and growth; but if the stressor continues for a long time it will reach a state of exhaustion with the death of the plant(Hanson and Hitze, 1982; Kramer, 1983). The use of sensors in unmanned aircraft can capture data on hydric, nutritional, thermal or sanitary stress of plants that are easily detectable by multispectral imaging. One of the indexes to determine the vigors in quantity, quality and development of the plant is the NDVI (Alonso, 2017). As is the case with all partially Lambertian surfaces, the incident radiation is partly reflected specularly and partly dispersed. The responsibility for the specular reflection is the cuticle that covers the leaves, which gives it the characteristic brightness of some species. The non-reflected light penetrates inside the sheet and is successively refracted, reflected and diffracted. As a consequence, emergent radiation has a diffuse character. This dispersion depends on the structure of the leaf itself, the composition of its cells (such as the presence of starch crystals) and its degree of humidity.(University of Jaen, 2004). In the near infrared, the leaves with greater development of the

lacunae parenchyma produce greater dispersion. For this reason, broadleaf plants tend to be more reflective in that spectral region than narrow-leaved plants. (Ormeño, 1991). The presence of chloroplasts increases absorption, which is why the reflection must necessarily decrease, this is the reason why the leaves tend to have a higher reflectance on the underside than on the upper surface. The hairiness of some types of leaves also increases the reflectance in the visible and near infrared, but does not alter the near infrared. An interesting phenomenon to highlight is the senescence of the leaves, that is the aging process that leads to chlorosis (yellowing) and permanent wilting. Mentioned during the process, the chlorophyll content decreases in favor of the carotenoids, which produce reddish and brown colors, and the xanthophylls, which produce yellowish colors. In the near infrared the reflectance only varies when, as a consequence of the death of the blade, its internal structure changes. However, in the middle infrared there is an increase in reflectance over the entire spectral range, due to the progressive loss of water, although the absorption bands characteristic of water only disappears when moisture becomes non-existent (University of Jaen, 2004).

MATERIALS AND METHODS

Study Area: The study was carried outin the premises of the Irrigation Experimental Center of the Faculty of Natural Resources belonging to the Higher Polytechnic School of Chimborazo in the city of Riobamba - Ecuador. Geographical coordinates Latitude: 1°39´18.82´´S, Length: 78°40´39.99´´W. The gross area of the trial wasof 900m², distributed in nine plots of 10m x 10 m.

Methods: The methodology carried out is summarized in three phases. 1. Preliminary phase consisting of the collection of information and coordination for the field phase. 2. Field Phase consisting of three stages: Stage One - Design and Calibration of Lysimeters; Stage Two: Application of Treatments in the field; and Stage Three: On flights with unmanned Vehicle (power supply) type Multirotor with camera CANON SX260HS and integrated GPS in the four periods of growth of the crop.3. Cabinet Phase: Consolidation - Systematization of Information. For the calculation of the normalized differential index of vegetation of each stage of growth of the potato crop, the formula was applied:

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

Where NDVI = Normalized Vegetation Differential Index
NIR - Red = Responses in the near infrared or red and visible bands. For the treatment of the NDVI results of each flight, the Raster Data Reclassification and Supervised Classification processes are used using GIS software.

RESULTS

The sowing was carried out in plots of 9m² with spaces between plant each 0.30m and 1m distance between each row. A total of 2430 plants was sown in the three treatments (T) with three replications (R). The results obtained are: T1 the replacement of the irrigation water according to the measurement that throws the drainage lysimeter with three R.
T2 the replenishment of the irrigation water according to the measurement thrown by the evaporation tank type A with three R.
T3 the replacement of irrigation water according to the measure that throws the empirical formulas with three R. These treatments, correlated with images in the near infrared and visible red, captured with the CANON SX260HS camera, were used to calculate the Normalized Differential Vegetation Index (NDVI corresponds to each flight with spacing of 30 calendar days, being: April 17, May 17, June 17 and July 17, 2015. The images of the cameras of this type have a greater distortion in comparison with the images of the cameras of traditional mapping, and therefore a calibration of the camera is required to determine the specific parameters of the same (Laliberte et al., 2008)). If enough ground control points of good accuracy are available, a self-calibration adjustment package is executed by improving the accuracy of the photograph. (Wu et al., 1995). The pre-evaluation of the photos, calibration and initial control prior to the generation of the orthophotomose was carried out. Of the total of 151 photos taken, 137 passed the control (90%), which were selected for the ortho rectification stage. The initial processing and calibration of photos with respect to the height of flight (20 m), of the position data of each of the photos, was calculated with optimal resolution (0.62 cm / pixel). A total covered area of 2000 m2 was executed during the 4 flights. From the geolocation data included in the photos, the relative height of the terrain was calculated, in order to generate a cloud of mooring points or tie between images, and create the densified point cloud. From the set of calibrated photos, the ortho-rectification of the images is carried out with the help of 4 ground control points (GCPs). The matching or matching of the images is executed from the control points and the number of photos superimposed on the scenes (overlapping). Once the NDVI has been calculated, it yields values ranging from -1 to +1, which are adjusted to the plant growth, density to discriminate the values corresponding to wet and bare soil, therefore a threshold is determined $\geq +0.2$ corresponding to the growing plant. This value is considered as a starting point to understand the variation of absorption and reflectance of solar energy in the growing stages of the potato crop Solanum spp. Using the raster data reclassification method, the data is reclassified as described in the Table1.

DISCUSSION

The spectral reflectance of the plants depends on their nutritional status; the main character to be detected in relation to plant vigor is yellowing or chloros is with numerous deficiency states. The plant material is extremely sensitive to the lack of soluble nitrogen in the soil except for leguminous plants. A small amount of this element in an ammonia cal form produces a typical yellow color in the plant due to the decrease in chlorophyll content. This characteristic produces an increase in the reflectance in the visible, while, as a consequence of the loss of cellular layers, a decrease in reflectance occurs in the near and middle infrared. It is important to emphasize that the chlorosis can also be produced by the lack of another mineral not as essential as iron, whose deficiency gives rise to the so-called ferric chlorosis, characterized by a yellowing of the leaves that, as before, causes an increase of the reflectance in the visible; similar effects produce pests and / or diseases on plants. Certain crops in flowering during a long period of time modify their spectral signature with respect to other vegetative periods; therefore, this factor should be taken into account in the affected periods, contrasting the digital records obtained from satellite with the results of the field radiometry that, under these circumstances, becomes especially useful.

Table 1. Value of the Reclassified NDVI

Class	Valor de NDVI	Characteristic
1	0	Without Vegetation
2	0,1	Wet floor
3	0,2	Scattered Vegetation - Little Photosynthetic Activity
4	0,3	Scattered Vegetation - Little Photosynthetic Activity
5	0,4	Scattered Vegetation - Little Photosynthetic Activity
6	0,5	Concentrated Vegetation - Good Photosynthetic Activity
7	0,6	Concentrated Vegetation - Good Photosynthetic Activity
8	0,7	Dense Vegetation - High Photosynthetic Activity
9	0,8	Dense Vegetation - High Photosynthetic Activity
10	0,9	Dense Vegetation - High Photosynthetic Activity

Table 2. Number of Pixels of the NDVI Values in Flight Treatments 1

NDVI	3 (0,2)	4 (0,3)	5 (0,4)	6 (0,5)	7 (0,6)	8 (0,7)	9 (0,8)	10 (0,9)
PLOT								
T1R1	0	1841	1257	1668	314	22	0	0
T1R2	0	2821	2407	2776	1313	357	77	10
T1R3	0	4632	4241	5843	3084	927	123	7
T2R1	0	2426	1757	2140	704	125	12	0
T2R2	0	5473	4159	3798	1229	274	45	4
T2R3	0	12792	13537	15466	10639	5148	1800	392
T3R1	0	3139	2241	2318	439	43	3	0
T3R2	0	3326	3015	3490	1362	132	6	0
T3R3	0	4720	4775	5526	3238	1202	330	41

Table 3. Number of Pixels of the NDVI Values in the Treatments - Flight 2

NDVI	3 (0,2)	4 (0,3)	5 (0,4)	6 (0,5)	7 (0,6)	8 (0,7)	9 (0,8)	10 (0,9)
PLOT								
T1R1	1039	2208	1671	2307	966	29	0	0
T1R2	877	2062	2525	1972	1630	160	0	0
T1R3	876	1941	2143	3415	1403	48	0	0
T2R1	1307	2155	2308	1714	1714	25	0	0
T2R2	883	2267	2719	2893	2893	68	0	0
T2R3	1304	4374	5397	6964	6964	977	0	0
T3R1	1184	3114	3113	3491	3491	192	0	0
T3R2	983	2224	2963	3115	3115	214	0	0
T3R3	1352	2016	2142	2509	2509	6	0	0

Table 4. Number of Pixels of the NDVI Values in the Treatments - Flight 3

NDVI	3 (0,2)	4 (0,3)	5 (0,4)	6 (0,5)	7 (0,6)	8 (0,7)	9 (0,8)	10 (0,9)
PLOT								
T1R1	737	3168	4860	4282	3346	287	3	0
T1R2	1508	4744	4030	5355	2812	149	0	0
T1R3	2844	5305	4459	4345	2816	541	35	0
T2R1	1498	4713	5539	5591	4180	596	12	0
T2R2	3582	9038	9726	12285	8314	2985	565	0
T2R3	4078	8887	10527	9902	7107	2668	434	0
T3R1	1969	6518	9554	11687	9930	3539	644	0
T3R2	1456	4444	3269	4484	2578	356	4	0
T3R3	2977	4733	3784	3711	2365	369	16	0

Tabla 5. Número de Pixeles de los Valores de NDVI en los Tratamientos del Vuelo 4

NDVI	3 (0,2)	4 (0,3)	5 (0,4)	6 (0,5)	7 (0,6)	8 (0,7)	9 (0,8)	10 (0,9)
PARCELA								
T1R1	8672	7516	5230	220	256	0	0	0
T1R2	8039	5847	2832	780	59	0	0	0
T1R3	5413	5231	3050	1920	381	0	0	0
T2R1	12260	9573	5830	2315	370	0	0	0
T2R2	6466	7019	4540	3514	668	0	0	0
T2R3	9573	9933	6916	4023	922	0	0	0
T3R1	13206	12441	8462	4716	902	0	0	0
T3R2	5566	5661	3733	1815	341	0	0	0
T3R3	8019	6951	4201	1837	403	0	0	0

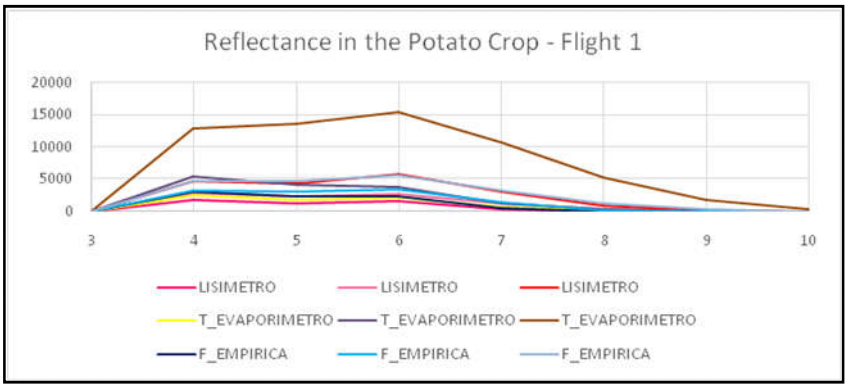

Figure 1. The reflectance of the Potato Crop in the stage of vegetative growth (Flight 1) April 17, 2015

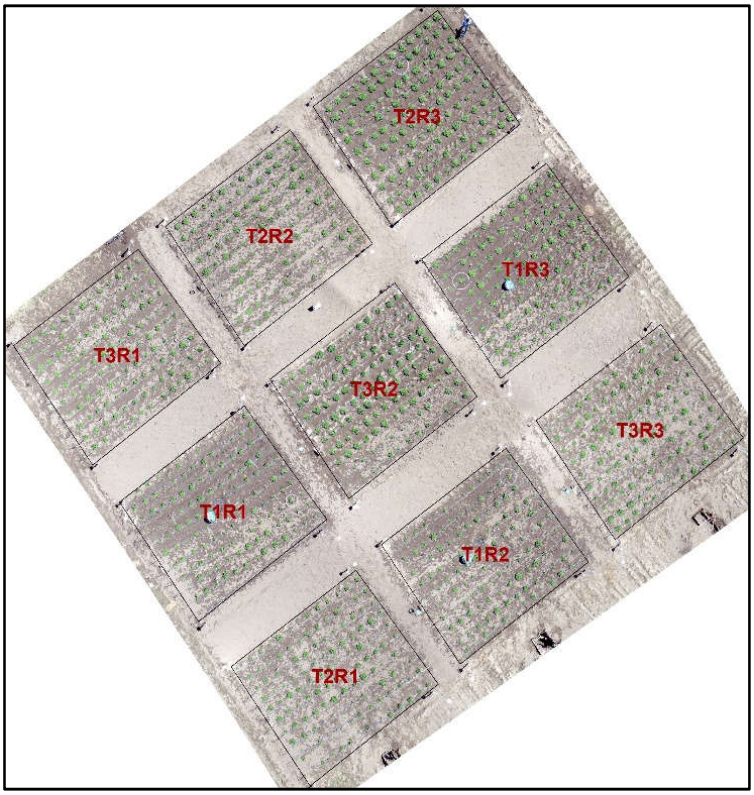

Figure 2. Vegetative Growth of Potato Crop (Flight 1)

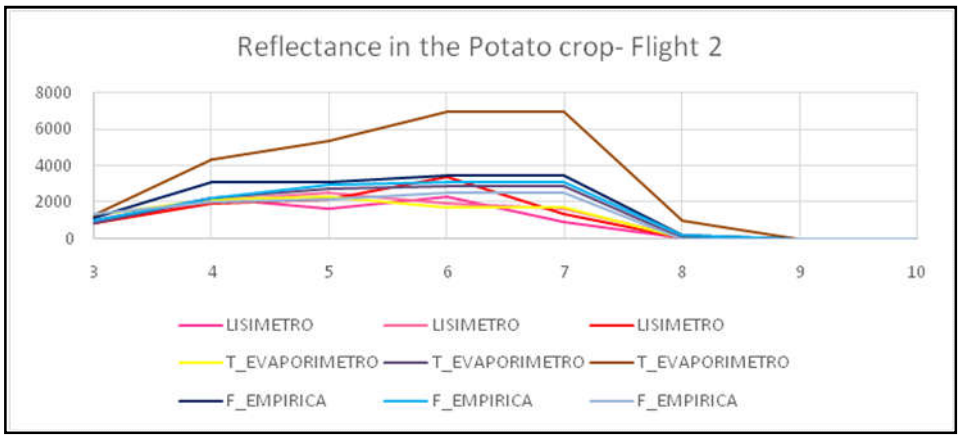

Figure 3. The reflectance of the Potato Crop in the stage of the beginning of production of Tubers (Flight 2) May 17, 2015

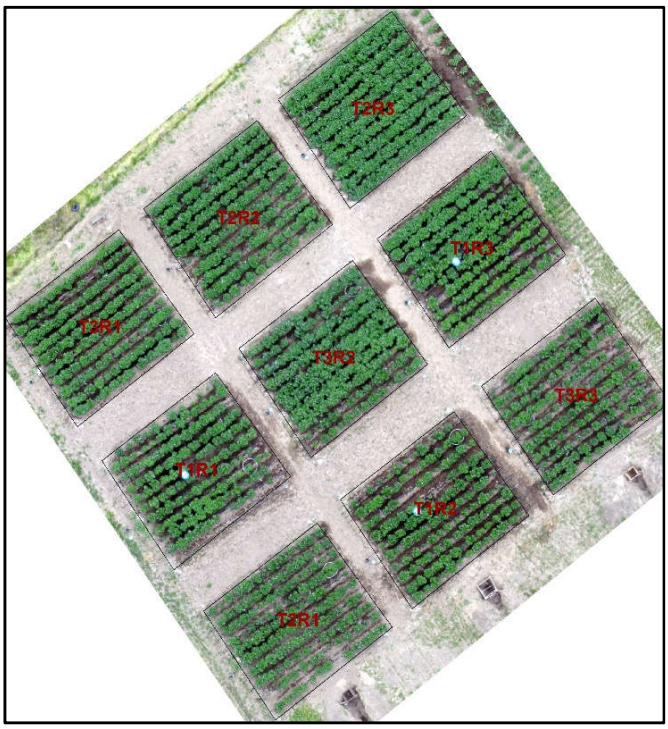

Figure 4. Start of the production of tubers of the Potato Crop (Flight 2)

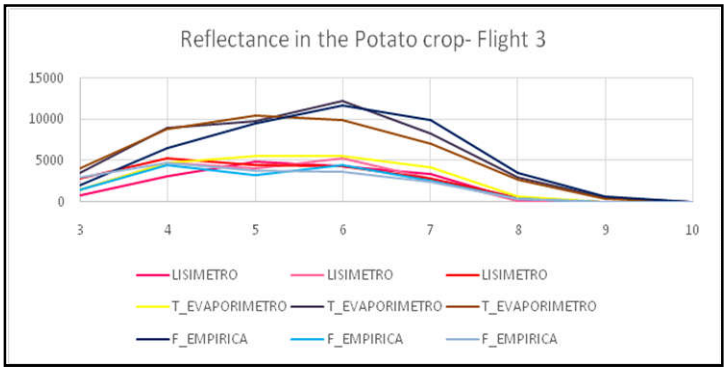

Figure 5. The reflectance of the Potato Crop in the stage of growth of the tubers (Flight 3) June 17, 2015

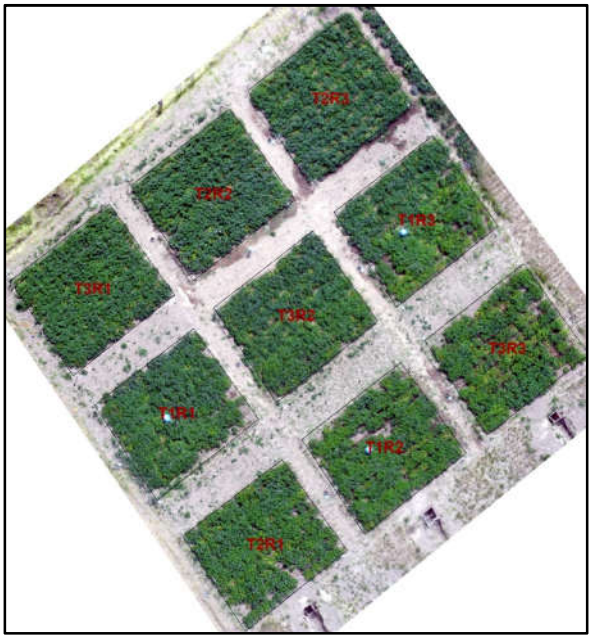

Figure 6. The growth of Potato Crop Tubers (Flight 3)

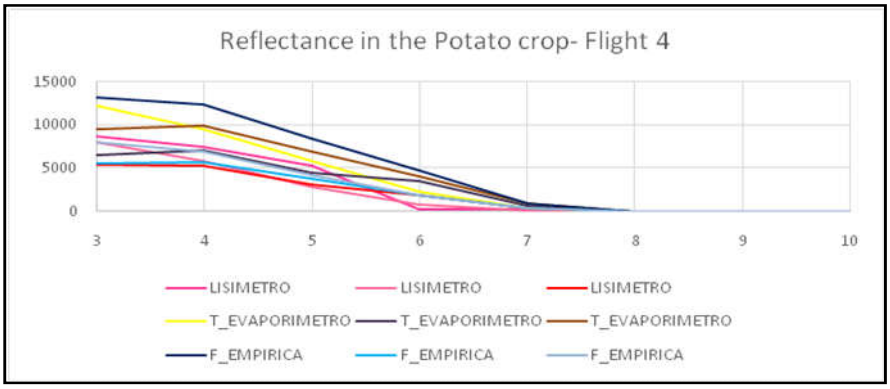

Figure 7. The reflectance of the Potato Crop in the stage of maturation or Senescence (Flight 4) July 17, 2015

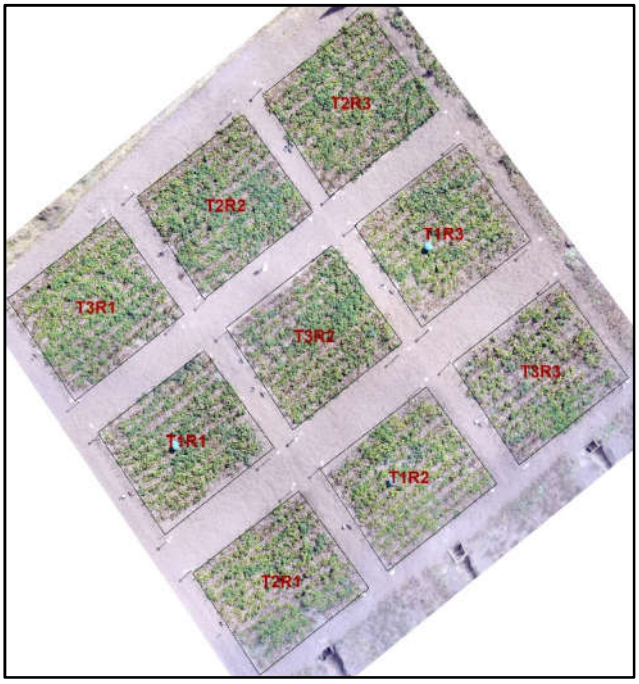

Figure 8. Maturation or Senescence of the Potato Cultivation (Flight 4)

In woody species the color and the distribution of the fruit for the exposed reasons also take on importance; the case is patent in the conifers in which the proportion of infrutescences (pineapples) has, together with the bark of trunks and branches, great spectral repercussion.(University of Jaen, 2004). In the stage of vegetative growth of the plant crop where the first image of the trials was captured, it is observed (see Figure 1 and Figure 2) that the test corresponding to the Evaporimeter Tank Repetition three (T2R3), a certain number of plants reach the NDVI value of 0.9 class N°10 with high photosynthetic activity; but most of these plants are in class N°6 with NDVI values of 0.5.In Table 2, the number of pixels of each class of the NDVI value is shown, where the plants of the Repetition One Lysimeter (T1R1) assay do not have a good photosynthetic activity despite having NDVI values that vary between 0,3 to 0.9; where the greatest number of pixels is presented in class N°4 with the NDVI value of 0.3. For the flight N°2 that corresponds to the stage of the Start of tuber production it is observed that the plants where the Evaporimeter Tank was installed have NDVI values that oscillate from 0.2 to 0.7, thus being the Repetition two (T2R3) that present higher values that corresponds to a good production of tubers maintaining an adequate moisture content, as shown in Figure 3 and 4.

The treatment Evaporimeter tank presents a better production of tubers than the rest of the treatments. In Table 3, the number of pixels of each class of the NDVI value is evidenced, being that the plants of the Repetition Lysimeter test (T1R1) do not have a good production of tubers despite having values of NDVI that They range from 0.2 to 0.7 where it has the highest number of pixels in the NDVI 0.3 value. In the same way, the treatment of the Evaporimeter Tank repetition one behaves (T2R1). For the flight N°3 that corresponds to the growth stage of the tubers, it is observed that the plants where the Evaporimeter Tank was installed have NDVI values that range from 0.2 to 0.8, thus being the Repetition two (T2R2) that present higher values in the growth of tubers, as observed in Figure 5 and 6. The treatment that lower growth of tubers corresponds to that of the empirical formula repetition three (T3R3). In Table 4, the number of pixels of each class of the NDVI value is shown, being that the plants of the Empirical Formula of Repetition three (T3R3) do not present good characteristics of tuber growth despite having NDVI values that oscillate between 0.2 to 0.8, where it presents a greater number of pixels in the value NDVI 0.3. In the same way, the repetition of the same treatment behaves (T3R2). For the flight N°4 that corresponds to the stage of maturation and senescence of the potato crop, it is observed that the plants where the

Empirical Formula repetition one was installed (T3R1) are the one that in better conditions still occurs in this stage, not being thus with the test of the repetition Lysimeter two (T1R2) where a high degree of wilt and senescence of the plant is observed as seen in Figure 7 and 8. The NDVI values range from 0.2 to 0.6 being the values highest of class N°3 as observed in Table 5.

Conclusion

According to the results obtained, it is confirmed that the adult and healthy plants in the reflectance spectrum have a strong absorption (low reflectance) in the blue (0.4-0.5 μm), an increase in the reflectance in the green (0.5-0.6 μm), strong absorption in the red (0.6-0.7 μm) and a strong reflectance and transmittance in the infrared (0.7 to 1.5 μm).The response in reflectance in the Visible region of plants is determined by the effect and behavior of chlorophylls, carotenes and anthocyanins. The response in the infrared is determined by the discontinuity between cell walls and intracellular air spaces in the leaf structure (Mirik, 2007). In this research, it is concluded that the Treatment that works best for the growth and development of the potato crop was the Evaporimeter Tank, and the Treatment that was not a success in this area with its biophysical and environmental characteristics is the Lysimeter test. Understanding that the analysis was made from the Reflectance of each plot and was captured with the multispectral camera.

REFERENCES

Alonso, D. 2017. NDVI: Quées y cómo calcularon con SAG desde QGIS. Disponible en línea en: https://mappinggis.com/2015/06/ndvi-que-es-y-como-calcularlo-con-saga-desde-qgis/

FAO. Food and Agriculture Organization. 2008. El Cambio climático y la producción de alimentos.

Hanson, A. y Hitze, W. 1982. Metabolic responses of mesophytes to plant water deficits. Annual Review of Plant Physiology 10 – 22 pp.

Kramer, P. 1983. Water stress and plant growth. New York 55p.

Laliberte, A. S., Winters, C., & Rango, A. 2008. A procedure for orthorectification of sub-decimeter resolution imagery obtained with an unmanned aerial vehicle (UAV). In Proc. ASPRS Annual Conf (pp. 08-047).

Mirik, M., Michels Jr., G.J; Kassymzhanova-Mirik, S., Elliott, N.C. 2007. Reflectance characteristics of Russian wheat aphid (Hemiptera: Aphididae stress and abundance in winter wheat. Computers and Electronics in Agriculture 57:123-134.

Ormeño, S. 1991. Fundamentos Físicos de la Teledetección. E.U.I.T. Topografía. Madrid.

Universidad de Jaen. 2004. Fundamentos Espectrales. Disponibleenlíneaen:http://www.ujaen.es/ huesped/ pidoceps/telav/fundespec/reflectancia_vegetal.htm

Watson, R., Zinyowera, M. y Moss, R. 1997. The regional impacts of climate change: an assessment of vulnerability. Summary for policymakers. Report of IPCC Working group II. Cambridge 16pp.

Wu, L., J.M. Baker, and R.R. Allmaras. 1995. Numerical and Field Evaluation of Soil Water Samples by Suction Lysimeters. J. Environ. Qual. 24:147-152.

****