In-season Site-specific Control of Cruciferous WEEDS at Broad-scale using QUICKBIRD IMAGERY

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Introduction

This research explores the use of multi-spectral high-spatial resolution QuickBird satellite imagery to detect cruciferous weed patches in winter wheat fields and to develop in-season site-specific cruciferous treatment maps at broad-scale. Cruciferous weeds, *Diplotaxis* spp. (generally *D. virgata* Cav. DC. and *D. muralis* L.) and *Sinapis* spp., (generally *S. arvensis* L. and *S. alba* L.) (Fig. 1) are competitive broad-leaved weeds that reduce the yield of winter cereal crops such as wheat. These weeds cannot be adequately controlled by pre-sowing herbicides in cereals and some specific herbicides are usually applied at post-emergence.

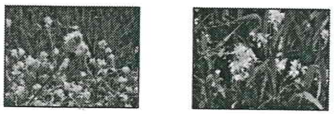

Figure 1. Diplotaxis spp. and Sinapis spp.

Cruciferous weeds are distributed generally in patches but herbicides are usually broadcast over entire fields (Fig. 2) and the potential for over-application and unnecessary pollution is evident. Considering the fact that weed infestations can be relatively stable in location from year to year, late-season weed detection maps using remote sensing could be used to design site-specific control methods in subsequent years, or to apply in-season post-emergence herbicides if adequate pre-emergence control was not achieved.

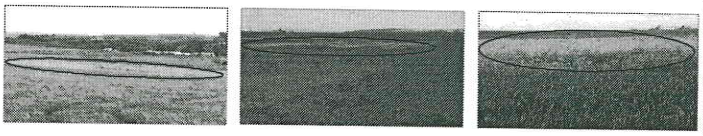

Figure 2. Cruciferous weed patches in winter wheat fields

Materials and methods

The study was conducted in an area of approximately 102 km² located in the province of Córdoba, Andalusia, southern Spain (Fig. 3) where most of the wheat fields were naturally and highly infested by cruciferous weed. A multispectral (spectral range: Blue, B; Green, G; Red, R. Near-infrared, NIR bands) QuickBird satellite image, (Fig. 4) with a spatial resolution of 2.4 m- pixel was taken on March 19, 2009 (spring in the experimental conditions). When the QuickBird image was taken, the winter wheat crop showed the typical green colour of vegetative growth stage, and cruciferous weeds displayed an intensive yellow colour corresponding to the flowering growth stage.

Figure 3. Location of study area in Córdoba, southern Spain.

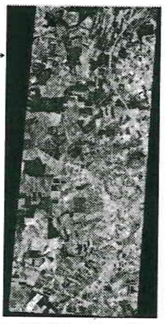

Figure 4. QuickBird multispectral image

A segmentation procedure was used to identify and select the areas where wheat fields were present in the QuickBird scene. The image was segmented into multi-pixel objects using the multi-resolution algorithm included in the commercial software Definiens Developer 7. This procedure resulted in a ***QuickBird-segmented Image*** showing the spatial distribution of the homogeneous objects in the scene (Fig.5).

Figure 5. QuickBird-segmented image

The overall winter legumes, olive orchards, urban soil and road land uses were identified in the QuickBird-segmented image according to their NDVI values. The winter wheat land use was defined by deleting those previous land uses (made up of winter legumes, olive orchards and urban soil plus roads land uses). As a result of this process, a new QuickBird image was obtained (Fig.6) that showed the spatial distribution of the overall winter wheat fields, named ***QuickBird segmented winter wheat image.***

Figure 6. QuickBird-segmented winter wheat image: 263 wheat fields corresponding to 2.656 ha.

The winter wheat fields were visited at the time at which the QuickBird satellite image was taken in order to georeference the training and ground truth points of cruciferous-free winter wheat and cruciferous weed patches to validate the classification procedures. Two supervised classification methods, Vegetation Indices and the Maximum Likelihood Classifier (MLC), were evaluated to examine their suitability for the classification of cruciferous weed patches at broad-scale (i.e., considering the 263 wheat fields of the *QuickBird-segmented winter wheat image*). A numerical confusion matrix analysis was used to determine the accuracy of the method by comparing the percentage of classified pixels of each class with the verified ground truth class, subsequently indicating the correct assessment and the errors between the classes studied. The confusion matrix provides the Overall Accuracy (OA), the user's accuracy (UA) for winter wheat and for cruciferous weed patches. The best classification methods were selected to develop in-season site-specific cruciferous weed patch treatment maps. For a complete description of materials and methods, please see De Castro *et al.*, 2013.

Results

The analysis showed that cruciferous weed patches were accurately discriminated at a broad-scale. The best classification of the cruciferous weed patches was achieved with the B/G index and the MLC method (Table 1). To obtain site-specific treatment maps from the most accurate classified imagery SARI® (Sectioning and Assessment of Remote Images) software (García-Torres *et al.*, 2009) was used to split the images into regular grids (15 m x 15 m) and classify them according to the level of cruciferous weed infestation within each grid (Fig. 8).

Table 1. Classification statistics for each land use using different classification methods at QuickBird-segmented winter wheat image.

Land use	OA (%)	UA	Area (%)
Vegetation index (B/G)			
Cruciferous weeds	89.45	77.85	33.96
Wheat		92.62	57.63
Maximum Likelihood Classifier			
Cruciferous weeds	91.30	84.81	38.69
Wheat		94.89	57.40

OA: Overall Accuracy (%), UA: User Accuracy (%), Area (%): percent of surface occupied for each land use

Figure 7. Classified maps for the QuickBird-segmented winter wheat image created according the MLC method

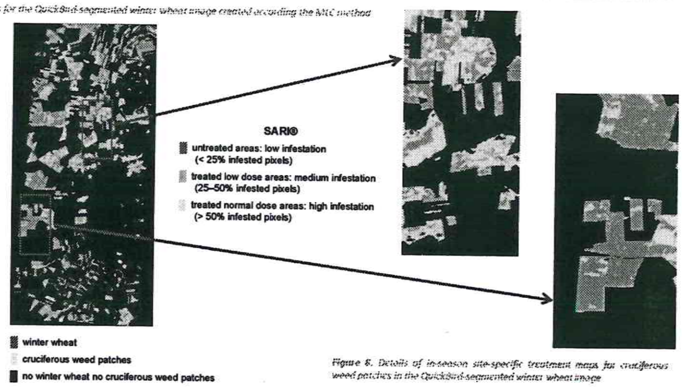

Figure 8. Details of in-season site-specific treatment maps for cruciferous weed patches in the QuickBird-segmented winter wheat image

CONCLUSIONS

- Cruciferous weeds were accurately discriminate at broad-scale using a QuickBird satellite image.
- The site-specific treatment maps indicated that there is a great potential for reducing herbicide use through in-season cruciferous weed patch site-specific control at broad-scale.
- For example, it can be determined that by applying site-specific treatment maps on a broad-scale, herbicide savings of 61.31% for the no-treatment areas and 13.02% for the low-dose herbicide areas were obtained.

References

García-Torres, L., López-Granados, F., Peña-Barragán, J. M., Caballero-Novella, J. J. and Jurado-Expósito, M. 2009. Automatic procedure to section remote images and to characterize agri-environmental indicators. *Spanish Office for Patents and Trademarks, Madrid, 24 June 2009, PCTES2009/07247*, pp. 48, (in Spanish).

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