Prediction of potato high-yield zones of a field: bivariate frequency ratio technique

Khalid A. Al-Gaadi[1,2], Abdalhaleem A. Hassaballa[1,3], Rangaswamy Madugundu[1,*], ElKamil Tola[1,2] and Ronnel B. Fulleros[2]

[1]Precision Agriculture Research Chair, King Saud University, Riyadh, Saudi Arabia
[2]Department of Agricultural Engineering, College of Food and Agriculture Sciences, King Saud University, Riyadh, Saudi Arabia
[3]Department of Agricultural Engineering, Faculty of Engineering, University of Khartoum, Khartoum, Sudan

Bivariate frequency ratio (BFR) technique was employed to determine high-yield zones in a 30 ha potato (*Solanum tuberosum* L.) field located in Wadi-Ad-Dawasir, Saudi Arabia. BFR was performed by inputting selected yield tendency factors (YTFs) and potato actual yield (Y_A). The YTFs were NDVI-derived from Sentinel-2 images, soil electrical conductivity, nitrogen, pH and texture. The obtained yield tendency map (Y_P) was assessed against Y_A using the area under the curve metric. Although low accuracy (41–58%) was observed with the individual YTFs, high-yield zones were determined with an accuracy of 90% using the cumulative response of YTFs.

Keywords: Bivariate frequency ratio, potato field, soil parameters, yield prediction.

SPATIAL variation of crop productivity within a field is usually a result of soil properties and crop response. Identifying the most likely causes of crop yield variability and exploring the magnitude of variation within an agricultural field can greatly help in achieving effective site-specific management in accordance with agro-meteorological systems[1–8]. On the other hand, soil physico-chemical properties can vary within sub-metre scales[9]. Some studies have reported that variation in the concentration of soil properties within the field leads to spatial variability in crop yields[10,11]. Soil parameters such as soil electrical conductivity (EC), pH, nutrients, compaction and bulk density are considered as major fluctuating yield tendency factors (YTFs) responsible for spatial variation of yield[12–15]. Previous studies have discussed management strategies for improving the resources and optimizing crop production[14–17].

The use of geo-spatial techniques in the assessment of yield spatial variability and its effect on crop yield has been well discussed[6,18,19]. Knowledge on the effect of YTFs, collectively and individually, on the performance of an agricultural crop can elucidate the reason for spatial variation in crop productivity[20]. A method that is proposed to assess yield tendency should be based on independent parameters that are correlated directly or indirectly with the spatial variation of crop yield[21].

Bivariate analysis, a statistical analysis technique, helps in the quantitative assessment of susceptibility/tendency of occurrence of events by calculating the weight of each individual class of event factors[22,23]. One of the most popular bivariate approaches is the frequency ratio (FR)[24], which has greater rigour compared to other bivariate techniques[23,25]. The area under the curve (AUC) is one of the most important metrics for evaluating the performance of any classification model[26,27]. Suzen and Vedat[28] succeeded in mapping the tendency by examining independent and dependent factors, and their contribution to bivariate frequency ratio (BFR) statistics.

The present study was aimed to (i) determine high-yield tendency zones of a potato (*Solanum tuberosum* L.) field using the BFR technique by assessing the spatial correlation between selected YTFs and actual potato yield (Y_A), and (ii) assess the accuracy of the generated high-yield tendency map using the AUC analysis tool.

Study area

The study was conducted on a 30 ha centre-pivot irrigated field in a farm belonging to the Saudi Agricultural Development Company, Wadi-Ad-Dawasir, Saudi Arabia, between 19.90° and 20.33°N lat., and 44.81° and 44.95°E long. (Figure 1). Temperature in the study site ranged from 6°C (winter) to 43°C (summer). The relative humidity was normally stable at 24%, while average wind speed was 13 km/h and the mean annual rainfall was about 37.6 mm (refs 29, 30). The major cultivated crops in the study farm were potatoes, maize, durum wheat, watermelon and alfalfa.

Field data

Potato crop was cultivated from November 2016 to March 2017 with a density of 4–5 plants/m^2. The GPS (Trimble GeoXH 6000)-assisted soil samples and potato yield (Y_A) were collected from 120 sampling locations (Figure 1), 2–3 days prior to the harvest of potatoes. Sampling was performed for the entire experimental field

*For correspondence. (e-mail: rmadugundu@ksu.edu.sa)