Methodology and indices for the spatial evaluation of different planting patterns

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An optimized spatial planting pattern can help to minimize negative intraspecific competition for light, nutrients and water. Furthermore, the competitiveness against weeds can be increased and an improved microclimate may help reduce diseases. In addition to the conventional drill seeding technique, where the seeds are placed rather randomly within the row, there are now single grain seed drills, with more precise spacing within the row as well as prototypes of precision sowing machines, which enable an equidistant planting pattern.

So far, there is a lack of methods and criteria to assess and evaluate the spatial pattern of different sowing techniques in the field. Therefore, we developed a standardized and reproducible approach and respective indices.

The methods were developed and tested building on two field experiments. First, a winter wheat experiment conducted in Berlin-Dahlem testing conventional vs. equidistant sowing since 2018. Second, an experiment conducted in Dahnsdorf in Southwest Brandenburg, testing winter wheat and winter rye in conventional vs. single grain sowing since 2019. Photos of the planting pattern realized by different sowing techniques were taken just after emergence (BBCH 9) using a RGB-camera mounted on a standardized photo-frame (0,25m^2). The photos were processed using the GIS-software ArcGIS, tagging each point of plant emergence. Using Voronoi partitioning the theoretical planting space was allocated as a polygon to each plant.

Following indices relevant for spatial evaluation were derived: (i) number of plants, (ii) mean space per plant, (iii) coefficient of variation of space per plant (CVSP), as well as (iv) mean polygon-circle-ratio (MPCR), i.e., mean roundness/compactness of polygons. CVSP describes the evenness of the single plants' spaces in the different planting patterns. MPCR describes the mean of the ratio of the area of the individual plants' polygons to a circle of equal edge length; it ranges theoretically between zero and one. These indices enable a comparison of actual vs. target state and in combination, they allow a comprehensive comparative evaluation of different planting patterns.

As the manual tagging of each plant's emergence is very laborious and hence has its limitations regarding large-sale applications in experimental and practical agronomic applications, we are currently working on an AI-assisted image-recognition approach for tagging plant emergence.