Minimization of Fertilizer Application Error due to Centrifugal Spreading

Teddy VIRIN[1)], Emmanuel PIRON[1)], Jonas KOKO[2)], Philippe MARTINET[3)], Michel BERDUCAT[4)]

[1)] Cemagref, 03150 Montoldre, France, E-mail : teddy.virin@cemagref.fr, emmanuel.piron@cemagref.fr

[2)] University of Blaise Pascal, LIMOS, 63177 Aubière Cedex, France, E-mail: koko@isima.fr

[3)] University of Blaise Pascal, LASMEA, 63177 Aubière Cedex, France, E-mail: martinet@lasmea.univ-bpclermont.fr

[4)] Cemagref, 63172 Aubière Cedex, France, E-mail : michel.berducat@cemagref.fr

Introduction

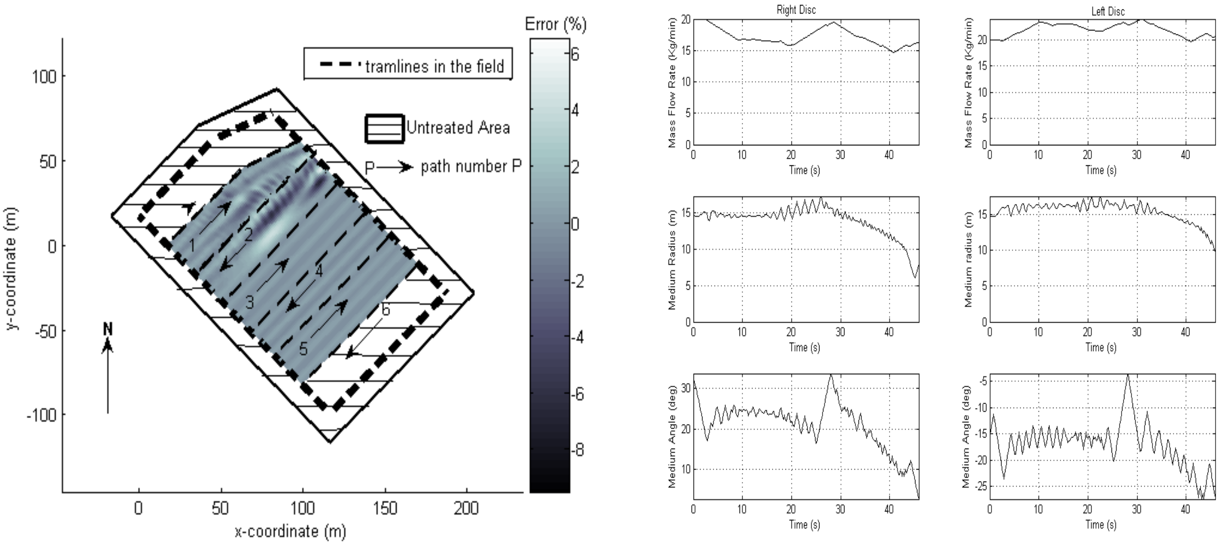
Fertilization is an agricultural task mainly carried out by centrifugal spreaders with double spinning discs which are simple machines efficient to uniformly distribute mineral fertilizers. Indeed, they can give satisfying results with regularly spaced parallel tramlines. Nevertheless, this method is quickly limited when geometrical singularities occur such as non-parallel paths, end of field, start and end of spreading. At these spots, some over or under-application can be observed and can result in the watercourses pollution. These application errors are in fact due to the present fertilization strategy which only permits to obtain correct transverse distribution overlaps instead of looking for best arrangement of the actual spatial heterogeneous distribution: the spread patterns. To reduce these errors, some works were made about optimal path calculus but this method is unsuitable when trajectories are already imposed by other agricultural operations. Then, the objective has been to compute the optimal parameters of the spread pattern analytical model which have to be applied during spreading process with imposed paths in order to reduce the discrepancies between prescribed dose and dose actually distributed. For a constant desired dose, an optimization algorithm was implemented to improve fertilizer application with parallel and non-parallel paths in the field without taking into account the boundaries. Simulations gived very satisfying results.

Optimization Methodology

The parameters which have to be computed are the mass flow rate, the medium radius that is the distance between the spinning disc centre and the spread pattern centre, and the medium angle corresponding to the angle between the travel direction and the axis passing by the centre of the disc and the one of the spread pattern. These variables are evaluated by minimizing a functional built from the spread pattern model. Some bound constraints over the temporal derivatives were introduced to take into account the mechanical limits of the spreader. Faced with a large-scale problem, the studied spatial domain was decomposed into sub domains so that each tramline was individually treated. To solve the problem an augmented lagrangian technique associated with a limited memory BFGS method was employed.

An Example of Simulation Result

The considered field is illustrated in figure 1(a). The distances separating two consecutive tramlines are included between 20 m and 24 m. The trajectories are parallel and non-parallel. The prescribed dose was fixed at 100 Kg/Ha and the speed of tractor at 10 Km/h. The visualised error is included between –8.7% and 6.3% . These results are very satisfying if we compare with the error obtained without optimization which can reach –15% and 95% at some spots. Figure 1(b) depicts the evolution of the different optimal parameters during time for the path number 2 because of the geometrical singularity which it presents. It shows that these ones respect the mechanical constraints of the spreader.



(a) (b)

Figure 1: Simulation result obtained after optimization: (a) Application error computed without taking into account boundary zone – (b) Optimal parameters for each disc in the path number 2.

Conclusion

By considering an optimization problem which takes into account a spatial spread pattern model, fertilization application error can be reduced considerably in the field. Thanks to this technique, reference controls for the spreader are evaluated in an optimal way even though paths are non-parallel.