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冬小麦-夏玉米轮作体系灌溉制度多目标优化模型

Multi-objective optimization model of irrigation schedule for winter wheat-summer maize rotation system

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中文摘要:

该文针对望都灌溉试验站全年作物种植模式，分别建立冬小麦及夏玉米水分生产函数模型，运用粒子群优化算法（PSO）求解模型中的敏感指数，并以该模型为基础建立冬小麦-夏玉米全周期灌溉制度多目标优化模型，利用改进分组非支配排序遗传算法（GNSGA-Ⅱ）对模型进行求解，得出全年不同可用灌溉水量情况下的灌水日期与灌水量。结果显示，随着可用总灌水量的增加，冬小麦和夏玉米的灌水量与产量均随之增加，但由于受到两种作物不同敏感指数的影响使得二者增加的趋势有所不同。当全年总灌水量为472 mm时两种作物均接近充分灌溉，若继续增加灌溉水量，则灌水的边际效益逐渐减小。依据优化结果可在全年合理分配利用有限的水资源以获得较高的作物总产值。

英文摘要:

Abstract: Irrigation schedule optimization of deficit irrigation is an effective approach for water saving. Water production function models of winter wheat-summer maize were established respectively based on soil water balance model and water production function model for Wangdu irrigation station planting patterns. Jensen multiplication model for water production function models was used in this paper. Sensitive indexes of Jensen model were important parameters, which reflected the influencing extent of lacking water in all growth stages to yield and their error magnitude influences the precision of deficit irrigation schedule model. Particle swarm optimization(PSO) algorithm was used to solve sensitive indexes of this model, which can eliminate the problems of partial estimation and low fitting precision for traditional regression analysis algorithm. And a multi-objective optimization model of irrigation scheduling for winter wheat-summer maize rotation was established. In order to solve the model, a group non-dominated sorting genetic algorithm Ⅱ （GNSGA-Ⅱ）based on grouping sort was put forward. The real-coded including irrigation volume and time interval was adopted when designing genetic encoding, so we can get the exact irrigation dates and irrigation volume. Finally, the exact irrigation volume and irrigation dates were obtained under different available irrigation volume. The results showed that the irrigation dates distribute all growth stages except over-wintering for winter wheat because of the minimum sensitive index. The distinction of irrigation date is no more than two days under different available irrigation volume, that is to say irrigating in the two days is appropriate comparatively no matter what the available irrigation water volume is. The irrigation volume and yield of winter wheat and summer maize increase along with the increase of total water volume, but show different trends for the two crops due to different sensitive indexes. Due to set the two objects which are maximal total output value and minimal irrigation water volume and genetic algorithm considered the two objects at the same time in the course of optimization, so there is no appearance that the actual irrigation volume equal to available irrigation volume in the Pareto non-inferior solution set. The total actual irrigation volume is 472mm (the irrigation volume of winter wheat is 225 mm while the summer maize is 247 mm) when the available irrigation volume less than 500mm in a year. The difference of actual irrigation volume and available irrigation volume is 28mm because the relative yield for the two crops are 0.975 and 0.978 when the total irrigation volume reach 472mm which means the two crops approach abundant irrigation. The marginal profit of irrigation will gradually decrease with the total water volume increase. The limited water resources can be reasonable allocated and used based on optimization results in a year in order to gain the higher total output value.

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