Agricultural Water Management 201 (2018) 58–69

Contents lists available at ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat

Evaluating performances of the first automatic system for paddy irrigation in Europe

Daniele Masseroni[a,*], Peter Moller[b], Reece Tyrell[b], Marco Romani[c], Alberto Lasagna[d], Guido Sali[a], Arianna Facchi[a], Claudio Gandolfi[a]

[a] Department of Agricultural and Environmental Sciences, University of Milan, 20133, Milan, MI, Italy
[b] Rubicon Water, Hawthorn East, 3123, VIC, Australia
[c] Centro Ricerche sul Riso, Ente Nazionale Risi (ENR), 27030, Castello d'Agogna, PV, Italy
[d] Consorzio di irrigazione e bonifica Est Sesia, 28100, Novara, NO, Italy

ARTICLE INFO

Article history:
Received 8 June 2017
Received in revised form
21 November 2017
Accepted 18 December 2017

Keywords:
Paddy field
Automatic system for irrigation
Remote-controlled gate
Hydraulic-control-economic performances

ABSTRACT

Italy is the leading rice producer in Europe, accounting for more than half of the total high-quality production of this crop. Rice is traditionally grown in fields that remain flooded starting with crop establishment until close to harvest. The water management in rice areas requires a high level of labor because it is based on maintaining a predetermined water height in paddy fields and because the regulation of input and output flow is typically operated manually by the farmers. This study aims to evaluate the hydraulic, control and economical performances of the first automatic and remote-controlled system applied for traditional rice irrigation in Europe and tested in Italy during 2016 agricultural season. In particular, (i) the effects of automation on the water balance; (ii) the reliability of the irrigation system for a real-time control of flow regulation and water level management in the field and (iii) the economic viability of the investment are investigated.

The results show that, despite the automatic system has not proven a decrease of water consumptions (ranging from 2000 to 3700 mm) or a significant increase of rice yield (of about 8 ton hectare^{-1}), it has not revealed any mechanical malfunctioning during the irrigation season and it allows to drastically reduce the time spent by workers for water level control and flow regulation. Lastly, the price of the automatic irrigation system (ranging from 638 to 689 € hectare^{-1}) appears to be in good agreement with respect to the willingness of farmers for innovation.

1. Introduction

1.1. Rice irrigation features in the Italian agricultural context

Rice is a staple crop for more than half the world's population. Approximately 90% of world rice production is grown in Asia, while the quantities produced in Europe are relatively limited (approximately 2 million tons). Italy, with more than half of the total European rice production, is the first producer of the old continent, while Spain, Greece, Portugal and France appear in the top five producers providing about 30%, 10%, 5% and 3% of the total European rice production, respectively (EUROSTAT, 2013; ISTAT, 2009) (Fig. 1).

The most important rice-growing area in Italy is a portion of the Padana plain located to the east of Ticino river, straddling the regions of Lombardy and Piedmont in northern Italy (more than 200.000 ha, 92% of the Italian rice surface; National Rice Centre, 2015). Although the main objective of the rice farms is productive, areas in which the prevailing crop is rice create a peculiar agro-ecosystem characterized by the presence of water in the fields for several months each year (Leibundgut and Kohn, 2014). This extensive water presence endows these areas with significant landscape and natural heritage values, ranging from the preservation of traditional rural landscapes to the safeguarding of different animal and plant species typical of wetland areas (Cesari de Maria et al., 2016; Masseroni et al., 2017b). The prolonged presence and circulation of water, due to continuous flooding of fields from wet-sowing until close to harvest, represents a distinguishing feature of these rice areas, some of which have also been included in the European ecological network NATURA 2000 and on the official list of the European Special Protected Areas (Habitat Directive, 92/43/EEC; European Commission, 1992) (Chiaradia et al., 2013). However, the traditional irrigation technique, based on continuous flooding during the growing season, still dominates in most areas (for exam-

* Corresponding author.
E-mail address: daniele.masseroni@unimi.it (D. Masseroni).

https://doi.org/10.1016/j.agwat.2017.12.019

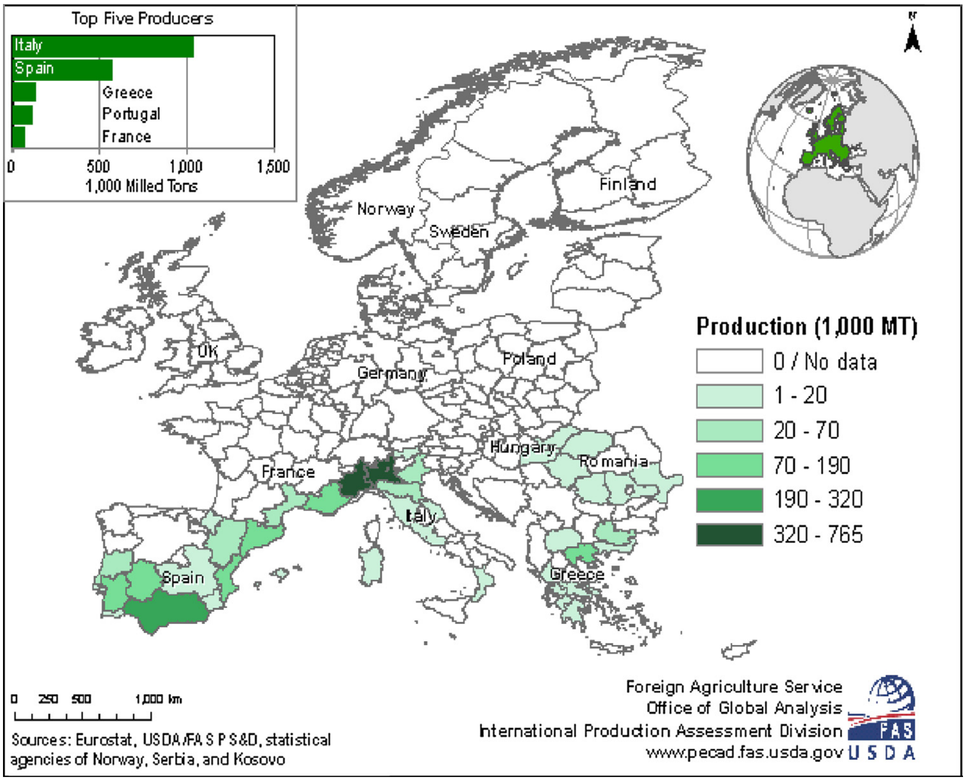

Fig. 1. Harvested rice production (2001–2010 average) in Europe.
Source: United State Department of Agriculture (USDA), Foreign Agricultural Service http page (https://www.pecad.fas.usda.gov/rssiws/al/europe_cropprod.htm?country=Europe&commodity=Rice)

ple, in 85% of the northern Italy rice area) and is characterized by very low irrigation efficiencies and a high level labor requirement performed by workers (named in Italian "acquaioli"), which combine rich hands-on experience and local traditional knowledge. Although there are no accurate literature measurements related to the time that farmers spend for irrigation management of their fields, it may be estimated that a significant fraction of the working day during the agricultural season is dedicated to the manual control and adjustment of the gates to maintain the correct levels of water inside the paddy fields. This fraction of the day can vary considerably depending on the extension of the cultivated area, the growing period and the fragmentation of the rice-growing property. Consequently, these features affect the fixed costs of individual companies, primarily for the assumption of seasonal workers' time that is dedicated full-time or part-time to irrigation management. The implementation of reliable automatic irrigation systems which support the manual operations of these workers is strictly encouraged especially by farmers in order to ensure a more rational allocation of water in the fields according crop conditions. Moreover, from the legislative point of view, the recommendations provided in the European Water Framework Directive (2000/60 CEE) (recently transposed into the Italian national law n°213 of the 15 July 2015) stress on the necessity to reduce the water consumptions through (i) the measure of irrigation consumptions, (ii) the improvement irrigation efficiency and (iii) the development of new irrigation management framework and tools.

1.2. Compendium of applications of automatic gravity-fed irrigation systems

Various attempts to develop and apply automatic gravity-fed irrigation systems have been reported in the literature (Niblack and Sanchez, 2008; Dassanayake et al., 2010; Shahidian and Serralheiro, 2012). In particular, automatic systems for bay irrigation, such as FarmConnect® (Rubicon Water, 2013) and Aquator® (GM Poly, 2013), are commercially available in Australia and North America. Adoption of these systems is growing, particularly in northern Victoria, in response to the combined influences of a modernised and automatic supply system, growers' access to higher and more consistent flow rates, increasing labour costs, and government incentives for on-farm improvements. To date, these systems have been largely applied for furrow or border irrigations, with suitable infrastructure to deliver water to the field in a controlled and uniform manner. Preliminary trials obtained by Koech et al. (2014a, 2014b) have shown that on maize, soybean, lucerne, pasture and cotton these systems are effective in improving application efficiency above the values routinely achieved by the growers. Along with these developments, in Australia, the cotton industry has been funding the development of a real-time optimisation system for furrow irrigation (Khatri and Smith 2006, 2007). Smart automated furrow irrigation of cotton are widely adopted on farms in the southern part of Australia (mainly in the state of Victoria) and in California (United States of America) where gravity-fed surface irrigation methods are currently adopted to irrigate large portions of cultivated areas (Gillies et al., 2010; Uddin et al., 2015). Different case studies in which these systems are adopted for wheat, barley, faba bean, canola and maize crops demonstrated that the application of automatic systems leads to a reduction of the time spent by the farmer for irrigation (Koech et al., 2014a,2014b) and to an increase in water application efficiency (Smith et al., 2016a,2016b). In these areas, farmers managed properties ranging from 200 to 800 hectares, with single fields characterized by a surface of approximately 8-10 ha. Irrigation of each field requires several hours and interviews with farmers show that they have to interrupt other farm chores to close and open the bay gates. These gates are habitually closed later than the optimal cut-off time, leading to a