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Review

Key cultivation techniques for hemp in Europe and China

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ABSTRACT

Hemp (*Cannabis sativa* L.) is a multiuse, multifunctional crop that provides raw material to a large number of traditional and innovative industrial applications. A relatively simple, low input cultivation technique and the sustainability of its products are the main drivers for a future expansion of the hemp crop. In Europe, the large political support of bioenergy in recent years has fuelled numerous studies on the potential cultivation of hemp for bioenergy production. In China the main drivers for a renewed interest in hemp are its traditional applications. For any given destination, the main target of hemp cultivation is the maximization of biomass production, but each end-use destination has specific quality requirements in terms of properties of the bast fibre, characteristics of the oil and proteins in the seeds, or profile of secondary metabolites in the inflorescence.

In this paper, traditional and innovative end use destinations and cultivation systems for hemp are introduced, together with some notes on hemp botany, biology, and resource use efficiency. This information, together with a review of the practical experience of hemp cultivation in Europe and China and knowledge gathered form scientific literature, highlights the effect of agronomic factors in determining the yield potential and quality level of hemp for specific end use destinations. To conclude, future perspectives and recommendations for hemp cultivation and research are discussed.

Contents

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1. Introduction

Hemp (*Cannabis sativa* L.) is considered one of the oldest crops known to man. It is estimated that its use dates back to 10,000 years ago (Schultes et al., 1974) and an hypothesis of co-evolution of the genus *Cannabis* with the human species has been postulated (McPartland and Guy, 2004).

A recent chemotaxonomic study (Hillig, 2005) confirms the common belief that *Cannabis* had its origin and centre of diversity in Central Asia (Vavilov, 1952; de Candolle, 1883).

The history of hemp cultivation in China is as old as the history of civilization, and it can be dated back to at least 6000 years ago according to archaeological findings and ancient records (Yang, 1991). As reviewed by Yang (1991), general descriptions of the experience and agricultural cultivation practice were recorded in the book of Si Shengzhi, approximately one century B.C.; and the scenario of the hemp farming and retting were depicted as early as XiZhou Dynasty (11-7 century B.C.). Ancient documents of hemp cultivation and use in Europe are scarce. According to Erodotus (484 B.C.), Scythians brought hemp to Europe from Asia during their migrations 1500 years B.C., while Teutons had an important role in diffusing hemp cultivation throughout Europe (Schultes, 1970). Columella, in the 1st century A.C., is among the firsts to make reference to hemp cultivation (cited by Bruna, 1955) but indications to specific agricultural techniques are relatively vague also in Plinium who is generally very detailed in his agronomic descriptions (Schultes, 1970; Somma, 1923). Documents referring to hemp cultivation in Europe are relatively scarce until the 15th century when the importance of this species, mainly as fibre crop for the production of textiles and ropes, grew to attain an important and well-documented commercial role from the 18th to the 19th centuries. The progressive decline of hemp cultivation in Europe (Fig. 1) during the 20th century is to ascribe both to the progressive diffusion of synthetic fibres but also to the increasing cost of labour (Allavena, 1962).

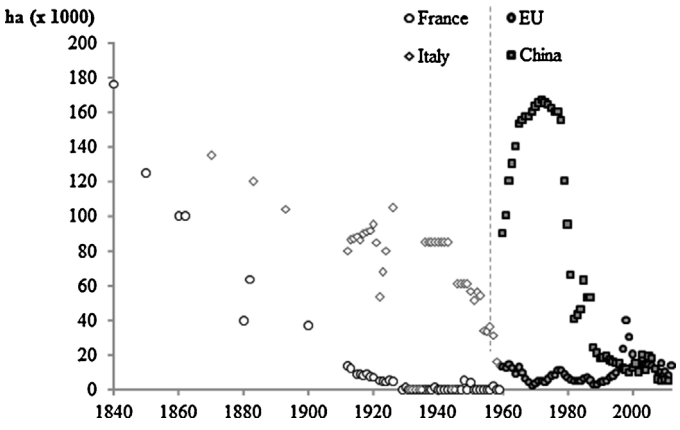

Fig. 1. Hemp area harvested (×1000 ha) in two representative European countries (France and Italy) from 1840 up to 1960 and from 1960 up to 2012 in Europe and China.

Source: FAO-Stat, Nova-Institut.

Parallel to the use of hemp as a fibre crop is that as a medicinal plant, and as ritual, intoxicating drug (Russo, 2007). The gene flow between fibre and drug strains is however relatively small (Hillig, 2004) indicating a net separation between the two end use destinations of the plant that brought numerous authors to consider fibre hemp (*C. sativa* L.) and drug hemp (*C. indica* Lam.) as two separate species (Anderson, 1980; Schultes, 1973).

Despite the interesting nutritional value of hemp seeds (Callaway, 2004) reference to their use as human food in history is relatively small (Schultes, 1973). In the areas where commercial hemp cultivation is diffused, dedicated hemp crops for the production of seeds are planted, following a specific agronomic technique, to obtain seed for the future fibre hemp plantations (Bócsa and Karus, 1998).

This brief history of hemp cultivation has highlighted the potential of hemp as a multiuse crop, a potential that is one of the main features that has fuelled the recent come back of interest over the cultivation of hemp (Karus and Vogt, 2004). Examples of actual and potential innovative application of hemp fibre are numerous. The use of hemp for the production of paper dates back to more than 2000 years, and considering that until the 19th century, paper making depended exclusively on rags that were mainly made of flax and hemp, hemp is strictly linked with the history of paper making (Van Roekel, 1994).

Hemp fibre can be used as reinforcement in composites materials (Garcia-Jaldon et al., 1998), to produce insulation mats and car interior panels (Holbery and Houston, 2006), to reinforce expanded starch foams in the food packaging sector (Bénézet et al., 2012). In the bio-building sector hemp shives alone (Jarabo et al., 2012; Li et al., 2006; Elfordy et al., 2008) or shives together with bast fibres (de Bruijn et al., 2009) mixed with a binder (lime, clay, plaster, etc.) are used to form hemp concrete.

Recently the support granted to bioenergy production has fuelled research on the use of hemp for the production of ethanol (Prade et al., 2011; Sipos et al., 2010), biogas (Kreuger et al., 2011), and biomass for combustion (Aluru et al., 2013; Prade et al., 2011; Rice, 2008) and in a number of papers hemp is depicted as a valuable option to produce sustainable bioenergy (Finnan and Styles, 2013; Rehman et al., 2013).

The quality of the above mentioned products depends on quality characteristics of the hemp fibre and particularly on the morphology of the fibre bundles and on the chemical composition of the elementary fibre (Rowell et al., 2000). Suitability of hemp fibre in polymer reinforcement or biocomposites depends on various fibre features as fibre surface characteristics and fibre finesses that influence interfacial bond strength between the fibres and the matrix (Gamelas, 2013), and fibres tensile strength (Placet, 2009). Moreover, also the variability of natural fibre properties, moisture absorption and cost relative to fibre processing are weak factors of natural fibres for composite applications (Deyholos and Potter, 2013). In order to render hemp fibre suitable for industrial applications, in addition to various extraction processes, numerous chemical, biological and physical treatments to the fibre are possible (Korte and Staiger, 2008; Kostic et al., 2008, 2010; Tak Oh et al., 2012) but selection of improved genotypes (Deyholos and Potter, 2013) and optimization of agrotechnique, on the basis of actual and future knowledge on the influence of agronomic factors on