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Research paper

The importance of yellow horn (*Xanthoceras sorbifolia*) for restoration of arid habitats and production of bioactive seed oils

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ABSTRACT

Yellow horn (*Xanthoceras sorbifolia*) is a woody deciduous shrub or small tree native to northwest China that has been widely planted for bioactive oil production and ecological restoration. Ten years of field experiments indicate that yellow horn is well adapted to desert and xeric habitats of Liaoning, Inner Mongolia, and Xinjiang, China, and is an excellent prospect for alternative agricultural production and revegetation of arid regions as well as production of bioactive oils. In Horqin Sandy Lands, 7–11 year old unselected mixed lines averaged 152.30 kg/ha seeds, and selected pure lines averaged 1944.89 kg/ha, with average seed oil content of 25% and 34%, respectively. Seeds contain about 90% unsaturated fatty acids (C18:1, C18:2, C18:3, C20:1, C20:2, C20:5, C22:1 and C24:1) and 10% fatty acids comprised primarily of C16:0 and C18:0. Yellow horn seed oils are very high quality with low acid levels of 0.52 mg KOH/g (73% of which is unsaturated C18). Interestingly, the concentration of C24:1, an important bioactive compound is over 2%. Yellow horn is a unique plant species with potentially strong value for both ecological restoration of arid habitats and control of desertification, as well as an important and sustainable producer of high quality bioactive oils, which are used for food, healthy diets, and medical products.

1. Introduction

Human population growth necessitates new approaches to fulfil basic needs for food, energy and freshwater. Large amounts of agricultural land are lost annually because of desertification and drought (Lieth, 1999; Munns, 2005). In fact, 11% of the earth's fertile soil has been degraded in recent years and 3% of the soil will be unable to fulfil any biological functions in the future (Lieth, 1999). By 2100, at least half—and perhaps as much as 56%—of the land surface of the planet will be classified as dryland (Huang et al., 2015). Scientists must develop sustainable biological systems and drought tolerant plants that tolerate arid conditions and desertification.

In 2014, consumption of vegetable oils reached 31.67 million metric tons in China, 3.2 times more than was consumed in 1996 (Wang, 2015). Growing populations and elevated living standards have increased global demands for healthy edible oils. Since 1995, global consumption of vegetable oils increased from 72 to 173.27 million metric tons (http://www.statista.com/statistics/263937/vegetable-oils-global-consumption). However, declines in soil fertility and arable land have seriously restricted the cultivation of traditional oil crops such as soybean, peanut, rapeseed and cotton seed (Knothe and Steidley, 2007; Rashid et al., 2008). Given that the world human population is 7 billion and rising rapidly, new ideas and innovative, sustainable agricultural methods must be developed.

China has about 1.28 million km^2 of deserts, 80% of which are located in northwest China, and not being exploited and utilized reasonably. In desert and arid zones of Liaoning Province, Inner Mongolia autonomous region, and the Xinjiang autonomous region in northwest China, the vegetation restoration is thought to be the most effective way of ecological protection. Some drought-tolerant plant species with agriculture and environmental value have been identified and screened, such as *Xanthoceras sorbifolia*, *Hippophae rhamnoides*, *Tamarix chinensis* and *Caragana korshinskii*.

Yellow horn (*Xanthoceras sorbifolia* Bunge, family Sapindaceae), a woody deciduous shrub or small tree, is native to northwest China (Fig. 1A), with a lifespan of more than 200 years (Zhang and Zhou, 2003). The oils extracted from seeds of yellow horn contain

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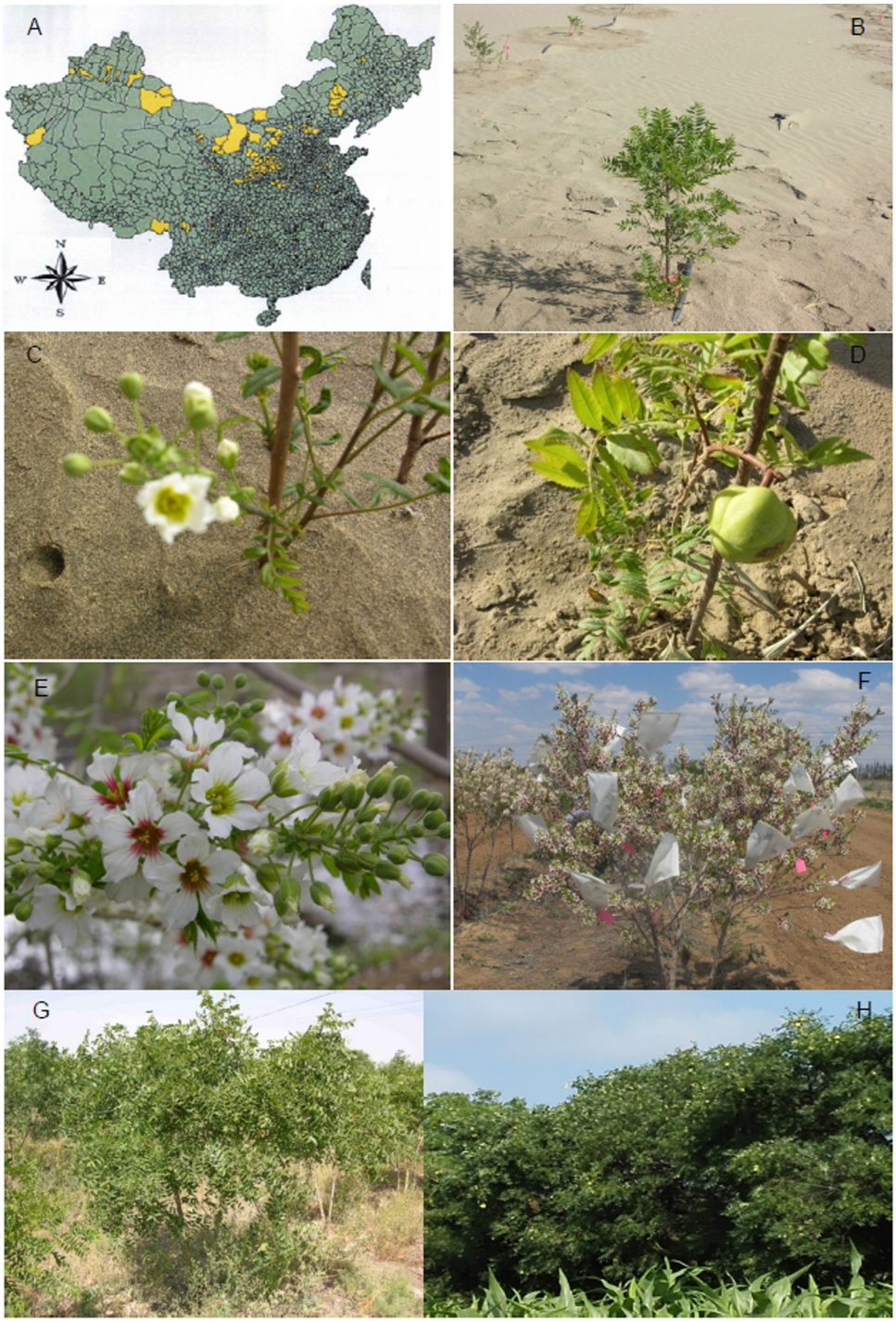

Fig. 1. Yellow areas indicate the distribution of yellow horn in China (A), individuals (B) growing in deserts, individual opened flower (C) and set fruit (D) in 2 to 3 years after plantation, one raceme (E) and thousands of flowers in one individual (F), the plantation of yellow horn established using unselected mixed (G) and bred fine lines (H). a: 5 cm; b: 5 cm; c: 7 cm; d: 6 cm; e: 6 cm; f: 4 cm; g: 6 cm; h: 8 cm. (Picture in A cited from Mu, 2006; the remaining photos pictured by C.-J. Ruan). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

rich bioactive compounds with powerful nutritional and medicinal properties that have been used by emperors and royal family members for more than 1000 years. Yellow horn seeds are also consumed directly as a traditional folk remedy for nocturnal enuresis and dysentery. It has also been used in traditional medicine for curing arterial sclerosis, hyperlipemia, hyperpiesia, chronic hepatitis and rheumatism (Wang, 1998). Furthermore, yellow horn is an important producer of bio-diesel (Li et al., 2010). With more than 60% oil in the kernel (Wang and Wang, 2002), it can produce enough biodiesel to be an energy-sustainable substitute for petrololium (Li et al., 2005).

Since 2000, with desertification and ecological deterioration, yellow horn has been widely planted in northwest and north China to restore farmland to forest, prevent and control desertification, and oil production. Our over 10 years of experimental field research indicate that yellow horn adapts well to arid and semi-arid habitats in Liaoning, Inner Mongolia, Shannxi, Gansu, and Xinjiang Autonomous Regions and Provinces in China. It is an agroecoengi-