Growth and Yield Performance of Jerusalem Artichoke Clones in a Semiarid Region of China

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ABSTRACT

This study investigated biomass yield and growth characteristics of 26 Jerusalem artichoke (Helianthus tuberosus L.) clones and assessed it as a bioenergy crop for a semiarid region of the Loess Plateau in China. Genotype, year, and genotype × year interaction contributed to differences in crop development, growth characteristics, and biomass yields (dry matter). Generally, biomass yields in 2011 were lower than in 2008, mainly due to a more severe soil moisture deficit in 2011. Shoot and tuber biomass yields (SBY) ranged from 18.9 to 35.0 Mg ha⁻¹ in 2008 and from 16.1 to 24.8 Mg ha⁻¹ in 2011. Clones HUB-2 and BJ-4 produced the highest shoot biomass yield (SBY), amounting to 31.3 and 25.6 Mg ha⁻¹, respectively, in the wetter year but higher drought sensitivity. Clones HUN-2, SD-2, and SHH-1 produced the second highest SBY, which varied between 14.3 and 20.1 Mg ha⁻¹. Clones GZ-1, HEN-1, HUB-1, IM-1, and SX-2 are recommended for tuber production and produced tuber yields >8 Mg ha⁻¹ in both seasons. Clones SD-2 and SHH-1 exhibited drought sensitivity indices <1.00, indicating that they were less sensitive to drought combined with a good yield level. Biplot analysis showed that HUB-2 and BJ-4 were the best performers in STBY and SBY. A combination of physiological traits associated with high STBY and drought tolerance may be most promising for further selection in a breeding program. To make a full assessment under more extreme conditions, we recommend a multiyear experiment at similar locations.

Jerusalem artichoke is a perennial warm-season relative of sunflower (Helianthus annuus L.), native to temperate regions of North America. This crop is one of the most important crops for industrial inulin production because its carbohydrate-rich tubers contain 75% inulin on a dry-weight basis (Kays and Nottingham, 2008; Baldini et al., 2004, 2011). The shoot biomass of Jerusalem artichoke has been considered as a potential biofuel feedstock, which can be a feedstock for direct combustion (Rutkauskas, 2005) and cellulosic ethanol (Tutt and Olt, 2011). The net calorific values of the shoot biomass of Jerusalem artichoke ranged from 18.0 to 18.5 MJ m⁻² (Rutkauskas, 2005). These values are relatively high compared with other biomass crops. For example, net energy yields amount to 6 MJ m⁻² yr⁻¹ for cellulosic ethanol from switchgrass (Panicum virgatum L.) grown on marginal cropland in the mid-continental United States was reported by Schmer et al. (2008). Furthermore, an ethanol yield of 6000 L ha⁻¹ from Jerusalem artichoke tubers was considered attainable in a German study (Stolzenburg, 2006).

Jerusalem artichoke has been considered as a biofuel feedstock (Rutkauskas, 2005; Curt et al., 2006; Leptomäki, 2006; Cheng et al., 2009) because of its high yield potential (Klass, 1998) and low input requirements in terms of pesticides, fertilizer, and water, combined with a relatively good adaptation to drought (Huang et al., 2004) and salinity (Zhao et al., 2009). As a high-yielding species, it can produce 70 to 80 Mg ha⁻¹ of fresh tubers, and the total aboveground dry matter can be >25 Mg ha⁻¹ (Ercoli et al., 1992).

The good performance of Jerusalem artichoke in Mediterranean (Baldini et al., 2004, 2006), tropical (Pimsaen et al., 2010), and saline areas (Zhao et al., 2009) has already been assessed. Diversity and variability among clone populations were revealed for morphological (Serieys et al., 2010; Liu et al., 2011), biological (Zhao et al., 2009), and productive characteristics (Pimsaen et al., 2010) and ethanol potential (Lelio et al., 2009). Appropriate cultivars with desirable characteristics for biomass source production are important. The crop has undergone relatively little systematic selection, however, suggesting that genetic improvement is possible and necessary (Kays and Nottingham, 2008). Until recently, there has been some lack of knowledge about Jerusalem artichoke cultivars suitable for biomass production, especially when grown on marginal land in semiarid regions.

Using marginal land is a policy option for growing energy crops for feedstock to meet the biofuel demand in China without causing further reduction in the food supply or environmental side effects (Qin et al., 2011; Li et al., 2010; Tian et al., 2009). The total area of marginal land was estimated at 100 million ha (Sang and Zhu, 2011), including 17.6 million ha, mainly located in northeastern, western, and central China, suitable for Jerusalem artichoke (Zhuang et al., 2011).

Substantial genetic variation in morphological and agronomic characteristics of 59 Jerusalem artichoke clones collected in China was reported by Liu et al. (2011) based on a field study performed in 2008. Twenty-six clones were selected according to their

Abbreviations: DSI, drought susceptibility index; SBY, shoot biomass yield; STBY, shoot and tuber biomass yield; WP, water productivity.